METAPHOR IN THE TEACHING OF ENVIRONMENTAL SCIENCE

by

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ABSTRACT

Studies of metaphors in teaching and learning have underlined the important role of metaphors in reasoning, but have sometimes failed to show the effect of metaphor on how scientific concepts are represented, and have sometimes overlooked hidden metaphors in their attempts to be explicit about how metaphor functions.

This study investigates metaphor in the context of teaching environmental science. It does not assume any simple correlation between surface linguistic cues and the presence or kind of metaphor. Two theoretical approaches have been chosen, Systemic Functional Linguistics (M. Halliday) which sees language as a social construction of meaning, and Image Schema (M Johnson and G Lakoff) which has developed in cognitive science and cognitive linguistics. These two approaches are used to discuss examples of metaphors from a number of lessons which have been observed and video-recorded, and in a variety of textbooks used as resource materials in teaching environmental science.

The choice of environmental science as the subject matter arises from two of its distinct characteristics. One is the fact that ideology triggers and shapes the interests, decisions and choices of materials, issues, arguments, reasons, etc. But there is nothing like one unique ideology, on the contrary conflicts of different ideologies raise differences about what will be selected and how it will be represented. At this point there is a special role taken on by metaphor. Metaphors provide the means for creating differences and similarities, thus bringing together or keeping apart ideologies. Second, the teaching of environmental science does not appear as the teaching of science only, bounded from anything else, but is a blend of accounts of scientific and commonsense knowledge. Metaphors appear at the overlapping points where this blending takes place.

It is not the purpose of the thesis to question, or to contribute to, the theoretical perspectives adopted. Rather, its interest is in how these perspectives provide, each in their own way, insights into the nature of the discourse of teaching environmental science, and thus to raise questions about its effectiveness.

To my parents,
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CONTENTS

CHAPTER 4: METAPHOR AS AN ISSUE OF REPRESENTATION

CHAPTER 5: FIELDWORK

CHAPTER 6: ANALYSING METAPHOR AS A LINGUISTIC PHENOMENON

CHAPTER 7: METAPHOR AS A COGNITIVE PHENOMENON
IMAGE SCHEMA APPROACH

CHAPTER 8: WHAT DO THE METAPHORICAL WAY OF TALKING AND METAPHORS IN TERMS OF IMAGE SCHEMATA AFFORD AND HOW?

CHAPTER 9: CONCLUSIONS

LIST OF APPENDICES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 The issue

This thesis is about metaphorical aspects of representations of environmental science as they are taught in the classroom. There are three areas of concern: environmental science, representations and teaching, related in such a way that each has a special interest in the other.

As far as environmental science and representations are concerned, my interest in metaphorical representations of environmental science is because of the prominent place such representations have in communicating environmental science within the context of a scientific research, policy making and representations of environmental science to the public. Metaphors are the means in which environmental problems are realised and can be possible communicated between people who have different interests (scientists, politicians, managers, policy makers, public).

Among the recent environmental problems which appear often in the media, the depletion of the ozone layer is illustrated and talked about as an ozone hole even if there is not such a thing but rather a thinning in concentration. As Hannigan (1995, p.3,45) has argued, the image of the hole was scientifically constructed to make the situation more dramatic and understandable. This metaphor is not just a device to motivate interest but is an inseparable part of the way the thinning in concentration of ozone is realised by the public and communicated. Also the effects of acid rain were dramatised when German environmentalists began to use the term /waldsterben/ (forest die back). This term has survived until today and is used now at a global scale (e.g. "oaks die back"). In representations of environmental science visual information has a significant role which is sometimes more prominent than the role of language (see for example the scepticism about genetically modified foods expressed in an image in Appendix 1).

Contemporary studies of environmental science (see Hannigan 1995), suggest that environmental risks and problems can be seen as socially constructed entities, without denying their objective reality in terms of independent causal powers of nature but acknowledging that the rank ordering of these problems by social actors does not always directly correspond to actual need. Therefore, in the construction of environmental problems scientific facts and authority are neither the only necessary nor the only sufficient condition. The dramatisation of the problem in symbolic and visual terms is an essential part for representing the problem as real and important (Hannigan, 1995, p.55).

Also recent studies in environmental politics argue that what was seen before as environmental conflict has now changed into a discursive conflict. It is rather now not a question of whether there is an environmental crisis, but how the latter is interpreted. This assumption raises to a more prominent level the importance of representations of environmental issues and makes more urgent the need for studying representations. According to these lines of thinking, groups (e.g. institutions, organisations, governments, e.t.c.) which have opposite interests are in conflict with each other with the inevitable consequence that they interpret environmental crises in ways which underlie their different ideologies.

As far as media are concerned with representations of environmental issues, the organisation of the latter in terms of 'story-lines' is thought of as a common, fundamental way of representing them. A 'story-line' provides the framework with both ideas, concepts and language within which an issue is seen and discussed (Hajer, 1995, p.56-57). The idea behind the concept 'story-lines' is that even for an event the details of which are not disputed, the event itself can be framed in a number of ways. Among these discursive strategies, metaphors, exemplified accounts of science and catch-phrases function as sorts of symbolic realisations of the core meaning of the frame. For example, the phrase 'spaceship earth' adopted in 60s and 70s mainly after the 1969 view of the planet as fragile and finite, from the moon (Hajer, 1995, p.62), has been a powerful metaphor which has framed a number of story-lines in the media (see Roth, 1978).

But although the importance of representations in respect of their implications is now evident in many studies - specially those which are concerned with the role of media and the shaping of environmental politics - there are still rather few attempts in recent research in environmental education to study what underlies representations of environmental science in the context of teaching. It is rather more likely that explicit accounts of metaphors, such as analogies about popular issues of environmental problems (e.g. Greenhouse effect), find their way more easily in studies of environmental education than covert metaphors which are about fundamental but not so popular entities of environmental science (e.g. representations of micro-organisms such as decomposers).

The interest of the present thesis is in how metaphor works in both covert and overt cases of metaphors, an inquiry which brings the analysis to the level of how environmental entities are represented. Representations of entities which are re-constructed in the classroom for the purpose of teaching are of special interest for a number of reasons, such as:

Representations of entities play a crucial role in order to identify, describe and justify environmental changes and damage. They provide arguments which build up understanding, beliefs, attitudes.

They are concerned with natural, physical phenomena which take place both at the macroscale (e.g. Nitrogen cycle) and microscale (e.g. the absorption of nitrates by plants' roots, photosynthesis). Examples and narratives do a lot of work in explaining phenomena at both scales.

They are constructed on the basis of complex relations between scientific and commonsense knowledge. For example students rely on their everyday experience of phenomena like raining and water flow in order to explain the water cycle but at the same time they need also to develop concepts like evaporation or transpiration from the scientific point of view. As a result ordinary language is interwoven with scientific language, sometimes inextricably.

They are related with concepts from a variety of disciplines including: chemistry, biology, geography, geology, economy, decision making.

Metaphorical representations of entities have two effects, sometimes simultaneously:

-they make something strange forcing us to see it in an unusual way

-they provide the means to see something as familiar

This double function imposes a delicate balance on meaning where something is illuminated because of the use of metaphor and something else is suppressed even because of the use of the same metaphor. The fact that this function sometimes takes place in a hidden way makes more interesting our effort to dig out how metaphors work in the teaching of environmental science.

From studies of metaphors as they occur in an educational context, it has often been claimed that metaphors:

- may facilitate understanding the abstract by pointing to similarities in domains like the students' everyday experience.

- may provide visualisation of the abstract
- may incite students' interest and insofar may have a motivational function.

But different approaches give different definitions to metaphors. According to the comparison view metaphor is an explicit comparison between two things in terms of something which is like/as something else. On the contrary both interaction and experiential theories are looking for hidden interactions of ideas sometimes below what is represented at the linguistic surface.

In this study, it is taken as given that the experiential accounts of metaphors (image schema approach) elaborated by a sociolinguistic point of view (Systemic Functional Linguistics) and some aspects of the interaction theories might give the means to analyse both implicit and explicit appearances of metaphors. This study also agrees with those who do not draw any sharp distinction between metaphors, analogies, and similarities.

As far as various approaches are concerned with the study of metaphor, representations and even systems of representations (e.g. images) there are usually three different points of view. More often studies take a quantitative stance which wants to look at things (e.g. metaphors, representations) marked out as clearly as possibly (e.g. words, expressions) and phenomena being as distinct as possible from one another (e.g. analogies vs. metaphors, literal vs. metaphorical). The opposite view, which is also very popular among studies of metaphor, tends to see things as parts of higher structures, such as sociological perspectives, institutions, or cognitive structures and puts more emphasis on implications and consequences, but often fails to give sufficient exemplified accounts in order to show how implications and consequences are grounded (materialised) in 'natural' contexts. There is also a third stance - followed in the present thesis - which recently has attracted more attention from both cognitive and sociolinguistic studies, looking at how specific phenomena such as metaphors belonging in higher structures of meaning organisations (e.g. discourses or genres) are worked out in specific situations. The latter view tends to exemplify the silent ways in which things are represented, so disagrees with the deterministic approach taken by the first approach.

1.2 The argument

The present thesis is organised and constructed around four research questions. The first question:

How do image schematic and Systemic Functional Linguistic approaches apply as analytic approaches in the context of teaching environmental science?

defines that two accounts of metaphor both interdisciplinary in their nature but one with a more cognitive direction (image schema) and the other with a more sociolinguistic perspective (S.F.L) are used here as analytic approaches. The challenge that this thesis faces is whether the application of the two approaches can show reliable and convincing uses of their analytic tools. As far as the former approach is concerned, aspects of it have not yet been applied in the context that we are looking at. On the contrary, S.F.L. have been applied by its founder (Halliday et al, 1993) and others in the teaching of science and for contents which most of them are either environmental science or relevant subjects (e.g. earth science and geography). Others also have applied some aspects of S.F.L. in environmental science (see for example Schleppegrell, 1997).

The second question,

What does the application of the schematic and linguistic analysis in the specific context suggests for their semantic forms and their functions: clause types and image schemata?

explores the limitations of the power of the analysis in constraining the units of analysis at the level of a single clause or image schema. Both kinds of analysis not only work in a way that metaphors do not need to be marked out syntactically as such in terms of 'something being something else' or 'being like something else', but show that even clause types are determined by interpersonal and textual aspects and a single image schema (e.g. container) never or very rarely appears on its own without being part of a more complicated structure of meaning relations in which more than one image schema is involved.

The third question, which is raised out of the outcomes of the two previous questions, concerns a shift in the direction to which the two analytic approaches are used:

How are entities of environmental science carried by the linguistic and schematic forms?
or in other words:
How is the content of environmental science realised linguistically and schematically?

The interest now is not in how aspects of the two approaches can be applied but how entities are represented and therefore realised. So instead of looking for applications of the two approaches we are looking at entities and how the latter are realised, in terms of the two approaches. The change in the direction provides a different dimension in looking at metaphors. While in the former, one can see that forms such as material processes are semantic forms since they can represent a variety of entities (from plant actions up to human actions), the latter dimension exemplifies semantic forms and therefore metaphors as well, as choices in how a single entity can be represented (plants' actions represented either as a material process or as nominalization). The third question is explored in the second part of the linguistic analysis (section 6.3) and in the discussion of the metaphorical extensions of each image schema.

The combination of the two dimensions (one reflected in question 1 and the other reflected in question 3) leads us to think of metaphor as a relation between semantic form and meaning, so metaphor is not defined as a single phenomenon but can have many aspects. In other words metaphor is variety in representing based on a choice, irrespective of whether this choice is consciously realised as such. Although this very simple definition of metaphor is the bottom line where many approaches agree, most of them - specially those which are applied in education - restrain metaphor to a very constrained spectrum of variety e.g. representations in terms of phrases such as: 'like' or 'as', and explicit mappings between different domains of experience.

At this point a very fundamental question is raised about what metaphor is: If variation in representation is accounted as a metaphor then what is not a metaphor? If the answer to this question is that what is not metaphor is literal, then what is implied is that there are 'true' and 'correct' representations against others. But since in the context that we are looking at, that is representations of environmental science for the interest of different groups and people and not only for the interest of scientists, there are not clear boundaries between what can be seen as the 'only' and 'correct' representation against others, and any categorical distinction between what is literal and what is metaphorical is difficult to sustain. Furthermore, defining as metaphor only 'very unusual' representations which because they are 'unusual' are easily picked up as such, keeps us away from 'regular' representations which because they are 'regular', often turn out to be invisible or silent. Then ironically, what is 'literal' turns out to be hidden and what is 'metaphorical' turns out to be overt. Nevertheless, the fact that in the present thesis there is no clear distinction of what is literal from what is metaphorical, or in other words that the issue of metaphor is not treated as one of definition, does not mean that all kinds of representations are looked at as if they are of the same kind. To put it in another way, the present thesis in its refusal to sharply divide what is metaphorical from what is literal, nevertheless does not accept that since there is not an 'absolute', 'true' representation, then anything goes in representations as if all of them are of the same value.

The last argument brings us inevitably to the next question which is about the value of the different ways in which things are represented. In this perspective, the present study of metaphor would have been too limited to its scope if it did not ask about the effect of metaphor. This is what the fourth question tries to explore:

What is the effect of the choices and use of certain semantic forms on how contents of environmental science are represented?

Different representations of environmental science do not only have an effect on how the nature of entities is represented (ontological implications), (whether an entity is represented as being like a thing or a process) but also on what is thought of as a better way of making knowledge about specific entities possible (epistemological implications), on how power relations between people, institutions and the environment are realised (ideological implications) and on what can be thought of as better approaches for learning about the environment (learning implications). Examples from textbooks and teaching show how these implications co-occur in a way that their effect is often not realised by the very people who use these representations and are affected by them.

1.3 Outline

The thesis is organised as follows:

Chapter 2 discusses basic categories and issues raised in studies about the environment. The purpose of this discussion is to show that entities in environmental science are defined and therefore represented in different ways depending on how they are looked at. Metaphors have an essential role in formulating the different ways in which entities are represented.

Chapter 3 reviews recent research in environmental education in respect to how students understand environmental concepts and how the latter are represented to them. The review underlines the lack of systematicity of these studies in relation to how they interpret their findings. It also raises representations of environmental science in teaching as a key issue in how concepts are comprehended by students.

In chapter 4 metaphor is defined as an issue of representation. A brief discussion of early and contemporary approaches to both representation and metaphor and a more extensive discussion of early and contemporary approaches to metaphor which is included in the Appendix (see Appendix 2) argue that many complexities around what metaphor is are due to the fact that metaphor is looked at mostly as an issue of definition from very diverse approaches which belong in different domains (e.g. philosophy of language or cognitive psychology). Many different views about metaphor tend to locate it at the very opposite ends of a number of dimensions. So, while some theories believe that metaphor is about words only, others claim that it is about cognitive functions. All these different approaches rely to some extent on what they count as representation. As stated in chapter 4, it is not the purpose of the present thesis to map all these different approaches and resolve the issue of metaphor as one of definition, but to provide some exemplified accounts of metaphor as they occur in a specific context. In order to do so, two approaches have been adopted and implemented in the analysis of metaphors. Sections 4.3 and 4.4 present the two approaches, these are Systemic Functional Linguistics and Image schemata. Then section 4.5 provides the framework in which the two approaches are applied as it has been built up in a number of recent studies in science education.

Chapter 5 presents the way in which the present study has been conducted.

Chapter 6 is divided into two parts. The first part (section 6.2) deals mainly with the first and the second research question so is looking for how aspects of Systemic Functional Linguistics can be applied in the context of teaching environmental science. In doing so, this long section tackles a number of important issues, such as:

1. it is argued why metaphors should be seen as parts of constructions of entities and not as parts of genres
2. that words are not just 'words' and why they cannot be the unit of analysis in the context that we are looking at
3. that the study of ideational processes should take into account interpersonal aspects and textual cohesion
4. that even language as a system of representation should not be seen alone but in relation to other means of representation (e.g. images)

Exemplified accounts in dealing with these issues are valued as important here if we want to set out as clearly as possible the framework within which aspects of Systemic Functional Linguistics can be used for the purpose of the present study.

Then the second part of the linguistic analysis (section 6.3) moves towards answering the third research question. It is argued here that the degree to which entities are represented as concrete or abstract (section 6.3.1) has an effect on how entities less accessible than commonsense ones are realised in their representations (section 6.3.2) and how the relation between the reader and entities of environmental science is realised (Appendix 5.1). Also, more or less abstract realisations of entities underlie what can be seen as explicit analogies (section 6.3.3). In this second part (section 6.3) of the linguistic analysis and in the discussion of chapter 6 (section 6.4) aspects in answering the fourth research question are discussed.

The structure of chapter 7 is very different from the structure of the previous chapter, even if the four research questions are dealt with in the same order as in chapter 6. In chapter 7 exemplified accounts of how five image schemata (agent structure, path-link, containment, carrier and cycle) can be seen as being implemented in the teaching of environmental science are provided. Each section consists of a discussion of a different schema. At the end of each section accounts are provided in answering the third and the fourth questions specially in respect to metaphorical extensions of image schemata. While four of the image schemata are discussed mainly in terms of their linguistic realisations, the cycle is discussed as a multi-modal construction of an image schema. Also, how various image schemata (mainly agent structures and containments) are implemented in the realisation of the relation between the 'self' and other entities - described as objectification of the self and personification - can be found in an Appendix (Appendix 5.2). Finally, the discussion of chapter 7 is focused on the implications representations of image schemata have on how entities can be realised, that is answering the fourth research question.

In chapter 8 the two analytic approaches are discussed together in an attempt to bring together answers to the third and fourth question. The first part of this chapter (section 8.2.1) deals more with how metaphors function while the second part (section 8.3.1) deals more with what metaphor is about.

Finally, chapter 9 summarises the main results in relation to the four research questions and discusses the limitations of the present research and some further implications concerning different areas of interest.

CHAPTER 2

ONTOLOGICAL CATEGORIES AND ISSUES RAISED BY STUDIES ABOUT THE ENVIRONMENT

2.1 Introduction

Recent thinking about Environmental Science and its relations with studies from other disciplines such as Environmental Sociology are discussed here. The multi-disciplinary nature of many approaches today in respect to the nature of environmental issues and problems which are defined as an amalgam of commonsense and scientific reasoning is underlined.

2.2 The identity and identification of entities

Ecology deals with all sorts of entities which other sciences like physics and chemistry deal with. So for example genes were theoretical entities whose existence was postulated in theories before we were able to observe them. Today with the available technology genes are not theoretical entities any more even if we cannot say that they have the same status as animals and plants, simply because the existence and the behaviour of the latter is more accessible to our commonsense knowledge.

There are also other kinds of entities like biological communities and ecosystems which do not have so clear a status as that of experimental entities - that is those which have come into existence in test-tube systems - and they are less doubtful, in terms of our commonsense understanding, than the theoretical entities. We might think of a pond as an entity more accessible to our commonsense knowledge than a gene. But for the interest of ecology it is not so easy to say whether a pond is identified as a single entity separated from its surroundings, and thus from other entities. Therefore and depending on what is the focus of our inquiry such an entity as a pond can be treated in some cases as a postulated entity rather than a naturally occurring entity.

The same sort of fuzziness between the categories in which entities are classified can also be noticed for the distinction between thing-like entities, process/event-like entities and place-like entities. Without doubt some entities can be clearly thought of as being thing-like entities such as all the kinds of plants and animals that surround us, and others like the seasons and the day-night cycle are thought of as event-like entities. But for entities which are either theoretical like the food web or whose meaning is grounded in theories, regardless of whether they are observable or not like the cell for example, it is not quite clear whether they belong to one category or another. Even cells can be thought of as process-like entities (Capra, 1982).

There is an essential connection between the definition of an entity and its location. Ecologists, like A Brennan (1988, p.7), used to say "what we are and ought to be is partly determined by where we are". But locations of entities do not always have the meaning of physical, spatial places in which entities are found. The concept of niche for example despite the fact that it used to be thought of as the physical location of an animal, is often a 'location' with a very metaphorical meaning; it indicates status relations among organisms and other categorical relations (Brennan, 1988, p.48). Niche is most of all a 'location' in the community/population of organisms and a 'location' in the food chain. In that way what an organism like a plant is depends on where this organism is 'located' in the food chain (Brennan, 1988, p.52).

The food chain itself is also realised quite often as a place-like entity. Various processes and actions of eating, dying, storing food which are involved in a food chain become passages and path ways of entities; organisms at different trophic levels become links in a food chain, and their living and non living properties are distinguished in terms of their location in it (Brennan, 1988, p.52). It should be noticed here that an organism's niche can be identified at the same time in more than one dimension, like temperature, humidity, the level of the water table, exposure to sunlight, etc. Each of these conditions adds a further dimension to our description of an organism's niche. As a result at least theoretically each organism can be identified as the volume in a n-dimensional hyperspace within which it can be maintained (Brennan, 1988, p.49).

At the same time what an organism is depends on what it does in relation to other entities and to the place in which it is located. So it is not so apparent as it might be thought whether for example bees are the agents which utilise plants as resources or/and bees are resources (pollinators) for plants, with plants therefore seeming to have the more active role. We should not underestimate the influence commonsense observations have on what sort of properties we attach to entities: bees are mobile therefore they are the agents while plants are static therefore they are resources (store-like) and subject to agents' actions (Brennan, 1988, p.45).

We can conclude that the identification of any entity apart from its intrinsic properties takes into account where the entity can be found, what the entity can do or in other words its ecological role and consequently what can happen to it. All these factors together constitute a package of properties and behaviours which tells us what an entity is. Looking at entities in that way it is inevitable that the identity of each is grounded in the relations this entity has with other entities.

2.3 What is a living and what is a non living entity

We can think about an entity as living or non living in two ways. Either because an entity is identified as so or because of the way the entity is treated; like a living entity or like a non living entity. Biologists relatively recently have come to realise that cells are not just the building blocks of other organisms but that they are organisms in their own right. So now when a living process in which the cell is involved, is mentioned, like reproduction, feeding, death this is not defined in terms of processes of other living entities but are defined as living properties for the cells themselves (Capra, 1982, p.102).

Other entities like viruses which exist on the borderline between living and non living matter have provided different definitions of what is living or non living which are quite far from our anthropocentric view (of what is living) (Capra, 1982, p.298). In this case where an entity is located determines whether it is living or not (Capra, 1982, p.299). Outside living cells, totally unable to function and multiply a virus cannot be called a living organism; inside a cell it forms a living system together with a cell, but one of a very special kind.

Certain theoretical accounts provide different definitions of what can be considered as living or non living and also different terminology. For example systems theory talks about living systems defined as organisations in the form of multi-levelled structures (Capra, 1982, p.26-27). Entities like living organisms, societies and social systems, like a family for example and whole ecosystems are then 'living systems' (Capra, 1982, p.287). What was considered before as a building block of an organism, a cell for example, is now defined as a living system. The soil is also understood as a living system which consists of organic and inorganic matter (Capra, 1982, p.270-271).

Finally, an entity can be treated in such a way that makes us think about it as living or non living. This is usually the case for entities which are not accessible to everyday human understanding, therefore these entities have to be thought of (conceptualised) in terms of something else which is more accessible to commonsense knowledge. For example the entire earth was thought to be a 'nurturing mother' in the ancient and middle ages (Capra, 1982, p.41). This was what is called today the organic view of nature, since it ascribes living properties to the earth's ecosystem as a whole. Earth is a source of energy in the same way as a mother who feeds her baby is a source of food for it. The personification also implies a relationship of interdependence between the earth and its parts and attaches to it a property that only living entities have; earth as an entity from which life is brought about.

In contrast with the ancient view of nature, the scientific revolution of the 17th century had as a consequence a very different model of how the world was thought to be. The earth as a nurturing mother metaphor was replaced by the world as a machine metaphor (Capra, 1982, p.41). The latter objectifies nature and removed from it every sort of living property. But later with the appearance of evolutionary theories and the systems theory the earth becomes once more alive. The world now is not thought of as already created and fully constructed, as the machine like metaphor claims, but as an evolving and ever changing system in which complex structures developed from simpler forms (Capra, 1982, p.59).

2.4 What can be considered as an individual, fundamental unit/entity

Ecology today does not attempt to find any fundamental unit in terms of which all ecological descriptions can be given. In fact more than one fundamental unit is used, depending on the scale of the analysis and the phenomenon that has to be described and explained (Brennan, 1988, p.63). To give some examples, once organisms are seen as linked elements of a food web, the web itself becomes a natural unit of study rather than the organism itself found in its environment (Brennan, 1988, p.52). Studying the concept of the food web further from the point of view of the theory of tropho-dynamics and the succession theory we could see ecosystems as dynamic wholes which through exchanges of matter and energy increase their complexity, maturity and stability. So at the end what becomes a fundamental ecological unit is the concept of the ecosystem as a gigantic superorganism in its own right developing toward a mature, stable state of complex diversity (Brennan, 1988, p.53).

The issue whether biological communities and ecosystems can be taken as fundamental units, is not so much one of reality but of usefulness. As we have seen above, a forest or a pond for example are easily enough identified from a commonsense point of view, but it is not always easy to see them as separated from their surroundings and described on their own as having properties of biological substance (Brennan, 1988, p.119-120).

Recently, ecological studies have taken a more individualistic approach to communities. So instead of looking at whole ecosystems as huge 'individual organisms' they investigate individual living entities, like plants for example for their enormous variation in dealing with processes such as defending themselves from an invasion of micro-organisms or changing their attractiveness to a herbivore. In this way the plant seems more like a population than an individual, for it constitutes a variable resource for herbivores and disease organisms (Brennan, 1988, p.54).

2.5 The relationship between a living entity and its environment

Many writers like F Capra (1982, p.51) and J Gibson (1979, p.18) stress the fact that in ecology the location of an entity at a certain place is very different from how in classical physics an entity is located in a three dimensional space. In ecology place has not the meaning of (mathematical) space as an empty container independent of what happens inside it. The ecological meaning of space is closer to the concept of place that we share in our everyday life. An environment and its habitats for example are in a dynamic relationship in which one acts on and is acted upon by the other.

Gibson (1979, p.8) reflects the interdependence between a living entity and its environment and the meaning and use of words. So according to him, the words *animal* and *environment* make an inseparable pair in a way that the use of one word, say *animal*, implies the simultaneous coexistence of the other; *environment*. And this is because one concept determines the existence of the other: no animal could exist without an environment surrounding it and equally the environment implies an animal to be surrounded.

The issue of agency concerning the relations between living entities brings with it the question of what sort of causal relations occur in nature. The answer depends on the view which dominates our way of thinking about nature. The mechanistic model translates every causal relation in terms of linear chains of cause-effect relations. On the contrary the organic view of nature sees causality in terms of cyclical patterns of information flow known as feedback loops (Capra, 1982, p.289). Cycles of life, food webs and pollution problems are thought of as circular systems of cause-effect relations in which systems of causes rather than single causes are involved. In these causal systems correcting, alternative mechanisms prevent or correct failures due to the flexible nature of the living systems in contrast with machines in which a broken part of them can stop their function entirely. But circular causality makes living systems and the relationships that are involved in them less predictable and less able to be controlled: too much effort to remove one cause of pollution can be proved to be worthless, on the other hand adding one more cause (pollutant) should not be underestimated since it can have a dramatic effect (for example concentrations of DDT in secondary consumers) (Chisholm, 1972, p.92).

2.6 The relationship between a part and a whole

Issues which give priority either to the part or the whole in the study of environment are grounded in the nature of explanation. Mainly two opposite modes of thinking determine the nature of explanations in ecology (Brennan, 1988, p.7). The first approach, dominant since the scientific revolution began, is the traditional atomistic and reductionist mode of explanation. According to this, all aspects of complex phenomena can be understood by reducing them to their constituent parts (Capra, 1982, p.101). Reductionism has been the outcome of the 'world as a machine metaphor' which influenced scientists to treat living organisms as machines and sooner or later to tend to believe that living organisms are nothing but machines (Capra, 1982, p.47).

In contrast with the reductionist mode, holistic approaches influenced recently by systems theory support the view that the whole, whatever it is (an ecosystem or an organism), has properties not reduced to those of its parts. So according to holistic explanations, studies in ecology should start by looking at the whole and how the parts function in respect to the whole since the latter determines the properties of the parts and not the other way round. The nature of the whole is always different from the mere sum of its parts and the specific structure of the whole arises from the interactions and interdependence of their parts (Capra, 1982, p.287).

Holistic approaches overemphasise the whole rather than the parts, while reductionistic approaches overemphasise the parts rather than the whole (Chisholm, 1972, p.138). The difference between the two views affects not only our knowledge of what the world looks like but also what is counted as the foundation of the knowledge itself. This issue is also related with the issue of what can be taken as the most fundamental unit in the study of the environment. Holistic modes of thinking give priority to ecosystems like forests and communities of populations, while reductionist modes give priority to individual organisms like trees and the building blocks of individual entities like cells.

Both the organic and the systems view of life emphasise the interdependence between a living system as a whole and its parts. This relation is often expressed in terms of a living system as a web. The living system as a web metaphor affects how we think both agency and causality in nature. If humans interfere in certain ways with one part of a living system, regardless of whether this is an organism or an entire community, their interference affects the other parts of the living system as well (Brennan, 1988, p.81).

2.7 Scale relations affect what and how we think about entities

By taking different perspectives while we are studying the relations between entities we notice that in general an entity consists of a unit which is embedded in a larger unit and at the same time a smaller unit is embedded in it. This phenomenon, described as nesting (Gibson, 1979, p.9) is noticed for all sort of entities: an event like decomposition is nested within another event like the carbon cycle. In some cases nesting and part-whole relations coincide: leaves are nested within trees and trees are nested within forests. The unit which is chosen for describing the environment depends on the scale on which the environment has been chosen to be described. In that way relations between entities are described in terms of superordinate and subordinate relations between units. At the end what counts in the study of the relations between entities is not simple agent/patient relations but the whole range of interactions between them (Chisholm, 1972, p.4). Take for example the role the decomposers have in the cycles of life and in the food webs. Whereas the presence of decomposers like mushrooms at a certain place looks as if these living organisms compete with other sorts of plants for space and food, the study of the same organisms from the microscopic point of view reveals symbiotic relations of cooperation and 'solidarity'; the decomposers break down the organic matter like dead plants and animals to inorganic matter like carbon and nitrates so making nutrients available to other plants, by giving them back to the soil. From the microscopic point of view the decomposers, by contributing to the circulation of matter and energy in the ecosystems, have an irreplaceable role in sustaining a whole community of organisms. To put it rather crudely, in nature the question who is making use of whom; the decomposers of the plants or the plants of the decomposers, depending on the scale we answer it, can have two contradictory answers.

Again the issue of spatial and temporal scale affects considerably what sorts of relations we see. Looking at the overall living system well-defined regularities and behaviour patterns are noticed. The whole system of a living organism like an animal seems to be static over short periods of time, but not in long periods of time when evolution is involved. If we look at the same system microscopically the relations between its parts are not so rigidly determined in the same way that the whole organism is determined. Stability consists in maintaining the same overall structure in spite of ongoing changes and replacements of its components (Capra, 1982, p.292). The dual character of a living system, as Capra (1982, p.292) has pointed out, causes some confusion when we think in terms of commonsense knowledge. We are used to thinking of stability in terms such as *fixed, unvarying, steady* but this is not the case in systems theory; stability is sustained through dynamic processes.

2.8 Summary

The present review of studies which are concerned with ontological issues raised by environmental science, shows that different theoretical approaches, which often turn out to be different ideologies (e.g. mechanistic vs. organic approaches) have an effect on how almost every ontological aspect of environmental science is represented and realised. In studies of the environment, powerful metaphors are at work, even if they are not always present and realised as such, to mention some: 'life as a web', 'earth as a nurturing mother' and 'the world as a machine' metaphors, which influence representations of the environment and consequently what and how we think about it.

Environmental science seems not to be detachable from these 'theory constitutive' metaphors and also some commonsense thinking is implemented in what can be seen as scientific reasoning about the environment. So, questions about the identification of an entity, the relations between entities concerning their actions and locations, as well as part-whole and scale relations, can get different answers depending on from which point of view they are looked at:

commonsense	vs.	ecology
one theory	against	another
an interest	vs.	other interests
one paradigm	vs.	another paradigm.

To give an example, which will be discussed later looking at how aspects of environmental science are represented in teaching, what can be taken for granted in commonsense reasoning about the definition of a pond or a forest can be seen as problematic concerning their definition and study in science.

CHAPTER 3

RECENT RESEARCH IN ENVIRONMENTAL EDUCATION

3.1 Introduction

The environment and its associated problems is an increasingly important topic for science education. Most of the recent science curriculum models have emphasised the interrelatedness of science concepts with awareness of environmental problems. Over the years schools have tried and tested a number of approaches to introduce environmental education in their curriculum. Environmental education is taught either as a separate subject or as part of other related subjects, like biology and earth science. The latest approaches emphasise the interdisciplinary nature of environmental education and suggest that it should not be taught separately from other subjects or just as part of them, but that it should be taught in the form of short or long term projects in which subjects of science and social sciences are integrated. The underlying reason behind these approaches is the belief that environmental issues are the primary concern not only of science but of other disciplines as well, like sociology and political science.

Several studies have found that students have difficulties in explaining higher order concepts such as food webs and nutrient cycling in terms other than those provided in their texts (Brody et al., 1988-89). Most of these studies underline the need to investigate students' prior ideas about environmental concepts so that teaching will be directed properly to concepts which are difficult to understand. Recently also, an increasing number of studies put emphasis on how environmental issues and concepts related to them are represented in the media, in textbooks and in teaching. These studies argue that the causes of misconceptions lie mostly in the way environmental problems and concepts are represented to students and to the public.

3.2 Research on students' understanding of environmental entities, issues and problems

Looking at the research literature on pupils' misconceptions in environmental science it becomes apparent that most of the difficulties in understanding concepts are caused by the ontological categories to which pupils relate these concepts. It has been found that pupils' reasoning depends heavily on the phenomenological properties of observable entities and that if they are called on to express their ideas about unobservable entities or entities with which they have little experience, they often do so in terms of the entities with which they have more experience. For example, children think about plants as organisms which take their food from their environment and not as organisms which need to make their food first within them (Leach et al, 1996a, p.22). So plants are thought of as similar to animals in the way they get their food resources. On the other hand, plants are thought of as different to animals in respect to respiration. Pupils based on their own experience with breathing and also by seeing animals breathing, relate respiration with breathing and therefore think of photosynthesis as the opposite process of respiration. As a result, they believe that while photosynthesis is for plants respiration is for animals. Even at an older age pupils still think of the two processes as opposite so they cannot see how they can take place at the same time in plants (Leach et al, 1996a, p.22).

Pupils also when asked about the 'needs' of plants, show by their responses that they think about plants as ontologically 'near' to animals. Plants are thought of needing light and air, like animals and people, in order to stay 'alive' and 'healthy' (Wood-Robinson, 1991, p.131). Even by the age of 16 students have difficulties in understanding how unobservable entities like light, and gases like oxygen and carbon dioxide are incorporated in the making of plants' food (Leach et al, 1996a, p.23).

A number of studies have found that pupils conceptualise organisms like plants and relations between them in terms of teleological and anthropomorphic reasoning (Jungwirth, 1975). It will be argued that these results together with the findings of the studies discussed above can be further analysed (interpreted) and suggest that there is an underlying basic schematic reasoning which deals like a package with most of the concepts related with the life of plants, having also its effects on new knowledge students learn about plants. The underlying reasoning is an Agent structure and its experiential basis is grounded in human and animal behaviour.

This sort of agency explains the often contradictory responses of pupils to several research tasks of various studies. Take for example the findings of Jungwirth (1975) who suggests that students usually interpret literally teachers' and textbooks' language on plants growing. Statements such as "cacti grew spines in order to..." are interpreted by students as if cacti have control over their structure and act like animal Actors. On the other hand, if students are asked to recall animate organisms from a number of given entities they are more likely to refer to animals than plants (Leach et al, 1996b, p.131). In other words, due to agency experientially grounded in the behaviour of animals, the latter are seen as 'more animate' than plants. Furthermore, realisations of agency in terms of animals behaviour affect interpretations (readings) of the processes of other organisms, in this case plant growth. Young children even seem to believe that nature cannot exist without human agency. When they were asked where organisms get needs such as food and water, they often mentioned human beings (Leach et al, 1996, p.130). Agency as an underlying reasoning pattern organises and constrains knowledge about organisms as a package: plants are seen in general as less animate than animals, plants cannot respire because respiration is seen as breathing, but processes of plants in terms of what they need, how they get their food resources and their growth share the same basic schematic reasoning with processes in which animals are involved.

An example of what the entailments of pupils' underlying reasoning about agency can be is their understanding of the process of evolution. Studies reviewed by Wood-Robinson (1994) show that students who have not received any formal instruction on the subject of evolution provide explanations which are most often expressed in everyday language;

"*When it turned all cold, the foxes fought to keep themselves alive and gradually they began to grow thicker coats until they were able to survive properly... yes, they were sort of determined to stay alive.*"

(12-year old student)

Notice that adaptation in this extract is explained as the deliberate attempts of foxes to keep themselves alive in response to environmental changes (Robinson, 1994, p.43). The overemphasised role of agency of an individual organism in the process of evolution is in complete contrast with the extract below;

"*Well, possibly there were some foxes with thin coats and some foxes with slightly thicker coats, but the foxes with thin coats would have frozen to death and the foxes with slightly thicker coats may have survived long enough to make more offspring with thick and thin coats, and the thin ones would die out, so the thicker-coated ones would survive more so they eventually ended up with very thick coats*"

(12-year old student)

Furthermore, initial associations of evolution with a 'strong' sense of agency have as a result that other organisms like plants are not mentioned by students in an evolutionary context, even if the opportunity to do so was provided (Robinson, 1994, p.43).

Pupils' difficulties in dealing with the existence of the invisible affects their understanding of complicated processes and phenomena, like the process of photosynthesis and the cycling of matter. As we have seen earlier, children find it difficult to conceptualise plant body mass as coming from an invisible atmospheric gas and water, rather than a more 'solid' substance such as soil (Leach et al, 1996a, p.31). In the case of the role of decay in the cycling of matter, even the majority of pupils up to the age of 16 cannot see any need to explain where all the matter goes during the process of decay (Leach et al, 1996a, p.29). Younger pupils appeared to assume that matter actually disappears during the decay process. Studies also show children's confusion about the nature and role of unobservable entities like bacteria and decomposers involved in the decay process. Decomposers and bacteria are more likely to be referred to as germs and microbes with which agency apparently is more strongly associated. The effect of decomposers is related mostly to the bad health of humans, animals and plants. The invisible nature of decomposers is probably the most important reason which prevents children from thinking about them as living.

Many authors (Driver et al, 1994, p.90) have suggested that causes of pupils' difficulties with several environmental concepts should be sought in whether pupils have grasped the underlying ontology of the entities involved in these concepts. Young pupils have difficulties in perceiving air as a mixture of gases. The existence of air or gas as unseen entities, which is very important in understanding processes such as photosynthesis, is only developed later in the school years. The same is also evident for the concept of light as existing in space. Young children also cannot see matter as being necessarily conserved. When they are asked what happens to matter in various cases of transformations, like fire burning or water evaporating their response is that matter simply disappears. As has often been underlined by many studies, the view that material substances in the world do not just appear or disappear, but that matter itself is conserved in these transformations, constitutes a major change in students' ontology. So it will be too optimistic to expect them to understand concepts like the cycling of matter before they have grasped first the concept of the conservation of matter. This is especially significant for living material. The latter is thought by young children to be of a different kind from other kinds of material substances. Therefore, even if they think that non living material is conserved the same is not the case for living material when they think that if an organism dies, it just rots away. Again these difficulties with the ontology of basic underlying concepts undermine students' understanding of more sophisticated environmental concepts.

Another source of obstacles for the comprehension of concepts like food webs is thought to be children's reasoning in terms of linear causal chains (Driver et al, 1994, p.91). Anderson (1986) has also identified linear causality as a characteristic of commonsense reasoning, drawing on the work of Lakoff and Johnson (1980) who have described causality as 'the experiential gestalt of causation'. What all these descriptions have in common is that linear causal reasoning has a basic schematic underlying explanatory structure of an agent causing an effect as a uni-directional linear sequence of events in time. The difficulties start when this linear sequence is applied to complicated concepts like the food web (Leach et al, 1996b, p.140). It has been found that students can more easily think of the consequences of the removal of an organism from a lower trophic level on the population size of organisms from higher trophic levels, (e.g. effect of removing grass on rabbits) than the other way round; for example the effect of the removal of hawks on the population of the species at lower levels.

The significant and silent effects representations of knowledge might have on children's understanding have already been mentioned in the studies which put their emphasis on the part of the recipient of knowledge, as a further development that future research studies should follow. Driver (1996) has pointed out the possible effect the teaching of environmental processes in isolation might have on pupils' understanding of these processes and she has suggested that a teaching approach which starts with the relationships between organisms and life processes may lead to more integrated learning and should be included in addition to addressing the processes in isolation. Wood-Robinson (1991) has also referred to a number of studies which show that even if pupils' misconceptions have been changed after teaching, a year later their knowledge often reverts to the same misunderstandings they had before teaching. Many authors suggest that in some cases the commonsense language that is used in teaching not only does not help students to resolve conceptual difficulties but causes more confusion. Barker and Carr (1989) argue that the idea of plants 'making food' which should replace the common misconception of plants absorbing food, causes further misunderstanding in the way the idea is represented at the linguistic level. The concepts of 'making food' and 'food maker' are associated with human activities and with a concept of 'eating'. Therefore the concept of photosynthesis should be addressed more carefully as a distinct mode of nutrition.

In conclusion, it should be noticed that children's understanding of environmental concepts is not irrelevant to what has been discussed as the basic ontological dimensions of environmental science. The review of the former suggests that the main difficulties students face in understanding aspects of environmental science fit with the most important issues raised from the literature of environmental science (see table 1)

3.3 Studies on representations of knowledge

Although most of the studies mentioned above acknowledge that many difficulties in understanding are likely to be caused by the way knowledge is represented to students, it has been mainly the realisation of the different nature of the so called second generation of environmental problems which has been the crucial factor driving researchers' interest towards the representations of knowledge. The concept 'second generation problems' is used to characterise most of the modern problems such as acid rain, global warming, ozone depletion and toxic contamination which are found not locally (like pollution) but at a global scale and are more likely to be invisible to the naked eye than problems which are located locally. As a result, the public perception of these problems rely on their representations from the scientific experts, the media and various environmental groups (Hannigan, 1995, p.24).

Studies in environmental education (Brody, 1994 and Young et al, 1996) have pointed out the implications of second generation problems in teaching. Direct experience is not possible for most of the large scale environmental issues. Children can see, feel, smell or even taste a local ecological crisis such as pollution, in order to be convinced first of all of its existence, but they cannot have any physical experience with issues like global warming. The realisation of the latter depends on how they are represented in textbooks and in teaching. Plainly, the kind of representation which involves little or no physical experience is based on language and images.

As a result, for second generation problems the study of the representations of knowledge and their effects on students' reasoning, came not out of choice as the most reasonable and best available way for research. The need for studying students' ideas about such issues has been recently reinforced by the excessive media attention to them.

Coincidentally, with the appearance of second generation problems in the literature of environmental education, science education has attracted the increased interest of

Environmental Science

The identity and identification of entities

The identification of any entity apart from its intrinsic properties takes into account where the entity can be found, what the entity can do or in other words its ecological role and consequently what can happened to it. All these factors together consist a package of properties and behaviours which tells us what an entity is. Looking at entities in that way it is inevitable that the identity of each is grounded on the relations this entity has with other entities.

What can be considered as an individual, fundamental unit/entity

Different paradigms in ecology have different effects on what is counted as a fundamental unit of our knowledge about the environment. Ecology today does not attempt to find any fundamental unit in terms of which all ecological descriptions can be given. In fact there are more than one fundamental unit which are used, depending on the scale of the analysis and the phenomenon that has to be described and explained. The issue whether biological communities and ecosystems can be taken as fundamental units, is not so much one of reality but of usefulness. The identification of living entities and what is considered as an individual ecological unit are highly interdependent.

What is a living and what is a non living entity

We can think about an entity as living or non living in two ways. Either because an entity is identified as so or because of the way the entity is treated; like a living entity or like a non living entity. It is also possible that an entity which has been treated as having living properties to be identified later as a living entity.

The relationship between a living entity and its environment

Many writers stress the fact that in ecology the location of an entity at a certain place is very different from how in classical physics an entity is located in a three dimensional space. Many of them reflect the interdependence between a living entity and its environment on the meaning and use of words. They argue that one concept determines the existence of the other: no animal could exist without an environment surrounding it and equally the environment implies an animal to be surrounded.

Students' understanding

Basic schematic reasoning is underlying students thinking about entities. This reasoning is organised as packages of knowledge. The latter include a number of entities and their relations.

Students' understanding is better for those entities which are grounded in physical experience. Reasoning about these entities is often used as a tool by them in order to think about less familiar entities

Children's ideas on what is animate or inanimate often depend on the basic schematic reasoning which they use when they are thinking about entities. For example plants because they are not seen as primary Agents in the same way animals are thought to be, they are considered as less animate than animals. Unobservable entities like germs and microbes are often thought as non living entities, because they are not associated with animals but with the entities which carry them like dust and dirt.

Relations between living entities and their environment in children's mind should be better seen as part of the packages of their Knowledge about these entities. For example plants are thought by children as if they absorb their food from their surrounding environment and not as taking raw material which have to be synthesised by the plants.

The relationship between a part and a whole Issues which give priority either to the part or the whole in the study of environment are grounded on the nature of explanation. Mainly two opposite modes of thinking determine the nature of explanations in ecology. The first approach is the traditional atomistic and reductionist mode of explanation. According to this, all aspects of complex phenomena can be understood by reducing them to their constituent parts. In contrast with the reductionist mode holistic approaches support the view that the whole, whatever it is (an ecosystem or an organism), has properties not reduced to those of its parts. So according to holistic explanations, studies in ecology should start by looking at the whole and how the parts function in respect to the whole since the latter determines the properties of the parts and not the other way round.	The same as above is the case for children's reasoning about part-whole relations. For example pupils think of roots and leaves as the medium through which food is absorbed from the surrounding environment into plants body.
The relationship between human beings and nature, other living and non living entities The impacts of different scientific domains on our ways of thinking about our relationship with nature and with other living organisms are various. A central issue is whether any value is given to nature and to living entities other than human beings. This has a direct effect on how nature is treated by humans and what sort of agent relationships it is subject to.	Relations between human beings and other organisms are influenced by the fact that most of the underlying reasoning about living entities seems to be experientially grounded in human characteristics. Therefore reasoning about other organisms than humans is influenced and (depending on the context) constrained considerable according to how pupils think about human behaviour.
Scale relations affect what and how we think about entities By taking different perspectives while we are studying the relations between entities we notice that in general an entity consists of a unit which is embedded in a larger unit and at the same time a smaller unit is embedded in it. Changes of the scale have the effect of looking at the relations between entities in a very different way.	Scale relations which are not explicitly addressed in textbooks are not comprehended easily by students. For example, students refer to organisms as individuals and not as if they represent populations of individuals in cases like the food web.

(Table 1: Environmental Science and students' understanding)

linguists and discourse analysts. A landmark of this direction has been the work of Halliday and Martin (1993) 'Writing Science' in which they use ideas drawn from Systemic Functional Linguistics as a theoretical framework and analytical tool in order to study representations of science mainly in school textbooks. Most of the examples of applying discourse analysis in this work are from the subjects of geography, earth science and biology, domains which have always been thought of as close relatives to environmental science. Since then, following this new direction which emphasises the cognitive and interpersonal dimensions of representations of knowledge, a number of studies have attempted to provide a better understanding of how environmental concepts are represented in textbooks and in the teaching of environmental science.

These studies either look at the overall thematic organisation of the represented concepts, or put special emphasis on the nature of the language in which knowledge about the environment is represented. While the latter approach is usually characterised by generalised accounts of representations at the level of language and by a lack of systematic and specific, exemplified insights in language (see for example Stables, 1996), the former group of studies either includes specific references to linguistic elements, most often at the level of words as representations of concepts and simple verb phrases as the linguistic realisations of processes (see for example Sutton, 1992), or it does not make any reference to specific linguistic elements at all.

Both kinds of studies above are divided into those which investigate representations of specific environmental concepts, issues and problems, like Acid Rain or the Greenhouse Effect, most of them subjects of immediate public and media concern, and those studies which examine representations of knowledge not by making any reference to specific concepts or problems but by taking into account the current environmental agenda of issues as a whole (see for example De Young et al., 1996). The former studies which broadly investigate the effect of specific representations on students' learning or/and reasoning, do provide some analytical tools like conceptual maps or models or some pieces of technical linguistic analysis, but not usually going beyond the word or clause level and most often without being able to generalise the findings of these analyses.

A general observation can be made about the main difference between kinds of inquiries. Studies on reasoning do not question the nature of the knowledge which is represented to students. They take for granted that whatever this knowledge is and is about, it is 'correct' and 'true' knowledge which students have to learn in the end despite their difficulties in understanding it. A naive realism is implied here which accepts that scientific knowledge reflects reality as it is and at the same time underestimates the possible 'distortions' representations can impose on knowledge. The most 'naive' of these studies do not acknowledge even the role of representations implying that there is a direct relation between the recipient of knowledge and knowledge itself without anything intervening in this one to one relationship. This 'naive' realism is most strongly evident in curriculum developers who advocate that students' direct physical experience with nature will resolve most of their difficulties in understanding nature, as if nature 'speaks by itself'. An idea often expressed by environmental educators and environmental activists is the slogan "education *about* the environment, *in* the environment and *for* the environment". So these studies aim is to see what is at 'fault' in the individual if the latter cannot 'read' nature correctly.

On the other hand, studies on representations have shifted the 'blame' from the individual to the interaction between the recipient of knowledge and knowledge representations. While few of these studies are able to locate quite clearly that there are two sources of influences and constraints in this interaction; one from the kinds of knowledge representations used and the other from reality itself (expressed as a 'bottom line realism', see Ogborn 1994), many of the studies fail to acknowledge any realist accounts to the world, and overemphasise the role of the representations in a way which sounds as if 'everything can be achieved by students if better representations are implemented in teaching". The latter end up in the same place at which 'naive' realist studies on reasoning also arrive. The difference between the two is that instead of 'blaming the student', many studies on representations 'blame the teacher' and instead of propagating a 'naive' realism about knowledge, come across with a 'naive' realism about representations.

3.4 Conclusion

In conclusion I will argue that studies of pupils' reasoning, even if they have been insufficient in interpreting their findings, can make a considerable contribution to our understanding of the interaction between students' reasoning and knowledge representations. The findings of these studies provide evidence of an underlying basic schematic reasoning which is grounded in physical experience and phenomenological observations of reality. This underlying reasoning constructs its own ontology and ontological categories like packages of entities and processes of reasoning, such as the linear causal relations mentioned above. The relatively abstract descriptions one can give of such packages may be misleading. There is no suggestion that children's reasoning works at such a level of abstraction. Rather, some pattern belonging to familiar, well worked out and experientially grounded knowledge, is tried out as a match for new and unfamiliar knowledge. Many misunderstandings of students would be better seen as the implications and constraints that the use of these packages have on entities, like discomfort and confusion in the use of the unobservable entities.

Furthermore, what can be questioned is whether thinking in terms of 'packages' is purely the product of children's reasoning against what is represented to them or whether representations of environmental science in textbook material and in the classroom sustain and encourage reasoning in that way based on the rather intuitive and not explicitly worked out assumption that this is how children think.

The present thesis explores this question by studying means of representations, called metaphors, the presence of which is rarely realised as such in everyday and classroom exchanges of meaning. The following chapter discusses both theoretical and empirical accounts of the emergence, value and role of implicit means of representations.

CHAPTER 4

METAPHOR AS AN ISSUE OF REPRESENTATION

4.1 Brief account of early and contemporary approaches to metaphor

In the past there were two main, completely opposite positions about metaphors (Ortony, 1979, p.2). The origins of these two positions are found in philosophy and specifically in the philosophy of language. One position denied any cognitive value to metaphor and claimed that metaphor is wholly emotive, a feature of the language only, an ornament, and that its natural place is in literature. If a metaphor is found anywhere else outside of literature, as in a scientific text for example, then it must be translatable into a literal paraphrase. And this is because it is supposed that only literal language that has true value, and its content/meaning can be tested and either verified or not. The other position claims that metaphor is not just an ornament and parasitic for thinking, but is an essential characteristic of the creativity of language, and for all sorts of reasoning, including scientific thinking. This point of view is the dominant one today, but various and in some cases very different approaches belong to it. These approaches vary in terms of whether they assign any significant cognitive function to metaphor, to the extent that metaphor is reducible to a literal paraphrase or not, and also on whether they think that metaphor is a linguistic property which has to do primarily with words or phrases or whether it is a cognitive function which is about concepts and reasoning.

Two of the main streams which are currently influential are the comparison and the interaction view (Ortony et al, 1978, p.922,923). A brief account (a more extended theoretical discussion is in Appendix 2) of the similarities and differences of various approaches is given below by using examples (some of them already used in various studies) of metaphors which are found mainly within the context of everyday language and literature.

To start with let us take an example which has a syntactic structure very popular in early accounts about metaphors - very similar to Richards (1936) favourite example: "Man is a wolf":

"David is a pig"

Most of the studies which belong in the comparison view do not bother whether it makes any difference in this decontextualized example of metaphor if categories are involved or just members of categories, or how far context is essential in interpreting the metaphor. What they say is that the metaphor appears as a comparison between two objects or things, in this case between a man and an animal: 'David' and 'pig' which both share some properties, like getting what they want by being rude, also being dirty and nasty. They assume that this example is a metaphor because of the similarity between 'David' and 'pig', treated as it has the syntactic form: 'David is like a pig', without looking at in what respect 'David' and 'pig' are both similar and different at the same time. They also believe that similarity is the essential meaning of the metaphor which (for some of them) can be translated into a literal paraphrase focusing on the shared properties, without losing anything of the meaning of the metaphor.

The interaction view approaches the same metaphor functionally rather than grammatically so it is not bothered whether it appears with the syntactic form: 'David is like a pig' or the 'David is a pig'. According to the interaction view the metaphor is not about things or objects identified by single words but it is about systems of relationships which are mapped to each other. There is one system of relationships about 'David' that is called the primary subject of the metaphor mapped on the system of relationships of 'pig' which is the secondary subject of the metaphor. There is some problem here with Black's (1979) approach for what is meant as system of relationships and how this mapping takes place from one system to the other (see also Appendix 2).

But it is this very idea of mapping which is further developed in many different ways by cognitive psychologists and others in cognitive science today like Gentner's (1988) approach and Lakoff and Johnson (1980) accounts of metaphor. Roughly speaking according to all of them, David and pigs belong in different domains (called source and target domain) and it is a number of relationships within each domain which are picked up and mapped onto the relationships of the other domain. Apart from their differences these various approaches of the interaction view share a rather dynamic perspective, looking at metaphor as a cognitive process rather than the final outcome of this process in respect to what the metaphor can afford.

We should notice that some of the interaction theories have a problem in identifying a metaphor whenever one of the two subjects of the metaphor is not present and only a single word or phrase appears which is the result of the interaction of two domains or subjects. In other words for some of the interaction theories the syntactic form which needs two subjects: both 'David' and 'pig' to be discrete and present in the text even if not marked as such, like: 'David is like a pig' is necessary. For others like Richards and Lakoff for example the two subjects can be co-present in one word or phrase, like:

"The magic is gone" (where magic is love).

Another issue which concerns both comparison and interaction approaches is that most of the theories work out what metaphor is on very carefully selected examples and depending on how they analyse metaphors and in which context, some of them are more comfortable with syntactic forms in which nouns and adjectives are involved in terms of something being like something else:

"Janet is a block of ice"

or in terms of something which has properties that look like the properties of something else:

"Life has a sunrise and a sunset"

or where the metaphor is sort of hidden in a nominal phrase:

"the sunset of life"
"this is a sick relationship"

or cases in which verb structures are involved, like how something acts:

"He ran out of ideas"
"That idea will go a long way"

Some other approaches to metaphor which cannot be easily categorised under the comparison or the interaction view represent metaphor as a communicational act by giving accounts of the interaction between the reader and the writer or the speaker and the hearer whenever a metaphor occurs (Searle, 1995). So they claim that a metaphor might appear without any semantic or syntactic markers, as where the literal interpretation of the sentence :

"Where are your shoes?"

is a request for information about the location of the hearer's shoes. But, spoken by a mother to a child late for school, the question may take the meaning of :

> "Get going"

while spoken by a nurse to an elderly patient, it may be intended to mean:

> "I offer to get your shoes for you if you tell me where they are"

So in these cases it is the non-linguistic context of the situation which indicates what the sentence is being used to do. But even here there is no agreement at all whether cases like this should be taken as metaphors or as indirect speech acts. And it is actually this sort of hidden or covert metaphor which are the most problematic in many sense. Those - usually linguistic - studies which believe that covert metaphors like :

> "Where are your shoes?"
> "the sunset of life"
> "he ran out of ideas "

are not just indirect speech acts but have a special place in our reasoning, are those who tend to believe that almost all language and its changes are grounded in metaphors. On the other hand, those - usually empirical - studies which reduce the study of metaphors to those which are indicated in an explicit way, the so called overt metaphors, have very little to say either on how these metaphors occur naturally in context and how they are placed in the system of the language as a whole.

For the purpose of this thesis, the positions on metaphor which are common to Systemic Functional Linguistics, and the image schema approach of Lakoff and Johnson will be adopted. They are:

1. Metaphors are not necessarily marked out syntactically. An immediate consequence is that metaphors are not only or primarily about words or concepts only.
2. Context is essential in seeing how metaphor works and what is about. Metaphors always appear in context, therefore it will be a very artificial approach if a metaphor is taken out of its context and discussed as if it exists by itself.
3. In the study of metaphor emphasis should be put both on how metaphor works (often described as 'mapping' or 'model' and in the present study as '

discursive property') and what is about, that is what the metaphor affords, what sort of meaning relations it makes possible for those who communicate using it.

4. In relation to the latter what is at the heart of a metaphor both as a 'process' and a 'product' is a relation between form and meaning, that is how something is represented and what is the effect on its meaning because of the way it is represented. Therefore, metaphor is about representations and realisations of meaning relations.

The last point above brings metaphor into the realm of representations. Metaphor is seen as a means of representing meaning and knowledge.

4.2 Brief account of early and contemporary approaches to representation

As well as the concept of metaphor, the notion of representation is studied in philosophy, linguistics and psychology, since it is linked with such important questions as how we think, how knowledge make sense to us, how it can be possible, how it can be stored or be activated.

In cognitive psychology, representations are distinguished between external and internal representations (Eysenck et al, 1995, p.204). While the former are supposed to be 'real' entities found outside of us in the 'world' the latter are seen as mental entities found in our minds. The first immediate implication of this distinction is that one has to think about the two kinds of representations as being two different realms of experience. Consequently, the relation between the two kinds of representations has mainly been seen as a 'translation' of one system of representation into another (Lakoff, 1987). The question which has been raised is how entities which belong in our surrounding world, can be translated into entities which are only found in the mind and vice versa.

Another important distinction is between picture or image-like and language-like external representations. There is a parallel distinction in mental representations. The latter, even if they are about symbols which denote or refer to something outside themselves so that resemblance between them and external representations is not required, are also divided between image or model-like - called analogical - representations and language-like - called propositional - representations. Traditionally, studies have thought of analogical representations as being more like the encodings of picture-like external representations, while propositional representations have been thought of as the encodings of language-like representations. But recently, studies have shown that some concrete words evoke images more readily than other words, so words can be stored as images and not necessarily as propositions (Eysenck et al, 1995, p.211-212). Therefore one kind of encoding should not be seen as excluding another kind of encoding.

Picture-like and language-like representations have also often been linked with what has been thought of as concrete and abstract. In particular, a pictorial representation either external or internal is thought of as closer to what it represents because it is 'concrete' in the sense that it is strongly associated with the visual modality. On the other hand a linguistic representation is thought of as more abstract because of the distance between its modality and the thing it represents (Eysenck et al, 1995, p.206). But as has been illustrated above one needs to be careful with generalisations about systems of representations.

Finally, traditionally a distinction has been made between 'objects' and the 'relations' between things. Research on the organisation of concepts of 'object' has been marked by several theoretical stances such as the defining-attributive view and prototype theories (see for example Rosch, 1978). One tradition treats concepts on a similarity-based approach in which concept formation is based on the similarities between entities. Another tradition is primarily concerned with relational concepts. According to the latter, most of our knowledge is structured in complex ways, such as thinking in terms of events (Eysenck et al, 1995, p.234). The structures that encode this knowledge, which are called schemata, involve many different entities connected by many diverse relations (see for example Schank, 1972).

The concrete vs. abstract debate has also been continued within the two research traditions illustrated above. So some of the prototype theories reject the idea that abstractions underlie our concepts, and argue that individual entities lie at the heart of our concepts (Eysenck et al, 1995, p.242). Certain schemata theories on the other hand such as script theories are often blamed for not having a sufficient abstract set of structures so that their rigid structures are too inflexible to be applied to different situations and in a different context (Eysenck et al, 1995, p.266).

The present study challenges the view which wants to see (either external or internal) representations as either concrete or abstract. One can ask in what respect a picture is more concrete than a piece of text. Both image and language - as will be illustrated in the analysis - can be more abstract or more concrete in respect to how they represent something in different ways. The question of whether a representation is either abstract or concrete should be seen as one of degree always in relation to what is represented, to whom and in which context (see section 6.3.1).

An assumed split between form and meaning, often described in terms of a purely arbitrary relation between word and meaning, is still reflected strongly in linguistics since Saussure, even if it has been challenged recently by Halliday (1985) and more recently by Kress (1993). Still many studies in psychology often take for granted the arbitrary relation between meaning and words in their probes of internal representations, stating that they are looking for concepts and are not interested in their linguistic or imagistic representations.

Concerning the definition of metaphor, those studies which accept the arbitrary split between form and meaning and realise metaphor at the level of words only, inevitably see metaphor either as an incorrect choice of words or as an ornament without affecting in any way the meaning of what is supposed to be expressed.

Recent interaction accounts which see metaphor as a mental model or mapping carry some of the troubles which the dichotomies discussed above imposed on them. So for example while some studies are focused on images (various schema or script theories) others are primarily about concepts. The fact that the latter (like the Gentner and Gentner approach, 1983) often leave out of their accounts the issue of the nature of external representations implies the dichotomy between the two realms of experience and raises the old problem of the hypothetical translation of one system to the other.

The two approaches (Image Schema and Systemic Functional Linguistics) that are followed in the present study have made a considerable effort to break the old dichotomy between form and meaning. To give an example from Systemic Functional Linguistics, a material process is a clause which has the semantic function that one participant does something and this action can affect another participant. From the Image Schema point of view an image schema such as a containment relation imposes a relation of boundary and closure between entities. Notice that both approaches are primarily concerned about relational entities which are at the same time the units of analysis. Single entities are neither thought of as words or concepts in these two approaches, but grammatically are called 'participants', or from the Image Schema point of view are called 'entities'.

4.3 Metaphor as a discursive phenomenon
The view from Systemic Functional Grammar

4.3.1 Introduction

Systemic Functional Grammar has provided a new insight into metaphors. Metaphors are no longer seen as being primarily about words at the linguistic surface. But this does not mean that language takes a second place leaving the analysis of metaphors at the level of concept relations only.

4.3.2 A brief account of relevant aspects of Systemic Functional Linguistics

According to Systemic Functional Grammar (SFG), language is a system of meanings, accompanied by forms through which the meanings can be realised. It is functional in the sense that it is not intended to be a formal description of language which uses examples of actual uses of language in order to end up with some general categories of a linguistic theory (compare Saussure), but is designed to account for how language is used in making meaning (Halliday, 1985, p.xiii). The object of its inquiry is to study how meanings are expressed, following a top to bottom approach (from meaning to linguistic forms) (Halliday, 1985, p.xiv).

SFG does not give priority to grammar over syntax. It puts the two together as 'lexicogrammar' (Halliday, 1985, p.xiv). It aims to make it possible to analyse discourses either spoken or written in the context of ethnographic, literary, educational, pedagogical and other studies. In the context of education, Systemic Functional Linguistics is appropriate for looking at classroom communication and analysing the language of textbooks (Halliday, 1985, p.xv), both being interests of this thesis. But it should be emphasised that Halliday believes that discourse analysis without any analysis at the level of lexicogrammar is simply a 'running commentary on a text' (Halliday, 1985, p.xvii). Although text is defined as a semantic unit and not a grammatical one, meanings are realised through wordings. Therefore, without a theory of wordings any attempt to make explicit the interpretation of the text will be inadequate.

SFG is functional in that it constructs all the units of language such as sentences, clauses, words as organic configurations of functions. Each is interpreted as functional with respect to the whole. SFG is systemic in regarding meaning as choice. That is, language or any other semiotic system, is interpreted as networks of interlocking options, arranged as systems starting with the most general features and proceeding to more and more delicate levels (Halliday, 1985, p.xiv). The point is to ensure that very general semiotic features are ultimately connected to specific wordings. For example, to choose to mean 'action' as opposed to, say, 'being', is a high level choice. In SFG this gets connected to actual possible wordings, for example, in types of verb phrase (e.g. material processes). Examples of these relationships used in analysis of texts are in chapter 6.

At the most general functional level, Halliday identifies three fundamental components or metafunctions: the ideational, the interpersonal and the textual (Halliday, 1985, p.xiii). The textual has to do with the way in which information is distributed across clauses and sentences in a text. The interpersonal metafunction is concerned with the interaction between the writer/speaker and the reader/hearer as an exchange of messages between them. The ideational metafunction is the expression of experience, that is, our experience of the world that lies about us, and also inside us, the world of our imagination. Putting the three together, in an act of discourse we have something to say (ideational), in a relationship between people (interpersonal), which is constructed to have an appropriate continuity and coherence (textual).

4.3.3 Some specific aspects of Systemic Functional Linguistics which are important in the present research

One essential aspect of SFG in the present research is the analysis of processes. The basic semantic framework for the analysis of representations of processes is very simple. It consists of the process itself, the participant in the process, such as animals, people, things and the circumstances associated with the process like locations in time and place. These provide the frame of reference for interpreting our experience of what goes on. The concepts of process, participant and circumstance are semantic categories which explain in the most general way how phenomena (both physical and pragmatic/social) of the real world are represented as linguistic structures (Halliday, 1985, p.102).

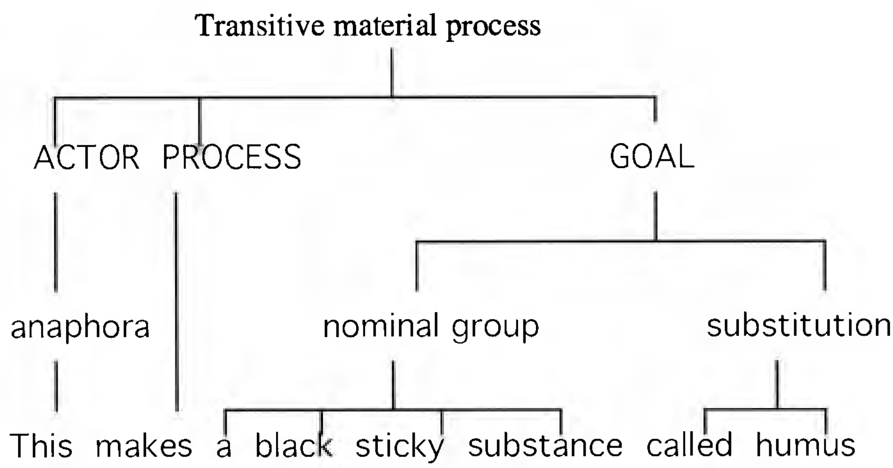
Three of the most frequent ways to represent processes are :

the process of doing or Material process the process of sensing or Mental process and

the process of being or Relational process.

Material processes express what some entity 'does', or what could be done to some entity, or how it is brought into being, and are all treated grammatically as types of Action. The participants are two; the Actor who/which is doing something and the Goal (not necessarily present in every process) who/which receives the actor's action. In this kind of process participants are not required to be human beings, but anything which is realised as a phenomenon of our experience and could be either a thing-like or process-like entity, such as action, event, quality, state or relation (Halliday, 1985, p.104). The example below is analysable as a Material process because it represents a process in which one participant does something to another participant:

This makes a black sticky substance called humus.



The analysis can be represented economically in a table, as follows:

This	makes	a black sticky substance	called humus
anaphora		nominal group	substitution
ACTOR	PROCESS	GOAL	

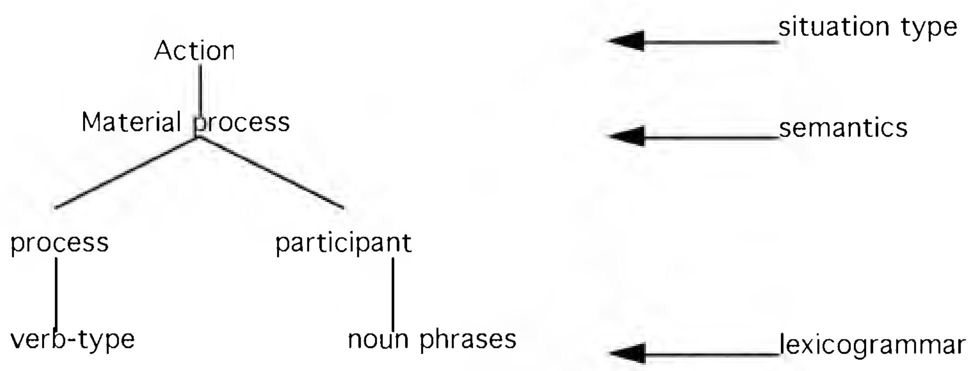
In tables such as the one above, each linguistic constituent is separated from others because of its distinctive function. Without changing the places the linguistic constituents have in the clause, those which function as participants are separated from those which function as processes or circumstances.

Turning now to relational processes, their central meaning is that 'something is'. They are distinguished into two modes. In the Attributive mode, an attribute is ascribed to some entity; either as a quality or as a possession. The participants are the Attribute and the Carrier. The second is the Identifying mode where one entity is used to identify another (it is reversible in contrast with the attributive mode). The participants are the Identified and Identifier (Halliday, 1985, p.112).

Finally, mental processes are clauses which express feeling, thinking and seeing. The two participants in the mental process are the Sensor and the Phenomenon. The sensor is the conscious being that is feeling, thinking or seeing. The phenomenon is what is 'sensed'-felt, thought or seen (Halliday, 1985, p.111).

4.3.4 Grammatical metaphor

Halliday's idea of 'grammatical' metaphor rests on distinguishing more or less 'natural' realisations of processes in wording (Halliday, 1985, p.321). The grammatical structures of processes just described can be represented abstractly as:



This forms the 'natural' set of choices. However, in a case such as:

This repeated uptake and release is part of the carbon cycle.

the noun phrase *This repeated uptake and release* which we expect to be a participant is actually a process acting grammatically as a participant. This Halliday calls 'grammatical metaphor'. This kind of grammatical metaphor is also called nominalization and has attracted most of the interest in the later work of Halliday and Martin (1993) in the context of teaching and writing science.

The use of grammatical metaphor does not have an effect on language only. Because of the interrelation between form and meaning, how something is being talked about has an effect on how it is thought of and therefore how it is treated and how we are engaged with it. So a nominalized action can be thought of and treated not as an action but as a thing which can have properties and be a participant, and, like all other thing-like entities, be involved in other actions (Halliday et al, 1993, p.15). There are also several other effects associated with nominalizations. One is that although we know that there was an actor and an affected, the specific identities of both have been lost. We can only guess their identity. Our attention is directed to the nominalized process and directed away from how it is accomplished. So the focus of attention has been altered by the speaker or writer away from what has happened to what it is (Kress et al, 1993, p.21).

This view about metaphors is consistent in that it studies metaphors in a framework of a linguistic theory which combines coherently context, grammatical form (linguistic surface) and meaning (semantics) (Halliday et al, 1993, p.31). Metaphor is not seen as an isolated change which occurs either at the level of wording (linguistic surface) or at the level of meaning (often described as concept replacement). Even metaphors that appear at first sight to be variation in the use of words only, according to Halliday, should be studied at the level of the functional use of words and the differences that it makes at every level of realisation (Halliday, 1985, p.320). To give an example mentioned before, the phrase "Bill is a pig" is not a metaphor only because of the selection of words, but also because an entity (man) is identified in terms of another entity instead of representing it as having certain attributes that are shared by another entity (pig). And for metaphors like: "he ran out of ideas" and "the idea will go a long way " the meaning of not having ideas is expressed in terms of a material process rather than a possessive attributive process (such as 'he hasn't got any ideas').

In chapter 6 the contribution of Halliday and Martin to studying the language of science, together with some other related studies will be discussed. The analysis given there will discuss examples of grammatical metaphor taken from a variety of environmental textbooks together with their possible effects on meaning.

4.3.5 Criticism of 'grammatical metaphor' and of Systemic Functional Linguistics

Halliday has been criticised that at the bottom level of the lexicogrammar, relations between content and expression are represented - following the Saussurean idea of the arbitrariness of the sign - as arbitrary (Halliday, 1985, p.xviii). Kress (1993) in his paper "Against arbitrariness", insists that the motivated production of a sign, well represented in children's first drawings - should not be underestimated. For Kress every sign whether linguistic or not is a semiotic entity in respect to the medium used to bring it into being, the process behind its production and the motivation of its producer.

Drawing from the argument against arbitrariness Kress (1993) questions the value of Halliday's distinction between congruent and incongruent language. This distinction is the outcome of a one to one correspondence between form and meaning imposed by the system of realisations. An action for example which, according to Halliday, is realised at the semiotic level as a material process, which is in turn naturally realised at the level of the lexicogrammar as a verb phrase, seems to provide a naive referential interpretation of the relation between language and world. Halliday reduces the significance of this argument by claiming that incongruence is the most dominant feature of adult language. Therefore what counts in discourse analysis is why certain choices both at the semiotic and lexicogrammatic level are made in order to realise certain meaning relations and the effect these choices have on the construction of new meanings. This is also the point of view which is adopted in this thesis. We are not asking whether the realisations of meaning are 'congruent' or not but what the effects on meaning of choosing one realisation instead of another can be.

Another issue which has attracted criticism from discourse analysts is the concept of context. Halliday speaks of a text as being 'in' some register (defined as the configuration of semantic resources that the member of a culture typically associates with a specific situation) while critical linguists argue that several registers (discourses) may be found 'in' the same text, a phenomenon often called 'discourse coalition' in studies of environmental sociology (Hajer, 1995, p.13). In this study a broad view of context is adopted. Environmental science cannot be seen as a single discourse well defined and separated from other discourses such as political rhetoric or biology. It is constructed on the basis of complex relations between scientific and commonsense knowledge and understanding, drawing concepts from a variety of disciplines such as chemistry, biology, geography, geology, economy and decision making.

Finally, an argument has been made that a detailed analysis at the level of the clause is not always a safe way to characterise particular entities and the processes in which they are involved. For example we cannot say that material processes are determined by their transitivity pattern at the surface linguistic form, with other components providing only optional extras. Analysing clauses such as: *their bodies decay,* even if they appear at the linguistic surface as intransitive material process, one cannot be sure by simply relying on the ideational metafunction whether the one participant involved in the process is Actor or Goal. The participant *bodies* might be the Goal and the Actor might be missing or *bodies* might be the Actor and the Goal at the same time. In this case if we really want to know the relationship between the entity *body* and the process *decay* we need to take account of thematic options. Indeed, *body* is a participant functioning as theme in several other processes in the text above and below the particular clause. Halliday has recognised the confusion such kinds of clauses can generate in their interpretation and introduced a new functional participant called Medium. This is the participant through which the process is realised irrespective of whether it is the agent of the process or the patient.

Others like Kress and Hodge (1993) elaborate further the relation between meaning and surface form in their accounts of the construction of the discourse. They regard language as consisting of a related set of categories and processes. The latter are represented as sets of models which describe the interrelation of objects and events (Kress et al, 1993, p.8).

As has been emphasised above the object of this thesis is neither to deal with problems that arise in the theory of Systemic Functional Linguistics, nor to compare this theory with other linguistic theories as tools to study environmental science. Some concepts of Halliday's Grammar, especially those to do with ideational processes, are used as one possible set of tools to study language used in teaching Environmental Science. Doing so provides a limited test of their value as tools in this restricted kind of domain. The tools from SFG proved, for this purpose, more effective for analysing written text-book material than they did for spoken classroom language, for which an image-schema approach was used.

4.4 Metaphor as a cognitive phenomenon
The view from the image schema approach of Lakoff and Johnson

4.4.1 Introduction

Debates over metaphor appear either as a matter of definition or as an empirical question. In the first case approaches look for the right and most effective definition while in the latter they look for those sets of empirical questions which can lead to empirical investigations. Lakoff and Johnson (1980) set the issue of metaphor as an empirical question which is looking for conceptual categorisations.

They are both against the traditional assumption which makes a sharp distinction between literal and figurative language. Lakoff in particular, refers to Reddy's work which shows that metaphor is not a kind of figurative language as the traditional approach supposes, but is a major and indispensable part of our ordinary way of conceptualizing the world (Lakoff, 1993, p.204). For Lakoff and Johnson even poetic metaphor is primarily about concepts rather than mere words.

Instead of the classical distinction between literal and figurative language, Lakoff and Johnson (1980) set up another distinction between concrete concepts which make sense via our immediate contact with the world and those which are abstract and emotional and are comprehended through metaphors. Non metaphorical concepts are those that emerge directly from our everyday bodily and social experience and are defined in their own terms. On the other hand, metaphorical concepts are those which are understood and structured not merely on their own terms, but rather in terms of other concepts. At this point we should notice the shift from metaphor as primarily a linguistic phenomenon and the implied distinction between literal and figurative language, to metaphor as primarily a cognitive phenomenon and the implied distinction between metaphorical and non metaphorical concepts. We also notice that what is defined as concrete and what is defined as abstract according to Lakoff and Johnson (1980) is not the outcome of already given categories but is the outcome of our involvement with the world, both physical and social.

4.4.2 A brief account of relevant aspects of experiential realism

Lakoff's and Johnson's ideas about the different kinds of concepts and how these differences emerge are grounded in what they call experiential realism. Experiential realism stands against the objectivist tradition. Objectivism claims that the world is made up of objects which have properties independent of any people or other beings who experience them. In other words human beings and the world are seen as two separate realities and if the latter is fixed and stable, as objectivism claims, then the difficulty is to see how the beliefs of the former change. Language, according to objectivist accounts, expresses the concepts and categories which we use to understand objects, their properties and relations, thus the words which are used must fit directly to reality. To achieve this aim, the meaning of words needs to be clear and precise without any kind of figurative speech such as metaphors. (Lakoff, 1987, p.165) Many, among them Lakoff and Johnson, believe that this is a naive view.

Experientialism answers the questions which objectivism leaves unanswered by approaching concept distinctions and meaning in a different way. Lakoff and Johnson attempt to characterise meaning in terms "of the nature and experience of the organisms doing the thinking". (Lakoff, 1987, p.266) With this definition priority is given not to meaning itself but to the process of meaning making. So meaning is thought of as a never ending 'process' rather than as a 'thing', as objectivism claims. Nevertheless there are constraints imposed on this process of meaning making (not everything is possible) by reality itself. At this point experientialism shares with objectivism a commitment to the existence of the real world and a recognition that reality places constraints on concepts.

Furthermore, experientialism goes beyond mere rationality, by breaking down the classical cognitive/emotive dichotomy which says that to be objective is to be rational and not to give in to emotions. This is because experientialism recognises the crucial role of metaphorical thought in uniting reason and imagination. According to it, reason involves categorisation, entailment and inference. Imagination, in one of its many aspects, involves seeing one kind of thing in terms of another (Lakoff and Johnson, 1980, p.193).

The main claims of experiential realism can be summarised in the following principles:

a) The core of our conceptual systems is directly grounded in perception, bodily movement and experience of a physical and social character.

b) Metaphors, metonymies and images are based in the majority of cases on bodily experience. They play a crucial role in thought because of their imaginative capacity, that allows the conceptualisation of abstract concepts which are not directly grounded in experience. So abstract concepts are also embodied - indirectly - since the metaphors, metonymies and images are based on our everyday concrete experience.

c) Both abstract and concrete concepts have an overall structure that goes beyond that of the mere summation of some concepts which have been put together because of some general rules.

d) Finally, every conceptual structure which has the above properties can be described as a cognitive model. The latter can be of four types (propositional, image schematic, metonymic and metaphoric) and are mainly mental models, that is, consist of imagined real entities.

4.4.3 Basic-level and image-schematic structures

So far we have seen that according to Lakoff and Johnson metaphor is not primarily about words but is about concepts, and instead of looking at what is metaphorical and what is literal we should rather look at what makes a concept abstract or concrete. In their accounts metaphor is thought of as a cognitive device which fills the gap that the distinction between the abstract and the concrete creates. So metaphor brings the abstract closer to the concrete by mapping aspects of the latter onto the former.

In their view of metaphor Lakoff and Johnson have also been influenced by the findings of Rosch's studies. These studies show that some categories, called 'basic level' categories which are neither concrete nor abstract are the best understood and the most frequently used by people. A well known example of Rosch's (1978) findings is that people are accustomed to think about chairs not in terms of specific categories such as arm chairs, nor also in terms of the very general category of furniture, but in terms of the concept 'chair' as a prototypical member of the category of chairs.

Rosch's findings have influenced Lakoff and Johnson to think about metaphorical projection as an essential process which is driven from a realm located between the abstract and the concrete. This is the realm of our preconceptual bodily experiences (Lakoff, 1987, p.267) which consists of two kinds of structures:

Basic-level structures which have to do with basic-level categories and basic-level concepts and

Image-schematic structures which are relatively simply structures that constantly recur in our everyday bodily experience.

Concrete concepts are directly understood within the level of basic level and image schematic structures, because of our bodily experience and immediate contact with these concepts. Knowledge about the concrete, due to the recurrent pattern of our experience, is organised in structures such as image-schematic and basic-level structures. Aspects of the latter, without being disengaged from their embodied realisation, are metaphorically projected onto abstract and superordinate concepts which belong in the abstract domain. Thus many abstract concepts are realised in terms of basic-level concepts and image schematic structures.

It should be noticed at this point that according to Rosch and others, most of commonsense reasoning takes place at this intermediate level of basic-level categories. In everyday life it is more likely that we are thinking in terms of chairs rather than furniture or specific instances of chairs such as dining chairs. Novices and experts too when they have to resolve problems which are beyond their specific domain also think in terms of basic level categories, often by using knowledge about specific categorical relations and concrete or theoretical entities and working it out at the level of basic level categories.

To give an example, the concept of causation often appears to have a directly emergent core that is elaborated metaphorically. It is understood as having some properties (Lakoff and Johnson count twelve of them) which characterise the 'prototype' of causation and "they recur together over and over in action after action as we go through our daily lives". (Lakoff and Johnson, 1980, p.71) They emerge from our direct manipulation of objects very early in life. The important features in this cluster of interactional properties are the existence of an Agent which does something and a Patient that undergoes a change to a new state. The action of the Agent and the change in the physical state of the Patient constitute a single event. In prototypical causation the Agent comes in contact with the Patient and what the Agent does precedes, at least to some extent, the change in the Patient. Indirect causation is not prototypical since there is no such overlap in time and space as has just been described. However, indirect cases of causation can emerge from direct prototypical causation through metaphorical projection. (Lakoff and Johnson, 1980, p.72)

4.4.4 The nature and function of image schemata

In the context of cognitive science, schemata are taken as "higher - level complex knowledge structures" which function as "ideational scaffolding" in the organisation and interpretation of experience. Many investigators who worked on the idea of schemata as knowledge structures, make an implicit assumption that schemata are stable knowledge structures. They are seen as stored in long term memory as discrete and relatively static sets of information ready to be retrieved whenever appropriate (Ortony et al, 1988, p.76). Others have proposed that schemata are unstructured property lists which are used for drawing similarities between things or events (Ortony et al, 1988, p.193).

The most common view of a schema is as a structured cluster of concepts which involves generic knowledge and may be used to represent events, sequences of events, percepts, situations, relations and even objects. Following mainly that view Lakoff and Johnson have developed further what they call image schemata.

Image schemata should be thought of as belonging in a mental space and as being abstract analogs of physical processes such as spatial manipulation and movement. For example we can rotate the concrete image of an object in mental space in the same way as we can rotate an object in physical space using our hands and eyes. Johnson illustrates the notion of an "abstract analog" using an example which is given by Anderson. Anderson (Anderson, 1980, Ch.3) suggests the length of a line as an analog for a person's weight. The length of a line would vary with the weight, but there is no detailed correlation between a line and a weight.

Typical image schemata will have parts and relations. Parts are usually a set of entities such as people, events, states of affairs, sources, goals. The relations might include causal relations, temporal sequences, part-whole patterns. In most cases a schema has a small number of parts standing in simple relations. Parts and relations are organised into unified wholes called gestalt structures (Johnson, 1987, p.28,41). Schematic structures connect up aspects of our experience and lead to inferences in our conceptual system. Image schemata are used to think with. They are dynamic, flexible, widely usable and adaptable patterns because they integrate a vast range of different experience that manifest the same recurring structures (Johnson, 1987, p.2).

4.4.5 Types of image schemata

There are several kinds of image schemata. Some of the most pervasive in our everyday experience and most often used in the present thesis are discussed below:

Containers

For much of the time we consciously or not consider containers such as rooms which we move in and out of, and we manipulate objects by placing them in containers. The recurrent structure in all of these cases which is metaphorically projected on abstract processes and concepts is the in-out orientation of physical boundedness. Whenever something is contained in something else it is kept separated from other things which are not in the container. The separation between things which are contained and those which are not makes them different. For example in textbooks of environmental science we read:

the carbon dioxide gets into the atmosphere
energy is trapped by green plants

The structural elements of the container schema are:

the interior, that is the thing which is contained
the exterior, that is everything which is located outside of the container
and the boundary which defines what is outside and what is contained.

Agent structures

Frequently we do things to the objects around us, for example by moving them from one place to another, or we might want to change the physical state of an object. Various kinds of agent structures are often found in lessons and textbooks of environmental science, such as:

plants are eaten by animals
trees take carbon dioxide in

Path-link

Two entities can be connected together by a link. In this case there is a spatial contiguity and closeness of the linked objects. Linkages might be not only physical and spatial but also temporal and causal connections between two objects or events. They can also be a path which connects two ends, the source and the goal. The source is the starting point, the goal is the end point, and the direction toward the destination (the goal) is the path. If you go from the source to the destination along the path, then you must pass through each intermediate point on the path. We can impose directionality on a path, that is, we move along a path from point A toward point B. Paths can have temporal dimensions mapped onto them as well as linkages.

Cycles

Cycles begin with some initial state, proceed through a sequence of connected events and end where they began, to start anew the recurring cyclic pattern. The cycle represents the return to the original state. It moves in one direction from start to finish in a forward-moving sequence of temporally related events. In many cases cycles constitute temporal boundaries for our activities, and these tend to be rigid, e.g. day-night cycle. Cycles also are multiple, overlapping and sequential. Our temporal existence is defined by the distinctive set of cyclical patterns in which we find ourselves embedded, such as the day-night cycle. Such cycles may be differentiated temporally or functionally. There is a difference between 'natural' and 'conventional' cycles. Zerubavel (1985) argues that conventional cycles seldom have any natural basis; however, they can become so pervasive that they come to define the character of our experience.

Carriers

The structural elements of the carrier schema involve at least two entities, the one which carries and the one which is carried. What the carrier schema underlines is that an entity is transposed not because of its action, but because of the agency of another entity. Usually, but not necessarily, carriers presuppose the containment schema in which the entity which is carried is found within the container, and an agent structure, even if in respect to the latter it is not always apparent due to which entity's action something is carried away (e.g. prevailing winds and the stream of a river).

There are also other image schemata which are found in the context of teaching environmental science but they are not the primary focus of the present study. To mention two of them:

Part-Whole

We experience our bodies as Wholes with parts. Many objects around us have a part-whole structure. When a plant is eaten by an animal it becomes part of it. A basic entailment is that if A is a part of B, then B is not a part of A.

Balance

In our daily lives we are constantly experiencing symmetries and asymmetries of forces relative to axes and points of various kinds. Despite the different manifestations of balance, there is a single image schema present in all such experiences: a symmetrical relation of force vectors relative to an axis. It is because of this shared Balance schema that so many different experiences of paired, reversal and opposite relations are named by the same word 'balance'. To give few examples:

push	vs.	pull
in	vs.	out
take	vs.	give
rise	vs.	fall

In these cases there are two processes which balance one another. The underlying principle which corresponds to our experience of balance is symmetry. Symmetry means that A balancing B implies and is implied by B balancing A. The entailment of the balance schema is that each action or process countervails the effect of the other.

An example of analysing a lesson from the point of view of the image schema approach using a notation which represents image schemata is given in Appendix 3.

4.4.6 Some implications of the image schematic approach

According to Lakoff and Johnson, basic-level and image schematic concepts are directly meaningful because they are embodied in our everyday physical and social experience. A sentence is also directly understood if it is associated with basic-level and image schematic concepts. Because of the distinction between direct and indirect understanding, truths are divided into central and non-central truths. Central truths are characterised in terms of directly understood concepts such as basic-level and image-schematic concepts. More interesting are the non-central truths because their comprehension involves indirect understanding through higher-level categories, metaphoric and metonymic understanding, abstractions, etc. (Lakoff, 1987, p.296)

Knowledge, like truth, depends on understanding, so we have also central and non-central knowledge. Central knowledge is based on our basic-level understanding of experience. What we perceive at the basic level of our perception and manipulation with objects is taken as real and known. Scientific knowledge and scientific understanding to a large degree depends on the technological extension of basic-level perception and manipulation. For example microscopes turn things that previously could not be seen into basic level perception and they do so in a consistent and reliable manner. As a result, scientific knowledge based on human understanding can be secure. For example the technological extension of our basic-level perception and manipulation makes our understanding of organisms as being made up of cells unchallenged. As Lakoff points it out, "it is stable and remains so because of the large number of observations of cell structure made through microscopes and the large number of manipulations of cell structure brought about through various technological extensions of our basic-level capacities". (Lakoff, 1987, p.299)

An investigation of the role of metaphor as the bridge between non-central truths related with non-central knowledge and central truths related with central knowledge, will show the power of metaphors to define reality. Metaphor focuses only on particular aspects of our directly understood experience and uses these aspects to highlight knowledge which is not understood. And because these aspects of directly understood knowledge which are used by metaphor are taken as true so the abstract entailments which are highlighted by them through metaphorical projection are taken as true too. (Lakoff and Johnson, 1980, p.157)

4.4.7 Conclusion

Both the Image Schema and the Systemic Functional Grammar approach take a step beyond the split between form and meaning that both objectivism and relativism impose on the process of making knowledge and understanding. Objectivism has developed a naive realism in which linguistic forms and concrete images are direct references to objects and things found in the world (Lakoff, 1987, p.340). Any metaphor which is seen at the level of objects and things can only be an explicit analogy between them which shows in what ways they resemble each other without violating their nature and the fixed relations that they have in the world. Metaphor is then seen at the level of symbols of objects and things, being able to be a word replacement which apart from entertaining us has no other function since the relation between an object or a concept and its symbol is also fixed and cannot be changed.

Relativism on the other hand claims that the criteria of associating a symbol with an object or a an idea are different between different cultures (even between different people) and change from time to time (Lakoff et al, 1980, p.188). Imagination and its main mechanism metaphor is not constrained in imposing new meanings on new symbols mainly because both are the products of the subjective human effort of understanding and creating new meanings without the external reality imposing any constraints on that endeavour. Metaphors are essential for both processes of understanding and creating new meanings but according to objectivist opponents of relativism its value in handling these processes is minimised since they are not governed by any rule or algorithm.

According to both objectivist and relativist accounts of form and meaning, any 'object' of inquiry can be either a symbol or an idea (or an object) this symbol represents, but there is no place for an entity to be both or to have properties from both form and meaning. Opposing this idea, Systemic Functional Linguistics and the Image Schema approach both provide detailed accounts of what can be in the middle between form and meaning. Semantic forms and image schematic structures can be realised by grammatical forms, rich images and concrete objects but at the same time realising and representing sets of meaning functions (like containment and agency) that are imposed on set of meanings (like the behaviour of cells and decomposers).

These kind of forms, which we will call semantic forms, have a multi-modal property. Various sets of meanings which come from different domains (e.g. biology, social actions) are realised by the same kind of semantic forms (e.g. containment schema or material process). For example agent structures (either schematically or linguistically) represent human actions, processes in which invisible entities are involved, and corporations' actions.

The present study provides examples from the teaching of environmental science; how certain sets of meanings are realised either schematically or linguistically, in other words how sets of meanings are 'materialised' in terms of semantic forms. For example, what does it mean for the thing-like entities and the process-like entities which are involved in the set of meanings which is about 'life processes'; the choice and use of certain types of participants, processes and circumstances. In other words, how are meanings shaped by semantic forms and to what extent? Therefore, what is investigated is the effects of the choices and uses of various semantic forms on meaning. A process-like entity or a thing-like entity (like an unobservable one: decomposers) can be represented in a way that resembles another process-like entity or thing-like entity (like an observable one: an animal) so that the two processes or things become ontologically closer.

4.5 Metaphor as a 'tool' for constructing and transforming entities at the ontological level

4.5.1 Introduction

The way in which metaphor is seen and studied in this thesis is inspired by the outcomes of three projects in science education, conducted in the Institute of Education, University of London.

4.5.2 Structuring metaphors and analogies

The purpose of the project Children and Teachers Talking Science (CHATTS) was to understand the processes by which primary teachers in the course of several discussion activities constructed sense and meaning for themselves concerning scientific ideas presented to them on videotape and in text (Hann et al, 1992(5), p.1). One of the main outcomes which is of special interest for the present thesis, is how individuals deal with information which is unfamiliar to them. Evidence from transcriptions of discussions between teachers suggest that when they are called on to explain an unfamiliar phenomenon which is represented to them, they first look for the properties of the entities involved. By getting a rough idea of the nature of the entities, individuals construct a structuring metaphor which helps them to imagine what the entities are like and what they can do (Hann et al, 1992(6), p.52). When they have managed to envisage an idea or an image of the nature of entities, then they can point to explicit analogies which will be the realisations of their structuring metaphor. To give an example, when they are faced with the phenomenon of the ozone layer which protects the earth from the sun's rays the initial structuring metaphor can be to think of filters which let some things through and not others (Hann et al, 1992(6), p.53). From there, specific analogies emerge, such as:

> "The ozone layer is like a giant colander above our heads."

After the first concrete realisations of a structuring metaphor appear, teachers' discussions turn to explore the similarities between the possible analogues and the phenomenon which is to be explained. In this process some exemplified analogies can be rejected as not suitable to capture the structuring metaphor. Also in the light of new information the structuring metaphor itself can be either rejected or modified in order to fit the phenomenon better (Hann et al, 1992(6), p.54).

Another outcome of the CHATTS project which is of special interest, is that analogy is not only an isolated heuristic tool which assists explanations but is an essential tool which is inherent in the act of explaining and part of the content of the explanation (Hann et al, 1992(6), p.54). Even if its role is not always apparent it can be found throughout an explanation, from the way an explanation is explored up to the process of stopping an explanation. It is important to underline the function the analogy seems to serve, that is, to change the level of the phenomenon to bring it nearer to the everyday scale, making it seem more real and tangible (Hann et al, 1992(6), p.59). This property of making the unfamiliar familiar and the unobservable observable, attached to the role and function of the image schema, is one of the most important themes in the present thesis.

4.5.3 Metaphors and models

An essential part of the project Commonsense Understanding of Science aimed to investigate the deep level of ontological similarity and difference on which metaphor and analogical reasoning depend (Ogborn et al, 1994(2), p.2). Among the various studies of this project, in a series of interviews teachers were asked to use metaphors to make some sense of scientific phenomena and ideas. It is mainly the results of these interviews which are of interest in respect to the role of the metaphor in people's understanding of science.

In this recent work what has been thought of in the CHATTS project as a structuring metaphor is now described as a model. The latter is identified as the metaphorical complex of ideas which guides people how to think about entities (Ogborn et al, 1994(3), p.4). Models, often described as metaphorical models, are not envisaged as being used explicitly, and indeed people might not even be aware of the presence and use of such models in their patterns of reasoning (Ogborn et al, 1994(3), p.3).

One of the most important outcomes from the study is that by adopting a metaphorical model, people can be driven to certain sort of inferences based on the properties of that model. If another model is adopted instead, they will end up with different inferences. But there will be also the possibility that two metaphorical models are activated on a complementary basis and that leads to a kind of mixing of metaphors as a way to resolve the differences or even contradictions that the use of the two metaphorical models implies. This complex of metaphors arises for example when people are called on to think about the role of genes and their relation to DNA. Thinking about genes as a thing-like entity which can serve the role of the Agent and at the same time as a sequence of instructions, has as a result that different metaphors are combined, contrasted or juxtaposed in the processes of thinking (Ogborn et al, 1994(3), p.11).

The results above suggest that in the process of thinking, metaphor does not appear as a single event or process. It rather appears as a complex of metaphors which should not be seen separately from its inferences. The latter are part of the metaphorical complex and are not simply an outcome of the metaphorical process. These findings are also in accordance with the finding of the same project that in the actual process of thinking metaphorically, the comprehension of metaphor cannot usefully be studied apart from its production (Ogborn et al, 1994(3), p.11). This view which gives equal importance both to the metaphorical process and the product or outcome of this process puts metaphor on a new plane, different from the way it has generally been studied previously.

The project Commonsense Understanding of Science underlines that how we think about entities relies on the context within which these entities are found. To give an example the entity 'body' can be thought of as a localised entity, but in the context of a body being affected by virus in the metaphor "A virus is an invisible intruder", 'body' is thought of as a container:

> "Because our bodies try to fight it when it enters us."

When people are faced with entities such as 'virus' and 'gravity' of which they do not have immediate experience they often accept the metaphors in which these entities are found as identities:

> "A virus is an invisible intruder."
> "Gravity is an invisible pull."

From the way they elaborate these metaphors it becomes evident that they acknowledge them as identities not because they do not bother to think more about the relation between the two entities in each sentence (e.g. 'virus' and 'intruder') but because they think that the two entities share the same ontology (Ogborn et al, 1994(2), p.13). 'Pulls' and 'intruders' offer an imaginable, reliable and tangible way to think about the otherwise unthinkable, the unobservable entities 'gravity' and 'virus'

So the metaphors here are not simply a case of seeing a similarity or making a comparison between two entities, but of thinking about them as what they are. 'Virus' and 'gravity' are seen as specific kinds of Agents in the same way 'intruders' and 'pull' act.

These results are also consistent with the CHATTS project which suggested that individuals in the process of understanding scientific concepts, start from constructing structuring metaphors and then search for examples in terms of explicit analogies which best realise their structuring metaphors.

4.5.4 Explanations and the construction of entities

The project "Explaining Science in the Classroom" looked at how explanations are constructed in the science classroom. A number of lessons were observed, video-taped and analysed for this purpose. The main outcome of this project has been to provide a language which offers a way of thinking about what explanations are, when and why they are felt to be needed, what constructing an explanation involves, how explanations transform knowledge, and different styles in which explaining can be done (Ogborn et al, 1996, p.8).

The view which is adopted in this project is that explanation should not be seen at the linguistic surface marked out by specific linguistic forms (Ogborn et al, 1996, p.138,139). Scientific explanation is defined as a story about how a set of entities can produce the phenomenon to be explained. This story is based on what things are and what they can do or what can be done to them (Ogborn et al, 1996 p.9). Explanations seen as stories can hardly ever appear as isolated single events. They are found inside and fit alongside one another to form larger patterns which are themselves explanations (Ogborn et al, 1996, p.17).

Like stories, explanations take their meaning within a context, which involves talking about what the entities are and in what ways they act in order to bring about a certain outcome or effect. The intention of the adoption of the concept 'entities' is to include not only concrete things and objects but scientific concepts, processes and ideas such as energy, photosynthesis and evaporation (Ogborn et al, 1996, p.38). The construction of entities is an inseparable part of the explanation and can be also considered as an explanation itself. To give an example, entities such as teeth have to be constructed anew as parts of the digestive system:

David: *Your teeth are part of your digestive system, your teeth take the food, smash it up into tiny bits, bite it off, smash it, make it into tiny bits.*

Here teeth are presented like machinery instead of the intentional action of chewing and their associations with emotions and feelings (smiling). Teeth are being given a new meaning and the teacher can be seen as constructing a new entity. In the context of the digestive system, constructing teeth anew is part of explaining how digestion takes place (Ogborn et al, 1996, p.39).

The construction of entities means that knowledge is transformed. New meanings are given to entities and replace or coexist with old meanings. In the example above as it is seen within its classroom context, eating becomes digestion. Analogy and metaphor are valuable tools in re-working knowledge, transforming entities and constructing new meanings. An example of an analogy or explicit metaphor used in a lesson is the representation of the eye as a camera (Ogborn et al, 1996, p.74). It should be noticed here that re-working of knowledge is thought of as a two way process very similar to Black's interaction view about metaphors: the eye is being re-worked to be like a camera and a camera is being re-worked to be like the eye. Also other examples of metaphors and analogies picked up from classroom observations of several lessons are discussed in a way which shows analogy and metaphor as tools of reasoning which works out what the entities are at the ontological level.

Another contribution of this project to the concept of metaphor is the suggestions that most of the work of the construction and transformation of entities in the classroom is undertaken by hidden metaphors, also called covert metaphors (Ogborn et al, 1996, p.74). Unlike explicit (overt) metaphors which are concentrated on 'terms', on words, there are metaphorical ways of talking about things, and even if they are not identified easily at the linguistic surface as a direct relation between linguistic form and meaning, they build up images about what these things are. In the following extract taken from one of the lessons which was observed and video-recorded during this project:

Teacher: *It's got a coating like rust - it's oxidised, OK? It's got a coating on the surface where it's reacted with the air... Look at that. There you can see a very very bright silver surface that is practically going very grey. The air is reacting with it very fast indeed.*

it is the way entities are discussed in terms of what is happening to them and what reacts with what, which builds up an image of the phenomenon of oxidisation. From this image inferences can be drawn about how somebody can speed up the phenomenon or prevent it, for example by covering the surface to prevent the coating (Ogborn et al, 1996, p.76).

In this thesis the position that is adopted is that metaphors in science education as well as in environmental education are about the construction of entities. Constructing entities involves a lot of transformation of entities especially in the context of environmental education since entities such as the human body are taken from their everyday context and become scientific entities. So metaphors serve the role of seeing familiar things in unusual ways but also of explaining what these things are in ways which can be accessible to commonsense understanding. The latter is due to the fact that - as the three projects discussed above have shown - the metaphorical work takes place at the ontological level. This is the level of what entities are made of, what they can do and what can be done to them. This level of talking is metaphorical in a way that an image of what the entities are is built up without necessarily drawing explicit similarities or differences with other entities. In most cases these similarities and the presence of the analogues are silent and are hidden in the way things are talked about and in the sorts of images which are constructed. Metaphors seen in this way are neither too concrete nor too abstract, but they are rather seen as complete packages of images which make people able to envisage a phenomenon as a whole and draw inferences about it.

4.5.5 Summary - Conclusion

The present chapter is important because it outlines the theoretical framework drawing on recent thinking from linguistics and cognitive science which will be used in the thesis.

The outcomes of the three projects discussed in this chapter summarised as:

1. Metaphors can and do create new imaginative ways of thinking about things.
2. The creation of prototype histories (like packages) provides a way to remove problems in thinking about an unfamiliar phenomenon and makes it seem obvious (e.g. CFCs destroying the ozone layer understood as the unproblematic prototype histories 'eating' or 'burning away').
3. The fact that very often analogy and metaphor work in a hidden way under the linguistic surface, particularly in the choice of verb phrases.

4. The importance of *action* since it emerges as a common theme, essential in commonsense reasoning about several phenomena. (*action* as a structuring metaphor, a metaphorical model or a prototype history and in the present study action described as the underlying image schema in representing and realising several phenomena).
5. The fact that the underlying patterns of reasoning, models, or categories are flexible and simple if they are seen at a deep ontological level, something which is in accordance with the findings of the present thesis: several phenomena are realised and represented in flexible and simple ways by few image schemata and ideational processes

will be the issues which will be explored and discussed extensively in the analysis of the present thesis.

CHAPTER 5

FIELDWORK

5.1 Data collection

Many researchers believe in the importance of classroom interaction, recorded as talk, as data for the study of teaching and learning (Edwards et al, 1987, p.51). Then the question of which sort of approach is appropriate for data collection depends on decisions about what are to count as data and to what those data are thought to be relevant, grounded in specific research interests and theoretical positions (Edwards et al, 1987, p.54).

5.1.1 Observations

Because of the absence of any rigid coding of metaphors before the observations, in this study there was no use of any schedule during the observations. Furthermore this study starts from the view that metaphors are the outcome of participants' (teachers and students) interaction in the classroom, which depend heavily on many factors in ways which are influenced by the structure of the teaching itself. Given also that the language of teachers and students, and other behaviours associated with language is of crucial interest and importance for this enquiry, it was thought that any attempt to analyse and code metaphorical aspects of language in the real time of the observation would be impossible. So lessons were video-taped and tape recorded.

The creation of an audio-visual record gives us the benefit that it can be replayed after the event, as many times as necessary to make sense of that event. It gives also the opportunity to return to the original recording every time we want to check details in the transcript, which is itself selective and is not an identical representation of the recorded event. The videotaped classroom lessons are referred to in the rest of the thesis as 'lessons'.

Classroom observations were conducted so as to achieve:
- a variety of different topics located in the environmental science discourse, which are:

Acid Rain,
Carbon and Nitrogen Cycle,
Respiration and Photosynthesis
Sewage and Waste Treatment,
Green House Effect and Ozone layer

- some examples of the same topic taught by different teachers in different schools : such as "Cycles of life and Acid Rain", and

- at least one series of lessons which covers the teaching from the beginning until the end of an environmental unit with one group of students following the same teacher. This unit includes topics and classroom activities such as:

Different sort of environments around the world (two lessons)
Sewage and waste treatment
Organising a provisional agenda for some main environmental issues
Making posters which display the main environmental problems (two lessons)
Classroom debate on issues related with transportation in a big city
Environmental changes caused either by nature or by people
Acid Rain and its effects in the social, historical and natural environment, included a demonstration by teacher and some experimental work by students (two lessons)

To obtain these data the fieldwork was carried out in two distinct phases. The first phase involved classroom observation of one series of lessons in a Secondary school for girls located in outer north-west London. The second phase involved observations of lessons in two secondary schools, one having been used for the first phase, and the other a secondary school in Milton Keynes. To protect the anonymity of the schools, teachers and pupils, fictitious names have been used for the teachers, while the abbreviation: S has been used in the transcripts to signify when a student is talking. The school in north-west London is called School A and the school in the Milton Keynes area is called school B. The table below shows the number of lessons observed in the two schools, the duration of each lesson and the date when it was observed, the topics of the lessons, the age range of the students in each lesson and who was the teacher who taught each lesson:

Schools	Number of Lessons	Duration of each Lesson	Topics	Students' Age-range	Teachers
School A	1 series of 12 lessons	75 minutes 15.3-17.5.95	Earth in Balance	YR.8	Alan
	1 double lesson	75 minutes 25.11.94	Acid Rain & Carbon cycle	YR.8	Jane
School B	1 double lesson	90 minutes 8.6.95	Nitrogen Cycle	YR.10	Norman
	1 double lesson	90 minutes 9.6.95	Food Webs	YR.10	Norman
	2 double lessons	90 minutes 8.6.95	Waste not want not	YR.9	David

(Table: 2 Schools in which observations were conducted)

In School A the textbook: *Oxford Science Programme*, is used as the primary resource of written material. In the second school (School B) the project : *Salter's Science* , is used as Activity papers (work sheets) in the classroom. In order to build as complete a record as possible, copies of all reading materials used in the classrooms were collected, together with any piece of writing done on the blackboard in connection with the classroom work.

Most social scientists today believe that the presence of observers and their recording devices in the classroom are likely to be obtrusive, in that participants who know that they are being observed may well talk more, or talk less, or just talk differently (Edward et al, 1994, p.77). On this point we should say that in School A the researcher's and equipment's presence became, over time, familiar to teachers and students, because in the same school with the same teachers and groups of students quite a lot of classroom observations had taken place before - in the same way as in this study - for the purposes of the research project: 'Explanations in the science classroom'. In addition, the fact that a whole sequence of lessons had been video recorded in the same school, following the same group of students with the same teacher, for the purpose of this study, reduces any distortion over time in this specific classroom.

School B had been used quite frequently as a resource for educational research data. From the discussions which I had with the teachers before and after the video recordings of their lessons about their usual everyday classrooms' activities, I felt that the recorded lessons were no less typical as examples of teaching and learning than those that took place normally in my absence.

5.1.2 Textbooks

Another source of data used in this study is environmental science textbooks. Both classroom observations and environmental science textbooks are irreplaceable in the analysis, given that they correspond to the written and spoken functions of the teaching of environmental science which interact with each other. Textbooks are written in order to be elaborated in the classroom by the teacher and the students.

Textbooks were selected for analysis taking account of their variety and of the age range to which they are addressed. Topics on environmental science were collected from three series of science textbooks widely used in schools. One is Active Science in which issues about the environment are discussed in the unit under the title Earth Science. In the Nuffield Science series for the secondary school, environmental topics are part of Biology and in Oxford Science Programme there is a special unit for Environmental Science. These series of textbooks, because of the way they are written, impose different approaches to environmental education. To give an example the Oxford Science Programme and to a greater extent Active Science rely on students' activities more than on providing information. Therefore these textbooks promote the idea - even if it is not a distinct characteristic of their environmental topics - that learning about the environment is mainly the outcome of experimenting and acting within the environment. On the other hand Nuffield Science puts more emphasis on how students will construct their thinking from the way information is presented in an interesting and challenging way.

Another important aspect of textbooks is the way their contents are organised. In most textbooks, the contents are more or less available in a way that suits the demands of the classroom curriculum. That means that a chapter of each unit can be a subject of one lesson and the order of the chapters might correspond to the order of the lessons. Other textbooks which are not explicitly linked with the school curriculum have a narrative form and look like story-telling books. In the latter (*World in Danger : Earth* and *Air Ecology*) there are few or no suggested practical activities and each chapter can be seen as a thematic unit which tells an interesting story about the environment.

5.1.3 Conducting classroom observations

Data collection followed the same procedure for each of the two schools:

An initial contact was necessary with the head teachers of the science departments in order to obtain permission for carrying on research work in their schools. The aim of the study, and the method used for data collection was explained to them, asking for classes which were taught topics on environmental science. It was made clear that neither teachers' nor students' performance would be evaluated or assessed in any way. Then teachers from the two schools who taught topics related with environmental science were asked by the head teachers if they would be willing to be observed and video recorded during their classroom teaching.

There was a discussion with members of staff who had agreed to be observed, explaining what the study was looking for and how. Teachers were asked to follow their everyday teaching without providing anything outside the range of their normal classroom work . They were asked whether they would be able to carry with them the tape recorder with the microphone, given the fact that the video camera's microphone has very limited ability to record their speech, because of the ambient sound.

The next step was video and audio recording of environmental science lessons. One video camera and one tape recorder were used for each lesson. The video camera was set up on a tripod in order to achieve the best quality of picture, placed at one of the two back corners of the classroom behind the students. In a few cases the video camera was focused on a group of students when the teacher was moving around the groups of students and talking with them. Most of the time the video camera was focused on the teacher. Recordings lasted for the whole duration of each lesson except where this was impossible, as for example when students were too noisy during their group work, making it impossible to record either the teacher or the students. At the same time or at the end of each lesson notes were made about the specific context of each classroom.

Data were viewed as soon as they were available in order to assess their recorded quality so as to improve recording techniques and avoid mistakes during the next observations. At this stage some first attempts were made to see what sort of information these data might provide about teaching of environmental science.

As soon as the first audio tapes were ready the process of transcribing them was begun. Transcriptions were made by a person who is a native English speaker. Efforts were made to transcribe as many recorded lessons as the quality of the tapes permits. Lessons which contained little teacher's talk in a very noisy classroom environment were eliminated. Ten lessons out of twelve were transcribed from the recorded series of lessons under the subject: 'Earth in Balance' from School A. The remaining three double lessons have been transcribed except for the two double lessons under the topic: 'Waste not, want not', from School B of which only very few parts were able to be recorded. The transcriber was given instructions about the conventions to be followed for the format of the transcriptions.

Finally, the video tapes were reviewed in order to check the quality of the transcripts. After the end of that stage the further study of complete transcripts had began for data analysis.

5.2 Transcribing tape recorded lessons

As has often been pointed out, any transcript is not and can never be the spoken language itself. There are details of intonation, pitch, hesitations, false starts, errors, and periods of silent thought which usually excluded from the transcript. Even if we attempt to include every spoken word in a transcript, decisions have to be made about the features of the spoken discourse which are not normally part of any writing system.

Decisions on what to include in the transcript depend on the researcher's interest. In the present study we are not dealing specifically with the linguistic technicalities of teachers' talk so details of the spoken language are not relevant in the analysis. On the other hand there is a special interest on how language facilitates teachers' teaching practices and how meaning is structured through a continuing piece of talk. As a result conventions about the spoken language were kept to a minimum so as to achieve transcripts which are comprehensible without being too complicated to read.

The conventions of lay-out and notation which are common in conversational analysis were employed for the construction of the transcripts. At the top of the first page of every transcript a brief commentary gives information about the teachers' name, the age range of the group of students, the date when the recording took place, the topic which was taught and the name of the school. Each transcript indicates the class of speaker at the left margin of the page with (T) for the teacher and (S) for the students.

Given the fact that the main interest is on teacher's explaining, students are not identified individually either with names or with numbers and their gender is not identified in School B (School A is a school for girls only). Each (S) indicates a single student-speaker. In order to distinguish the individual speaker from those talking at the same time, contextual information is given in parenthesis. Talk enclosed by a single slash (/) means an overlap of teachers and students talking. The class of speaker is indicated in the same way as is described above in each enclosed segment. This convention gives additional, contextual information which enables the reader to appreciate the nature of the communication between teacher and student.

Line-numbering at the left margin of the page, makes reference to the transcript easier during the phase of data analysis. The traditional punctuation is elaborated with details of pausing. A double square bracket ([]) is used to mark a pause that is noticeable, while dots (....) are used to indicate speech about which the transcriber is uncertain. In the same way dots enclosed by parentheses ((...)) identifies spoken language which is totally unable to be transcribed. Contextual information which is accessible from the audio tapes, is given in parentheses with words written in italics. More information about the context of the communication between teacher and students, like facial expressions of approvement or dissaprovement, gestures, movements of teacher and students during the lesson, different sort of activities like writing on the blackboard, working in groups and etc., is available from the video tapes. An example of a piece of transcript with some of the most basic conventions is given below:

T: Al right, let's just do one thing at a time Mitch, animals breathe out carbon dioxide? / S.... / T ..Mitch, that's enough....[ ] Why do they breathe out carbon dioxide, where does the carbon dioxide come from?

S .... /

T: No, no the trees are going to do something else in a minute, we'll look at that. Where does this carbon dioxide coming from that we are breathing out?

S: the greenhouse effect... / T: We've got little green houses inside us? / S: (laughter).... /

5.3 Summary of the contents of recorded lessons

In this section summaries of the lessons which are most often used for the analysis are provided. These are most of the lessons which belong in the sequence of lessons under the title: 'Earth in Balance' and the double lesson about the Acid Rain and the Carbon Cycle.

Sequence of lessons covering a variety of topics under the heading: 'Earth in Balance'

In the first lesson of this series, the teacher introduced the new topic as similar to other topics of geography lessons. He asked students to call on everything they knew about environmental damage, following the first double page of the new topic called: 'Looking at the Environment' from the science textbook: 'Oxford Science Programme'. After a short discussion which contrasted the effects people's activity had on the environment when they lived in caves and the effect of people's activity on the environment today, the teacher moved on to discuss with the students the extent to which each one of us has an effect on the environment. That pushed the discussion on to the things people need to survive and on how people's activities to get what they need today has an effect on their environment and other surrounding environments.

The second lesson began by the teacher calling on the students to elaborate the textbook's questions which raised an interesting discussion during the previous lesson. A lot of effort was made to identify different sorts of environment by giving instances of them. Then the discussion turned on how one environment might have an effect on another. From time to time students were asked to copy in their exercise books something the teacher wrote on the blackboard, a paragraph or few sentences from the textbook and to answer specific questions from the textbook.

The next lesson started with a discussion about changes caused by human agency and changes caused by nature itself. Then the lesson focused on another sort of written material. This time a copy of a work sheet was given to the students showing a map of a marshland area and its surrounding environment. Questions were round a dispute between the council which planned to use the area as a landfill site for waste disposal and a group of people who were concerned about effects this decision will have on the surrounding environment. Teacher and students tended during the whole lesson to expand the subject of their discussion about polluted lands and seas outside of the context of the imaginary activity of the work sheet.

The fourth lesson continued with work on the activities suggested by the work sheet used during the last lesson. This time students answered questions, based on information provided by an extract from a newspaper about the decrease of sites with peat in Britain. The teacher went on to discuss with students the effect on the environment of burning peat or other resources of energy, like petrol, and on alternative resources of energy people must use in the near future.

The first section of the next lesson was spent by teachers and students trying to make an agenda of the most important issues which are related with the pollution globally today. From a list of issues which contained things like: traffic chaos, asthma, crashes of tankers, the accumulation of nuclear weapons, extinction of whales and sewage works; the teacher shifted the discussion to the Green House Effect and the damaging of the ozone layer. Chemical substances and changes relevant to the two issues were explained by the teacher, always trying to ground his explanations in what students already knew about them. References to pages from the textbook: 'Oxford Science Programme' were made whenever it was thought necessary.

The following two lessons were devoted to students' activities to make posters to address the main issues related to pollution. Students were divided into large groups and materials were provided to them in order to make the posters. If they wished they could have a look at textbook materials as sources of information. The teacher moved between the groups of pupils having interesting discussions with each of them about the nature of the issues represented in the posters, suggesting steps to follow in the poster making activity and more materials which might be included in the posters.

Students were informed from the beginning of the eighth lesson that they could have the promised debate on one of the issues which was discussed last time. Before they started some time was spent reminding themselves what were the main arguments around the issues discussed in the last lesson. The students then chose traffic problems as a theme for the debate and they were divided into two groups: environmentalists who suggested public transportation as a solution to pollution and traffic chaos and those who are not ready yet to leave their cars and use alternative transportation. The debate was quite tense at some points causing the teacher to interfere in order to calm down some students and suggest ways of looking at things differently in a broader context.

School A, Lesson on Acid Rain and Carbon Cycle

During the first section of the lesson the teacher got students to recall the definition of concepts like weathering, pollutants and their ideas on how to design an experiment showing the effect of dilute acid on different sort of materials. The discussion went on to details about planning experiments and how to report results. The second section of the lesson was devoted to the Carbon Cycle. The cycle was built on bit by bit by the teacher who used students knowledge about substances and processes that they knew from previous lessons. The Carbon Cycle was represented on the blackboard as a conceptual chart in a form of a cycle of the processes and entities which take place in it. At the end the teacher's explanations moved forwards and backwards through the constructed conceptual chart.

5.4 Methodological approach

This study starts from the expectation that metaphors will be widespread in the teaching of environmental science, without any simple correlation between surface linguistic cues and either the presence or type of metaphor.

The unit of analysis varies in scale, always however being a bounded unit of communication recognisable as such to a hearer/reader. The smallest can be a clause while the largest is the extent of a chapter or a section of a chapter. The objective of this study is to provide examples of representations of entities according to the categories of the image schemata and the different types of ideational processes, also taking into account interpersonal and textual elements.

The raw data from pieces of textbooks and transcriptions of classroom observations are primarily in the form of text. Visual representations in the form of maps, diagrams, drawings, charts as well as context elements from the video recorded lessons are also considered. The material is unstructured and difficult to deal with. The coding of the different kind of image schematic structures as it is provided mainly by Johnson (1987) as well as the description of the different types of ideational processes provide a framework for an analysis. Having this framework as a basis, attempts have been made to :

a) highlight the occurrence of each various semantic forms (both linguistic and schematic), by giving page and line,

b) relate these semantic forms as specifically as possible to the contexts in which they occur (e.g. topic, what is the 'given' and what is the 'new' in the teaching)

c) relate semantic forms of the same kind (either linguistic or schematic) to each other, constructing their complexes by representing them where appropriate.

CHAPTER 6

ANALYSING METAPHOR AS A LINGUISTIC PHENOMENON

6.1 Introduction

The present chapter is divided into three sections. In the first section aspects of Systemic Functional Linguistics are applied in analysing mainly textbook material. Emphasis is put on how semantic forms of ideational processes such as material processes can be identified in various texts. As this section is progressively developed, the need for taking into account the text structure and the interpersonal aspects of the exchanges of meaning in analysing ideational processes is underlined. The last part of this section deals with the phenomenon of grammatical metaphor and some first thoughts about the implications of the use of grammatical metaphors are discussed.

The second section studies how the construction of specific sets of entities is realised in textbooks. In doing so, the unit of analysis is not constrained at the clause level but constitutes larger pieces of text such as chapters or units of chapters. Both covert and overt metaphorical accounts of representations of entities are identified at the level of functions of semantic forms.

Finally, in the third section some possible ontological, epistemological, learning and ideological implications of the way entities are represented are discussed.

6.2 Systemic Functional Linguistic approach

6.2.1 Linguistic realisations of meaning and context

Halliday and Martin are opposed to the traditional view of language as a passive reflection of some pre-existing conceptual structure. According to them - as shown in section 4.3 - language does not merely reflect what the world is and how it is structured but it is actively engaged in bringing such structures into being. The latter are structures of language as well (Halliday et al, 1993. p.8). In particular human experience and scientific language are interdependent, construing each other by constructing systems of meaning in terms of organised knowledge.

A piece of scientific language, a scientific note for example, is a semiotic thing. The things that we do to it, like reading it or writing it on a page, are acts of meaning. At the same time this piece of text is an instance of language in use which takes place in a specific social practice. In this case we talk about the social context of the scientific practice. Halliday and Martin expand their general accounts about the dynamic interrelation between social context and language to the relationship between science as institution and scientific language. They do so because they assert that a given text, a scientific note, provides only a very partial perspective on the social practice of science. A detailed linguistic analysis at this level does not provide a meaningful interpretation of the discourse of science. In order to do the latter the institutional perspective has to be treated as more abstract because it generalises across a vast range of actual texts and an even larger range of potential verbalisations. Thus in science too there are two distinct levels of abstraction or semiotic planes (as they call them) which are interrelated dynamically.

From there what applies to language as a semiotic system applies also to scientific language in particular. Our engagement with the physical, biological and social resources provided in the science context produces semiosis or in other words meaning making. Semiosis enacted in this way involves three complementary modes of meaning: FIELD (the social action), TENOR (the role structure), and MODE (the symbolic organisation). The first (FIELD) "is building up a world of action in which physical and biological entities act, by themselves, or on other things; construing a world of semiotic activity in which typically conscious entities negotiate meaning and constructing a world of relationships among entities" (Halliday et al, 1993, p.27). The second (TENOR) is the mode of social relations drawing on interpersonal resources such as giving or offering information. And the third (MODE) is the way the text is organised into a coherent whole.

In order to give some account of how grammatical metaphors appear in the spoken and written mode of the discourse of teaching environmental science I will restrict my analysis to the level of the ideational metafunction. As we saw above (in the discussion of Systemic Functional Linguistics) processes which have to do with actions are realised at the clause level in terms of material processes, processes which involve human observations and reasoning are realised in terms of mental processes and those which have to do with attributing and defining are realised as relational processes.

6.2.2 Ideational metafunction and genres

Martin (1989) found in his study of geography texts that the main grammatical resources used to realise taxonomic relationships are relational processes and nominal groups. He also found that the most frequent ways which are used by textbooks to define technical terms are through identifying relational processes. Relational processes are the linguistic realisations of the first introduction of technical terms and their classifications and taxonomies. He comes to the conclusion that definitions, classifications and taxonomies constitute at the level of the more abstract semiotic plane one of the major genres found in science textbooks, called *reports*. Textbooks are seen basically as large 'reports' made up of a series of smaller ones. Both attributive and identifying relational processes are constitutive in realisations of 'reports'. On the other hand *explanation* is a genre found only when the smaller 'reports' focus on processes. 'Explanation' as a genre is supposed to be different from 'reports' mainly because it has a higher percentage of action verbs organised in logical sequences. In other words material processes constitute the linguistic realisations of 'explanations'. So according to Martin and Halliday:

1. There is a procedural difference between 'reports' and 'explanations'. 'Reports' precede 'explanations'.
2. 'Reports' are found more often and more extensively than 'explanations' which are located in small 'reports'.
3. Both 'explanations' and 'reports' are clearly distinguished genres without being mixed.
4. They are defined on the basis of clearly distinct operations: processes for 'explanations', versus descriptions and classifications for 'reports'.

5. Their operations are realised linguistically in clearly distinct ideational processes: relational processes for 'reports', versus material processes for 'explanations'.

6.2.3 Identifying ideational processes in texts and transcripts

6.2.3.1 Processes and what they represent in textbooks

Looking at various examples of environmental science textbooks we notice that material processes realise at the linguistic level not only explanations but introductions of terms, definitions and classifications as well. As soon as a new phenomenon or technical term appears even for the first time the very few relational processes in terms of something is... or is a kind of... or something has..., give place to whole sequences of material processes in terms of what something can do, what has happened to it and what is it made of. This finding is not surprising since environmental science is a discourse which shows how people make use of their own environment through their actions.

For example in the four paragraphs under the title: 'Caring for the soil' we notice the large number of material processes. This little section (Appendix 4.1) which is covered in a double page is taken from a resource book: 'World in danger-Earth' addressed to primary school students. It does not contain any classification of different kinds of environments according to their definitions and attributes. It talks about three different kinds of soil: terraced hillsides, the soil which is used for growing crops and the soil which is found in patches of cleared forests. These three different types of soil are defined in terms of what people can do to them, like:

(1) They [people] clear a patch of ground by cutting down the trees and burning them.

They	clear	a patch of ground	by cutting...them
ACTOR	PROCESS	GOAL	CIRCUMSTANCE of manner

in relation to what is the effect of specific natural phenomena which occur in the areas where these soils are found:

(2) Heavy rains can easily wash the soil away.

Heavy rain	can easily wash	the soil	away
ACTOR	PROCESS	GOAL	CIRCUMSTANCE of place

The three different kinds of soil are defined through sequences of material processes. In these processes all sorts of ACTORS can be found acting on different kinds of GOALS, like living things (e.g. plants like crops), non living things (e.g. soil) and also systems of living things and non living things (e.g. tropical forest). Human beings grow crops and living things like animals fertilise the soil. But also natural phenomena like heavy rains and non living things like chemical substances (e.g.water) have an effect on the soil. It seems that for the specific piece of text material processes are the best available linguistic resource to illustrate what sort of power human beings and natural phenomena have (to do things) and the effect of their power on different environments.

Looking at another section in the same textbook we can replicate the same findings. 'Explanations' are not necessarily about processes which are realised at the level of the clause as material processes. Moreover there is not any rigid sequence in which 'reports' and 'explanations' are to be found. Even if we assume that 'reports' are indicated by various forms of relational clauses, what appears to be the case is that relational processes can be found in any place in the section and not only either at the beginning or the end.

In the first page of the section *Soil cycles* (Appendix 4.2) living organisms like woodlice, millipedes and beetles are classified as specific kinds of animals called decomposers. These animals are both identified and classified as decomposers because of what they can do to non-living organisms. In a piece of text, which is less than a paragraph, and which is not a clear sequence of distinct, relational processes which precede distinct, material processes, appears a complex of embedded clauses which refer to one other:

Soil cycles
A group of small animals and plants help to break down nature's rubbish into smaller parts. These are the decomposers. Animals such as woodlice, millipedes and beetles are decomposers.

In this example the deictic anaphoric element *These* of the second sentence makes reference to the group of small animals and plants which could do certain things:

break down the waste products of other living organisms. In other words decomposers are classified first of all as living organisms in a nominal group: *A group of small animals and plants*, without the assistance of any relational clause. The relation of this group already classified as subcategory of living organisms, with its superordinate category of all living organisms, is represented as a material process. The latter describes what the entities of the subcategory can do to the waste products of the superordinate category. Then given what a decomposer is because of what it can do, some specific animals are classified, in terms of an identified relational process, as instances of the subcategory of decomposers:

(3) Animals such as woodlice, millipedes and beetles are decomposers.

woodlice,millipedes and beetles	are	decomposers
IDENTIFIED	PROCESS	IDENTIFIER

Following the complex of clauses backwards we find classifications as a movement of sub-inclusions to super-inclusions, or in other words as a shift from specific to more general taxonomies. Woodlice, millipedes and beetles are animal decomposers which are a group of small animals and plants.

6.2.3.2 Processes and what they represent in transcripts

Looking at transcripts, we notice that new meanings are built up on what is already given. What has to be recalled for the construction of new meanings depends on many interrelated factors, like the nature of the topic and whether this topic is being introduced for the first time or if it is being further developed for a better understanding. For example it is one thing to develop the idea of recycling on what students already know from the media and from everyday domestic practices that they have possibly come through and it is another thing to introduce the Carbon Cycle.

For the latter to be taught a lot of thing-like and process-like entities need to be introduced and elaborated before, like carbon dioxide, oxygen, atmosphere, respiration, photosynthesis e.t.c. All these entities, represented linguistically as participants, processes and circumstances, have to find their place in order to reconstruct the phenomenon in question. This is what teacher's questions do (you can see the complete transcript of this lesson in Appendix 3.3). They do something more than just recalling information from the past: they re-arrange those pieces of knowledge which are given in order to build up new meanings:

> *Where's the atmosphere?*
> *How does carbon dioxide get into the atmosphere?*
> *Where does the carbon dioxide come from?*
> *What is it doing in our lungs?*
> *What's the connection between respiration and photosynthesis?*

In this way the given pieces of knowledge are elaborated with more properties, they are involved in a number of new processes under various circumstances - some of them introduced for the first time: carbon dioxide is not only found in the atmosphere, but also in animals' lungs. They breath it out as a waste product. Plants use it in order to make their own food. But these new properties and behaviours of the entities do not violate properties and behaviours that have been established earlier for the same entities. Carbon dioxide still remains a gas and behaves like a gas whether or not is circulated through processes like respiration. Also entities which are introduced for the first time, like chlorophyll, have predictable properties and behaviours consistent with the existence (with properties and behaviours) of other entities.

Thing-like and process-like entities have to be recalled by their proper scientific names. Teachers usually ask students to name a whole process by using the proper nominalization for it:

T *What word, did we give to the act of trying to preserve environments or trying to preserve living things within those environments? Somebody else because you've both had your hands up a couple of times I think. Have you answered a question yet anybody else first of all? [] shs, go on then.*

S *Conservation.*

or they ask students to unpack a nominalization and give the processes which are described by it:

T *So, what is weathering, what do we mean by weathering? Natalie / S:...effect of the wind and rain... / T: Right, not, not necessarily wear it away but / S: .... / T: damage it and loosen it so that perhaps the surface looks crumbly. Right, so that's damage, [ ] to the surface of rocks or buildings, stone brought about by things like wind and rain and frost, the different weather conditions, which is why it's called weathering.*

In the same way as in textbooks, definitions of terms are realised linguistically not only as relational processes but as material processes as well. This is the case for defining nominalizations like weathering and conservation above, but also for terms which appear as nouns or nominal groups with a classifier^thing structure; a substantial part of their definition is what these entities can do and what can happen to them or what you can do with them. For example a student's definition of 'peat' and 'peat bog', which is given at the level of what they look like, is not considered as enough by the teacher who elaborates the student's answer with a series of material processes. The latter are the linguistic realisations of how a 'peat bog' is formed, how 'peat' is stored and how it is used:

T *Yep in Wales as well, now then sh sh sh [] a peat bog is formed over, a peat bog is formed over many many years. As the vegetation that is growing there dies ok more vegetation grows to take it's place and a great big layer of dead vegetation of dead plant material builds up ok. It starts to rot to a certain extent but because it's also water logged ok it doesn't rot away completely. [] As it does sort of tend to decay and as this layer builds up it forms what we know as peat. In a lot of areas people go out and they cut the peat. Ok, in ....if you put it in a sack and allow it to dry you can put it on a fire and burn it, it burns like wood or coal on a fire.*

In another lesson knowledge about 'silage' is considered not only in terms of definitions and attributes which describe what 'silage' looks like, but also how 'silage' is formed, how it is stored, why it is used and how. What people do with 'silage' and how they use it as well as its properties and behaviours are thought to be important pieces of knowledge for explaining its contribution to pollution:

T *How many of you have heard just of interest of something called silage.*
S *I've stayed on a farm.*
T *Right what is silage do you know?*
S *Oh I don't know , it's smelly anyway.*
T *It is very smelly. It's grass ok all silage is*
S *They feed it to animals.*
T *They feed it to animals great yes what they will do is to try and get some feed for the animals over the colder months of the year over the winter and so on when they might be indoors. They cut the grass and the grass is put into what is called a silage clump it's basically just a great big pile. They drive tractors up and down it to actually compress and squash the grass down ok and if the conditions are correct, Mahela, then that silage is preserved put plastic bags over it to stop air great big plastic sheets over to stop air getting in. You might see tyres on top of the plastic sheets to keep the plastic down. And the grass will be preserved in there. Come the winter all they have do is go in with a sort of fork thing on the front of a tractor and you can lift great wadges out and use it as a feed for cattle. If you were to get some grass lets imagine you've got a handful of grass and you sort of twisted it round like this what would drip out of it.*

...

T *What actually happens is when the grass is squashed by the tractors going up and down it, ok, all of this green liquid all of this juice gets forced out [] it's only shssh, it's only recent laws that have made farmers install tanks to collect all of this ok. Sometimes though it still gets into rivers [] the juice from grass is more toxic in the river than virtually anything else. If you think about a small town [] the juice getting in from one silage tank from one pile of silage into a river is potentially much more harmful to that river than the pollution that can be produced by an entire town. And the reason is that once the juice* *from grass from silage gets into the river in large quantities it uses up all the oxygen in the river. [] So that any of the life in there that depends on oxygen can't survive ok, so that is one very important pollutant from a farm.*

Living things which are found in rivers and depend on oxygen are in danger if the green substance from silage gets into the river in large amounts because this substance uses up all the oxygen in the river. The explanation of why the green substance which is washed out from silage tanks into a river is more harmful than the pollution that can be produced by an entire town demands a cast of participants like: farm animals, grass, silage clump, silage, tractors, farmers, the juice which forced out from grass, and etc. which behave in a such a way that affects the existence and the behaviour of other participants: rivers, oxygen, living things in rivers, and etc.

6.2.3.3 Discussion

The examples of ideational processes in textbooks and transcripts above show that knowledge about entities (e.g. definitions) can be realised in many different ways at the linguistic level (either as identifying processes or as a sequence of material processes). Looking at the prominent place of material processes in these examples one can notice that material processes realise meaning relations between entities such as what the entities can do, what can happen to them and what they are made of. The latter three dimensions as we have seen above in section 4.5 have been used as the analytical framework in which representations of constructions of entities are grounded.

As it has been emphasised (Ogborn, 1996), construction of entities in teaching science cannot be seen as located in 'reports' as distinct from 'explanations'. On the contrary, it is argued that construction of entities is an essential part of explanations. This is due to the definition of scientific explanation, discussed in section 4.5.4, as necessarily involving the process of constructing and transforming entities and defined as stories. Therefore, in contrast with what Martin claims, descriptions, definitions and classifications of entities should be rather seen as parts of explanations.

In sections 6.2.3.1 and 6.2.3.2, an attempt has been made to exemplify the argument that in the teaching of environmental science realisations of definitions are not necessarily in terms of relational processes. Relational processes are mixed up with material processes in a way that one can hardly see that they realise two clearly distinguished genres found in a relation in which reports are the larger parts and precede explanations. Furthermore, the argument discussed in the last paragraph, that definitions and descriptions of entities should be thought of as explanations themselves since they are about constructions and transformations of entities, leads us in this part of the analysis not to talking about genres, but to looking at the various ways constructions of entities are realised linguistically.

6.2.4 Processes, Participants And Circumstances

6.2.4.1 Grammatical constituents which function as Actors and Goals

As we can see in the examples given previously, ACTORS do not need to be only agents which are living things, like human beings, animals and plants, but can be any sort of entities like substances *the juice which is forced out from grass*, *water*, machines, like *tractors*, natural phenomena *heavy rain*, even systems of living and non-living things *grass, forest*. In the same way GOALS can be living things like *rice, crops*, materials such as *wood*, substances like *oxygen* and also systems of living and non-living things like *soil, rivers*.

Sometimes the same entity participates in various ways in more than one process, so it can be found in more than one clause. And this is because entities usually do not do one thing only or do not have just one property. It is the choices in the text which highlight certain behaviours and attributes of the entities and hide others. So for example in the section *Caring for the soil* certain kinds of human behaviour, like the slash and burn type of agriculture, have been selected in order to represent the effect of people's actions on their surrounding environment. Quite often the same entity appears as ACTOR in one clause and as GOAL in another clause in the same text. Looking at texts which are addressed to older students, like Nuffield Physics (Appendix 4.3), we notice again the same thing. The same entity *carbon dioxide* appears as both ACTOR and GOAL even in the same sentence:

(4) This carbon dioxide will enter the atmosphere and may be taken in by plants once again during photosynthesis.

This	carbon dioxide	will enter	the atmosphere	
and	[" "]	may be taken in		by plants
	ACTOR GOAL	PROCESS	CIRCUMST. of place	ACTOR

It is more often in texts addressed to late secondary school students that we find choices in the text which represent entities as ACTORS in relation to other entities and then as GOALS in another process in relation to the same entities. Cases in which each of the two participants in the same clause are at the same time both ACTOR and GOAL are extremely rare. The latter happens in reciprocal material processes with verb structures like: *oxygen reacts with food releasing energy.*

But what is usually the case is the consistent appearance of representations of entities. Entities do not exchange roles with each other. That is, some entities are found more often as GOALS than others, and these are very frequently the same entities even in very different text structures. In particular substance-like entities like Carbon dioxide, Nitrogen and Oxygen are found more often as GOALS even in very different structures, like passive verb structures without ACTORS and active structures of transitive, material processes. On the other hand living organisms like plants, animals and human beings are found more often as ACTORS.

It is not unusual to think about living organisms as the entities which interact with their surrounding world by doing things. For example people cut down and burn trees, grow crops, and if they are not happy with what they have got they move from place to place in order to find better means for their lives. Animals too eat other animals and/or plants and all of them intervene in various ways in their surroundings. Even unobservable creatures like microbes are also represented as living organisms which are thought of as interacting with other living or non-living organisms in similar ways as observable living things do. Observable non-living things are also participants in the same environment. The main difference between living and non-living things is that the former acting on the latter is realised linguistically in a consistent way by material processes of various forms in which ACTORS are usually living organisms.

What is difficult to make sense of from the point of view of commonsense understanding (see chapter 3) is how the invisible world of non-living entities like gases is involved in the interaction between the environment and its habitats. One way of thinking about the unobservable non-living entities is as if they are participants in the same world which is also shared by living organisms. Then the unobservable non-living things are treated in the same way as the observable non-living things are treated. So in the same way as the observable non-living things appear as GOALS, the unobservable non-living things appear as GOALS too. In other words choices at the linguistic level make us think about the unobservable world - either living or non-living - in the same way as the observable world. This property of 'making the unobservable observable' due to the way things are represented will be discussed in more detail later in section 6.3.2. At this point it should be noticed that association of agency with the nature of entities, as described above is a characteristic of texts which are addressed to young students and not so often for those who are in their last years of the secondary school. As we will see later in section 6.3.1, in the latter case processes are neutralised in terms of ACTORS' actions, and GOALS tend to be fused with processes in what are realised linguistically as nominalized processes.

Quite often entities are represented as nominal groups (see clause (2) in section 6.2.3.1), like *heavy rains, chemical fertilisers, tropical forests,* e.t.c. Most of them have a classifier^thing structure that means that the first term of the group called Premodifier: the classifier *heavy, chemical, tropical* is an attribute that classifies the Head - which usually appears as a noun *rains, fertilisers, forests.* In these cases the classifier indicates a particular subclass of the entity which appears as a category either of things, like fertiliser, or of phenomena, like rain, or of systems of living and non-living things, like forest.

Entities also are found as nominal groups which have an epithet^thing structure like *great danger* and *good flat land.* Epithets indicate some quality of the entities which vary in degree. Even if the epithet *good* indicates a temporal property while the classifier *flat* indicates a permanent one it is not always easy to say whether a property is classifier or epithet. For example we cannot say with a degree of certainty whether the property *flat* classifies a specific sub-category of the Head *land* or whether it is just a property of the land.

Numerative elements appear quite often in nominal groups. In non-technical texts like the section *Caring for the soil* (Appendix 4.1) most of the numeratives are inexact, like *some countries, more and more people, not enough forest, too many people* , *hundreds of years* .

In other cases an entity is realised as a nominal group which is a prepositional phrase. For prepositional phrases like *a patch of ground* (see clause (1)), *a patch of forest* the second noun called Postmodifier classifies the first noun in various ways, it tells us what kind of patch we are talking about. And the first noun the Head imposes a part-whole relation to the entity: we do not talk of the 'whole ground' or 'forest' but only of a part of them. The nominal group here stresses the similarities rather than the differences: that the 'patch of forest' has most of the main properties the 'whole forest' has. But in the case of the 'tropical forest' which has a classifier^thing structure the nominal group stresses differences rather than similarities between entities by defining and at the same time classifying the entity: the 'tropical forest' is a type of forest, which means that it shares many properties with the general category 'forest' but has some special properties which make it different from other forests or types of forests.

Combinations of grammatical forms in nominal groups can represent specialisations and abstractions of knowledge. They specify as far as needed the entities and their roles in processes, leaving out those properties and roles which are thought irrelevant. For example from the beginning of the section *Caring for the soil* we know roughly what the chapter is going to be about and what is not going to be about. And this is due to the nominal group *little good, flat land.* The group which appears in an existential process gives us an idea of what the page will talk about, namely, the agriculture of small areas of land, like terraced hillsides and patches of cleared forest. From the participants which appear in the first two or three clauses, what we do not expect to read about is things like life in the air or pollution of large cities. Also in another page under the title *Soil cycles* in the same book the participant *A group of small animals and plants* and its role in nature which is addressed in the first clause, makes clear that this page is going to talk of what are later called decomposers and microscopic bacteria (see clause (3)), and is not about wild animals in jungles.

The two nominal groups *little good, flat land* and *A group of small animals and plants* do their best to specify as early as possible the entities that will have the main role in the text. And they do that in a simple way because they consist of words familiar to young students, despite having a rather complex structure. The linguistic constituents of both groups are not technical terms but vernacular terms. The first, *little good, flat land* has an indefinite numerative^epithet^classifier^thing structure. The second, *A group of small animals and plants* consists of a nominal group with a deictic^thing structure *A group* which is the Head of the Postmodifier prepositional phrase *of small animals and plants.* The Postmodifier is the part of the group which comes after the Head and defines the category in which the Head is a subset. The prepositional phrase itself is a nominal group which has an epithet^thing1^thing2 structure.

The nominal group *little good, flat land* defines a category of a system of living and non-living things. The other *A group of small animals and plants* defines a category of living things. Both categories are neither generic nor specific. They avoid being generic because of the number of classifiers and epithets which specify the entities that the text is talking about. Neither are they specific because of the lack of technical terms and any reference to specific members of the categories. Specific members of the categories and membership relations appear later when a series of material processes establishes the identity and the things that the members of the categories can do. So for example in the text *Soil cycles* after knowing what this group of small animals and plants can do, namely *help to break down nature's rubbish into smaller parts* , we are told that this group is called decomposers and at the same time we are informed about some specific members of the category, like woodlice, millipedes and beetles. In a similar way in the text *Caring for the soil* after knowing how people's actions make use of *little good, flat land* specific members of this kind of land are named, such as terraced hillsides and patches of cleared forests, and membership relations within the entities of the same category are highlighted.

Nominal groups such as the ones we discuss here do what relational processes can do. Relational processes define and attach attributes to participants. If we look for an alternative way, in terms of the grammatical forms and not the lexical choices, to say what the nominal groups above are talking about, the most suitable way is to choose relational processes. It is very likely that epithets can be represented as attributes while classifiers can be broken into identifying processes. So the nominal group *A group of small animals and plants* might be given as *A group which consists of animals and plants that are small.* But for most of the simpler nominal groups more informational elements are needed in order to change the groups into processes. These elements are not found as linguistic constituents in the group but are hidden in its technical terms. For example if we unpack the nominal group *tropical forest* we need information about the nature of the tropical forest which is carried by the technical term *tropical* used as classifier.

The nominal groups discussed so far consist of nouns and adjectives. Verbs also are found in nominal groups which function as classifiers *burnt trees, flooded paddy fields.* In these cases the entities, which are represented as nominal groups, are the outcome of actions like burning and flooding which causes a change to the already existing in the text entities *trees* and *fields.* If we go back to the material processes from which these nominal groups come from we will notice that trees and fields are the GOALS of the material processes.

We also notice that quite often combinations of classifier^thing structures and prepositional phrases appear, like *the patch of cleared forest*, which make very fine distinctions between entities and allow them to take part in different processes either as ACTORS or as GOALS because of the variety of attributes attached to them. So in the example above the nominal group *the patch of cleared forest* appears as an ACTOR in the process of growing back:

(5) In the meantime the patch of cleared forest grows back.

but the nominal groups *a patch of ground* and *a patch of forest* appear as GOALS in the process of clearing out:

(1) They [people] clear a patch of ground by cutting....
(6) They [people] then move on to clear another patch of forest.

Finally, we notice that nominalized processes can be placed in nominal groups instead of their verb forms, like *the internal transport of chemical, by the decay of dead plants and animals.* The latter as a whole is an ACTOR in the material process

(7) Carbon dioxide is also released by the decay of dead plants and animals...

The *the decay* is the Head of the nominal group while the prepositional phrase *of dead plants and animals* is the Postmodifier which has a classifier^thing1^thing2 structure. What is interesting again here is that the ACTOR is itself the outcome of another action or rather sequence of actions which are carried on by the nominal group.

In this section linguistic realisations of entities in terms of their grammatical constituents have been discussed at the level of functions these entities have in ideational processes. Examples of representations of entities in texts have shown that entities can have more than one linguistic function such as being ACTOR and GOAL. These are the linguistic realisations of what entities can do and what can happen to them. These functions are consistent with the behaviour and properties of entities. Both observable and unobservable non-living entities are more likely to be represented as GOALS in relation to living either observable or unobservable entities. The latter are more likely to be thought of as ACTORS. But as has been illustrated in this section this simple association between a linguistic function and a property or behaviour of an entity is not the case in texts which are addressed to older students. Furthermore, representations of entities in terms of nominalized processes make less clear to the reader or hearer the present and nature of function at the linguistic level and therefore the behaviour of entities is not addressed explicitly.

Nominal groups are more than the linguistic realisations of properties in terms of adjectives. They can accomplish a number of delicate functions such as addressing part-whole relations, classifications and categorical relations. Also nominalized processes as parts of nominal groups can realise actions from which the nominal referred to them have evolved. As a result complicated structures of nominal groups carry a lot of information quite often implied by the function of the grammatical constituents. This explains why so often teachers insist that students should be able to recall what long nominal groups mean, especially when the knowledge carried in these grammatical constituents has been elaborated in many lessons before.

6.2.4.2 Grammatical constituents function as circumstances

Circumstances in the same way as ACTORS and GOALS consist of either one word, like the word *Today* in the clause (Appendix 4.1):

(8) Today, more and more people without any work are moving from the towns ...

or a nominal group. In most cases the nominal group has the form of a prepositional phrase, like *on hillsides* in the clause:

(9) People have to grow their crops on hillsides

Circumstances are the linguistic realisations of locations in place, like *on hillsides* above, of locations in time, representing when something has happened, like *Today* in the first clause above, or the duration of a process. There are also circumstances of purpose like the prepositional phrase *for rice growing* in the clause:

(10) The water changes the soil making it just right for rice growing.

and circumstances which are the linguistic realisations of how something has happened like the adverbial *easily* in clause (2)

All of them have an important role in the text structure. They say where and when things are located, where and when actions are happened, how things happen, what causes certain behaviours and what are the purposes of certain actions.

Looking at the section *Caring for the soil* (Appendix 4.1) in the textbook *Earth in Danger* we have found that the circumstances of place are not of the same kind but that they vary in the degree of defining places at different scales. For example in the beginning of the second paragraph the circumstance *In other countries* defines a very broad category of places in which certain behaviours of entities like *people, heavy rains, water* are noticed. The two circumstances of the second clause in the same paragraph *under water* and *in these flooded paddy fields* without naming any particular place define in a very specific way the kind of places where rice is planted. In doing that containment relations are applied which mean that one location of place is found within another. The location *under water* is placed within the location *in these flooded paddy fields* which is also contained in the location *In other countries.* What we also notice here is that one circumstantial element *In other countries* locates in place thing-like and process-like entities which are found in more than one clause. Participants, processes and various circumstances in the first three clauses of the second paragraph are located within this group of countries which are different from those mentioned in the first paragraph of the text under the circumstantial element *In some countries.*

In a similar way circumstances of locations in time provide a variable like feature which categorises sequences of participants and processes into different groups. The circumstance *Today* is pointing at the different behaviours of people between now and in the past *For hundreds of years.* Circumstances of time also can relate two material processes which belong in two separated clauses, like the circumstantial element *In the meantime* which indicates that when the process *move on to clear* had taken place something else happened: the process *grows back.* In addition, time circumstances can indicate the period of time in which something happens, like how people live for *hundreds of years* or for how long an entity has a certain property, like the entity *soil* being *rich* for *two or three years.*

Looking at the functions of the various circumstances in clauses we notice that each circumstance cannot be seen separately from the functions of the other linguistic constituents in the clause. We also notice that circumstantial elements function close either to thing-like entities, like locating them in place or to a process-like entities, like indicating where something has happened. In most cases it is relational and existential processes in which circumstances are found closer to a certain thing-like entity rather than closer to the process-like entity, like the circumstance *In some countries* in relation to *little good, flat land* in the existential process:

(11) In some countries there is little good, flat land.

On the other hand material processes rather than their participants alone are more likely to be related with circumstantial elements. So for example in the clause:

(9) People have to grow their crops on hillsides

if we look for the circumstantial element *on hillsides* we are not going to ask where crops are found but where people have to grow their crops. It is the act of growing crops which is located on hillsides rather than the crops themselves.

It is clearer to see whether a circumstance is related closer to a thing-like entity or a process-like entity if we look at the interpersonal dimension of texts and transcripts. For example in the beginning of the lesson about the Carbon cycle (Appendix 3.3) the teacher wrote 'Carbon dioxide gas in the atmosphere' at the top of the whiteboard and at the same time asked the students where the atmosphere is. The specific question:

(12) *Where's the atmosphere?*

asks for a circumstance of place *All around us* which locates *atmosphere* . Students' answers were followed by another teacher's question, this time seeking for a circumstance of manner:

(13) *How does carbon dioxide get into the atmosphere?*

But now the question implies that the atmosphere is not the only place in which carbon dioxide is found. In other words carbon dioxide was removed from somewhere else. The place from where it is removed is not questioned yet. The interest so far is in how this gas gets into the atmosphere. In this case the circumstance in question is related with a material process in which the *atmosphere* is involved and it is not related only with the entity *atmosphere* alone. The answer to that is a material process:

(14) *We breathe it out.*

and is not needed to be a circumstantial element, like by breathing it out or by plants' and animals' respiration. The answer above contains a circumstantial element of location in place *out* which draws the distinction between inside and outside. Knowing from what had followed before that question that the outside is the atmosphere all around us what is left unspecified is the inside from which carbon dioxide comes from. This is where teacher's next question is pointed:

(15) *Where does the carbon dioxide come from?*

Circumstances are very closely related either to thing-like entities or process-like entities or both. And even if questions have a specific type, of how something has happened for example, seeking a circumstance of manner, it does not mean that this is what has to follow as an answer. Circumstances also are not constrained semantically by the clause boundaries. 'Atmosphere' is located all around us or in other words outside of us and carbon dioxide is getting into the atmosphere during the process of breathing. From there a semantic relation between participants, processes and circumstances has been built up beyond the clause level and without the need of conjunctions. Atmosphere becomes the location within which another entity is found, that is carbon dioxide. So whether carbon dioxide is in the atmosphere, it is at the same time all around us. The latter relation between us and the carbon dioxide without being addressed to the students is taken as given when the teacher asks where the carbon dioxide comes from.

Looking at more technical texts which are addressed to older students we also notice a considerable number of all kinds of circumstances. But the organisation of the text as a whole has an effect on what kind of circumstances are chosen. For example the section *The Carbon Cycle* (Appendix 4.4) from the textbook *Environmental Science* is structured around the figure of the carbon cycle placed in the beginning of its first page (the whole section is one and a half pages).

As expected because of this choice most of the circumstances that are found in the text are locations in place. These sorts of circumstances do not merely trace out the locations where carbon dioxide is found, saying for example that carbon dioxide is found in the atmosphere, in the green parts of plants in animals blood and lungs, e.t.c. but are closely related to material processes which are the linguistic realisations of how carbon dioxide is transferred from one place to another and what does it do or what has happened to it. As a result these circumstances of locations in place are not of the same kind but they vary according to the process they are related with. For example a circumstance of place can be the linguistic realisation of something which is inside something else, like the compound carbon dioxide in the atmosphere:

(16) The carbon might be thought of as beginning as part of the compound carbon dioxide (CO_2) in the atmosphere.

or of something which is getting into something else because of its action, or is taken into something else, like carbon dioxide which is taken into plants:

(17) This gas is taken in through the leaves of green plants and...

or the other way round, something is getting out of something else because of its action or it is released into somewhere else because of its container action, like carbon found in decomposers is released as carbon dioxide in the atmosphere:

(18) These organisms [decomposers] will use the carbohydrates present in the material as an energy source (by respiration) and so carbon will be released as carbon dioxide in the atmosphere.

or a circumstance is the passage through which an entity passes in order to get somewhere else, like plants that are eaten get through the digestive system of animals:

(19) Plants that are eaten will pass through the digestive system of a herbivore.

or a circumstance can be the place where a participant remains inactive in relation to other participants for a considerable amount of time, like for example when carbohydrates are stored as fat in the body of animals:

(20) From here it [carbohydrate] may be used to provide energy (by respiration) or it may be stored in the body after being converted to fat.

or finally a circumstance can be the place where an entity is active and either being changed or changes another entity, like for example the carbon dioxide in water:

(21) The carbon dioxide may dissolve in water and produce bicarbonate ions which are available to aquatic plants.

The carbon cycle, presented in another textbook called *Air Ecology* under the heading *A cycle of gases* (Appendix 4.5) is structured in a very different way than in the textbook that we have discussed above. It not only differs from the contents and the diagram of *A cycle of gases* , due to how this textbook is used as a whole, but also due to the author's intentions and to what has followed in the chapters before this page. The circumstances which are chosen here are oriented to the context in which this text is placed, the story of the earth. As a result circumstances of locations in time are of special interest, like:

(22) Over 3,000 million years ago...
...about 2,700 million years ago...
Over millions of years...

And conjunctions between clauses which represent how the carbon dioxide gets from one place to the other are in terms of locations in time, like:

(23) Green plants also do this when there is no light.

What textbooks of various sorts either technical or not, and also classroom talk have in common is that the same linguistic constituents exchange roles in different clauses. Plants for example in one clause can be the places in which carbon dioxide is taken in and stored or used in a number of different ways, but in other clauses plants can be the participants, which do things (ACTOR), like making glucose. Animals also can be treated as a circumstances of place in some clauses but in other clauses animals are either the entities which do things or something is happened to them. As we have also noticed in the beginning of this chapter the fact that circumstances can be any kind of nominal group or prepositional phrase in the same way as for example ACTORS and GOALS appear, opens up all possibilities for the function of participant and the function of circumstance to exchange roles with each other in clauses. In the same way as a process-like entity can be represented as a nominalized process, as we have seen in the last section, a location in time can be represented as a nominalized process or as a nominalization that is the linguistic realisation of a process-like entity. So for example we notice circumstances like:

(24) Oxygen is essential for all animal life, including ourselves, in the process called respiration (breathing).

in the section *A cycle of gases* from the textbook *Air Ecology* and also:

(25) The oxidation of carbohydrate during respiration will end in the carbon entering the atmospheric stage of the cycle again as carbon dioxide.

In these cases a process-like entity represented as a nominalization *respiration* is thought of as an event within which another event *oxidation* is located. Even if nominalized processes are made for the purpose of treating an event or a process as a thing-like entity, this is not the case here since the function of the nominalized circumstance serves the role of the location in time and not a location in place.

6.2.4.3 Transitivity

Both transitive and intransitive material processes are found in the two sections *Caring for the soil* and *Soil cycles* from the textbook: 'World in danger-Earth' (Appendix 4.1 and 4.2). In clauses like:

The water changes the soil ...

from example (10),*water* is the entity which brought about the change and *soil* is the entity to which the process is extended. In other words the process extends beyond the ACTOR *water*, to another entity *soil* which is the GOAL of the material process:

The water	changes	the soil
ACTOR	PROCESS	GOAL

As we can see in this example the ACTOR is not an animate entity or a human being not even a living thing, but a substance. We notice that in many cases substances like the one above or natural phenomena such as *heavy rain* or even systems of living and non-living things e.g. *forest* have the function of ACTOR. In the same way GOALS can be living things such as plants *rice, crops*, materials such as *wood* and also systems of living and non-living things like *soil.* There is a question here whether there is a grammatical metaphor or not. Does the role ACTOR requires that the nominal that takes the role has the semantic feature of animate and human or does the nominal acquire that function by virtue of being an ACTOR? According to Halliday (1994, p.111) material processes should not necessarily be concrete, physical events but they can be abstract doings and happenings. Therefore, ACTORS do not need to be only animate agents even if the more abstract the process becomes to be the more difficult it turns to be to identify a participant as an ACTOR and distinguish it from the GOAL. Nevertheless this issue will be elaborated later in this chapter and when the conceptual demands of choices at the linguistic level and what sort of thinking the latter afford will be discussed in section 6.3.1.

ACTORS are not necessarily found only in the first place of the clauses and GOALS are not necessarily placed only in the end. As for other kinds of ideational processes participants can be found in any place in the clause. It is quite often the case that clauses start with circumstantial elements of time or place and participants follow afterwards:

existential:	(11) In some countries there is little good, flat land
material process with:	
a) a circumstance of time in the first place:	(8) Today more and more people without any work are moving from the towns and cities to live in the forest.
b) a circumstance of place in the first place:	(26) In other countries the heavy rains are used for growing crops such as rice

Also ACTORS do not need to precede GOALS. In passive material structures the GOAL is always placed before the ACTOR, like the clause below which is taken from the Nuffield Physics textbook:

(27) Carbon is used over and over again by living organisms.

Carbon	is used	over and over again	by living organisms
GOAL	PROCESS	CIRCUMSTANCE	ACTOR

Quite often passive material structures are without ACTORS at all, like in clause (26) and in:

(28) Rice is planted under water...

Rice	is planted	under water...
GOAL	PROCESS	PLACE CIRCUMSTANCE

In these cases - which will be discussed extensively in section 6.3.1 - agency, particularly human agency, is absent due to the passive structure of the process. But as Halliday has pointed out, in passive material structures without ACTORS we can still ask by whom the process takes place, in other words such structures leave a potential place for ACTORS which have been omitted. 'Planting' is a verb which expects a living human subject.

On the contrary, active material structures in most of the cases have ACTORS but they can either have GOALS or not. In intransitive material processes, ACTORS' action is not extended to another entity:

(29) The forest cannot grow back so fast ...

The forest	cannot grow back	so fast
ACTOR	PROCESS	CIRCUMSTANCE (rate)

Even if both transitive and intransitive material processes are found, most of the clauses are transitive in texts addressed to early secondary students. In the two cases of intransitive processes in the section *Caring for the soil* (Appendix 4.1) one has to do with movement:

(8) Today, more and more people without any work are moving from the towns and cities to live in the forest.

Today...	people	are moving	from...
CIRCUMSTANCE	ACTOR	PROCESS	EMBEDDED CLAUSE

and the other one is the verb structure of growing:

(5) In the meantime the patch of cleared forest grows back.

In the meantime	the patch of...	grows	back
TIME CIRCUMSTANCE	NOMINALIZED PROCESS ACTOR	PROCESS	TIME CIRCUMSTANCE

in contrast with the same verb structure which is used in transitive material processes:

(9) People have to grow their crops on hillsides.

People	have to grow	their crops	on hillsides
ACTOR	PROCESS	GOAL	PLACE CIRCUMSTANCE

As discussed previously, verb structures like these can be transformed into nominal groups, like in example (26):

In other countries the heavy rains are used for growing crops such as rice... Some farmers in Europe use a natural or **organic** system for growing crops...

In these cases of grammatical metaphor an event-like entity such as clause (9), is packed into a nominal group *growing crops* and is treated like a thing-like entity.

Nominalized processes (as mentioned above for clause (7)) are often treated as thing-like entities in texts which are addressed usually to late secondary students:

Carbon dioxide is also released by the decay of dead plants and animals and by the burning of fossil fuels like coal and oil.

In this case the action of releasing carbon dioxide is due to ACTORS which are nominal groups:

the decay of dead plants and animals
the burning of fossil fuels

Deciding whether an entity functions as an ACTOR or as a GOAL in intransitive material processes, is not always easy. For the material processes presented above:

(29) The forest cannot grow back so fast ... and
(8) Today, more and more people without any work are moving from the towns and cities to live in the forest.

we cannot say just by looking at the language whether the forest grows by itself or because of the action of another entity which is external to the forest. In the same way we cannot say whether or not people move by themselves or because of the agency of other entities external to them. Processes of this kind, like growing up and moving, appear in various texts addressed to the whole range of ages. Following Halliday's (1994, p.162) point the question at issue with these kinds of processes is: is the process brought about by itself or from outside? From that point of view we do not just see the relation between a process-like entity and a thing-like entity as one of extension - as has been pointed above - but also as one of causation. What we are looking for is how a thing-like entity is engaged in a process or an event. Is the process *grow back* brought about by the entity *forest*, or by some other entity? At this point we will stick with Halliday's approach which investigates such cases as the one above at a more abstract level. This abstract level of analysis without making any distinction between different kinds of ideational processes, assumes that each process has associated with it one entity which is the key figure in that process. This entity is the "one through the process is actualised, and without which there would be no process at all" - in Halliday's terms. This function is called MEDIUM and represents the entity through which the process comes into existence. In our examples the MEDIUMs are *the forest* and *more and more people.* The MEDIUM represents the entity which participates directly in the process or event:

the forest	grows back
...people	are moving
MEDIUM	PROCESS

We will come back later to this kind of process for which it is not easy to decide whether their one participant is an ACTOR or not. We will also introduce some other categories of material process which differ from those which are about actions. At the moment we should also notice that in the spoken mode as well there appear clauses in various contexts which are recognised only at this basic level of MEDIUM/PROCESS structure:

T Yep in Wales as well, now then sh sh sh [] a peat bog is formed over, a peat bog is formed over many many years. As the vegetation that is growing there dies ok more vegetation grows to take it's place and a great big layer of dead vegetation of dead plant material builds up ok. It starts to rot to a certain extent but because it's also water logged ok it doesn't rot away completely.

the vegetation	dies
more vegetation	grows
a great...materials	builds up
it [vegetation]	doesn't rot away
MEDIUM	PROCESS

6.2.5 Part-whole and part-part relations between material processes

Sequences of material processes are present not only as part-part relations, where one clause precedes the other, as in the clause complex presented earlier (Appendix 4.3):

(4) This carbon dioxide will enter the atmosphere and may be taken in by plants once again during photosynthesis.

This	carbon dioxide	will enter	the atmosphere	
and	[" "]	may be taken in		by plants
	ACTOR GOAL	PROCESS	CIRCUMST. of place	ACTOR

but are also present as part-whole relations where for example one clause is embedded in another. Embedded clauses, referred to by anaphoric elements, can contain more than one process and they constitute a participant (usually an ACTOR) for the process in which they are embedded:

(8) Today, more and more people without any work are moving from the towns and cities to live in the forest.

(30) This puts the land in great danger because there are just too many people and not enough forest.

[Today... forest]	This	puts	the land	in great danger	because...
EMBEDDED PROCESS	DEICTIC ANAPHORA ACTOR	PROCESS	GOAL	CIRCUMST. QUANTITY	CAUSAL CLAUSE

The sentence *Today, ... forest.* referred to by the deictic anaphoric element *This*, is embedded into the next sentence *This puts ... forest.* The deictic *This* is the ACTOR of the abstract process which puts the land in great danger. The material process is abstract because literally there is not any entity which is placed somewhere else: it is as if the land is placed in a situation that makes it vulnerable. In this new situation things can happen that have an effect to the land. The ACTOR also is not a concrete entity but is abstract as well in a sense that it is people's actions which put the land at risk. At the end what is the outcome of this part-whole relation between clauses is that the abstract material process *puts the land in great danger* does not connect literally one thing-like entity with another but a whole range of processes *people are moving from the towns and cities to live in the forest* with a participant *the land*, which even if it appears linguistically as a single entity is a system of living and non-living entities.

Part-whole relations between clauses are one of the textual realisations of how an explanation is constructed. In these cases, like the one that we have seen above, a phenomenon might be explained as an outcome of a series of actions in which specific entities are involved. At the ideational level this series of actions is realised as sequences of material processes. We should notice here that scaffolding of explanations appears to be only partial if we look them in a short piece of text, because they are usually built up continuously at various places in a textbook. Going back to our example above we could still ask why the gathering of many people puts the forest at risk, if we just stop at the two sentences presented in the table of the previous paragraph. People's actions and the effect of them on their surrounding environment are discussed in the paragraphs before in the section *Caring for the soil*.

Depending on what is given and what is new in relation to the didactic choices of the writer/s of the textbook, an explanation might be found at the level of how something has happened and might be developed later at the level of why something has happened. For example this is the case for the explanation which is built up in the following piece of text from the section *Caring for the soil* (Appendix 4.1):

Some farmers in Europe use a natural or **organic** system for growing crops. They use animals such as pigs to eat the remains of the old crop. The pigs add their dung. This **fertilizes** the soil...

Natural fertilisation is explained at the level of how it has happened and not at the level of why people are using organic systems for growing crops. At the textual level the explanation is constructed as an exemplification of what might be meant by a natural system of growing crops. The example is carried on by a series of embedded clauses. Probably because the piece of text is short, there is no need for conjunctions between the clauses. The latter are connected to each other by anaphoric elements. The two anaphoric elements are of two kinds: the *they* of the second sentence is an anaphora to the ACTOR *farmers* and the deictic *this* of the last sentence is an anaphora to the whole previous clause: *The pigs add their dung.* Again what is interesting here is that a whole embedded clause referred to by the deictic *this* becomes an ACTOR in a transitive, material process: *This **fertilizes** the soil.*

Embedded clauses such as the one above may be found also in cases of cause-effect relations. A whole clause may be embedded as a deictic anaphora in another clause. The embedded process and the clause in which it is embedded are causally related even if both clauses are not realised linguistically as causal clauses. In the same chapter we notice:

People living in tropical forests find ways to live off the land. They clear a patch of ground by cutting down the trees and burning them. This makes the soil rich for two or three years.

People's actions have an effect on the soil. The soil is made rich for two or three years. This cause-effect relation is realised as a material process *This makes the soil rich for two or three years* in which the ACTOR is a material process itself: *They clear a patch of ground* and a series of nominalized processes: *by cutting down the trees and burning them.*

Sequences of material processes which are not accompanied by circumstantial elements of time confuse the reader whether the two or more events take place at the same time or one follows the other. Conjunctive elements like *and* can receive two different interpretations: that the two events are going together or that the one has to precede the other in a sequence. The confusion becomes worse when one of the participants is the same for both processes. If there is only one ACTOR which is the agent of two material processes, like in the case below, we cannot say for sure whether the same ACTOR *microscopic life* does two jobs *rots down dead animals* and *makes carbon dioxide* at the same time or one after the other:

(31) Microscopic life rots down dead animals and makes carbon dioxide gas.

Microscopic life	rots down	dead animals
	makes	carbon dioxide gas
ACTOR	PROCESSES	GOALS

With abstract ACTORS, like *microscopic life*, which represent a whole cluster of instances, thus concrete entities, and appear as categories of entities, it is hard to say whether the same entities are involved in both processes at the same time or different instances of the same category do different things at different times.

Part-whole relations between clauses described as embedded clauses are the linguistic realisations of sets of relations between entities. These sets of relations get more complicated when the entities involved not only are represented as simple thing-like entities - even if they are entire material processes - referred to by anaphoric elements and nominalized processes, but function in the same way simple entities do, that is like ACTORS and GOALS. As a result, the comprehension of material processes such as *This fertilizes the soil...* and *This makes the soil rich for two or three years...* even if it seems at the first place that they have an easily comprehended structure of material process in terms of 'A does something to B', demands the implementation of knowledge about the entities involved which is not present in the material process itself.

6.2.6 Material processes as they interact with other systems of representations.

Almost all material processes of a very technical text *The Carbon Cycle* (Appendix 4.4) addressed to late secondary students use verbal groups in the passive voice. Even mental processes are in passive voice, like:

(32) This is represented diagrammatically in fig. 3.16.
(16) The carbon might be thought of as beginning as part of the compound carbon dioxide in the atmosphere.

Passive structures of material processes, as we have also seen earlier, may have ACTORS, like:

(33) The carbohydrates may be used by the plant as a source of energy for its life processes.
(34) In this case, the carbohydrate will be oxidized by a process known as respiration.

ACTORS can be either entities, like living organisms *plant* or nominalizations like *respiration.* The latter is a case of highly abstracted process (cases like these will be discussed later in more detail in section 6.3.1) in which agency is suppressed significantly for two reasons: the process itself is realised linguistically as an indirect action because of the passive form, and the agent is a nominalized process. As a result in the material process (34) above, a whole process *respiration* is the participant (ACTOR) of another process *oxidized.* The latter is also part of the process described in the previous clause, because of the deictic anaphoric element *In this case.* The same nominalization *respiration* is a direct ACTOR in the following example in which GOALS are classified into two categories those which are waste products like *carbon dioxide, water* and those which will be used by the plant like *energy:*

(35) This process releases energy - and carbon dioxide and water as waste products.

But most of the passive material structures are without ACTORS which are taken as self-evident, constructed earlier in the text. So for example for processes like:

(17) This gas is taken in through the leaves of green plants and is converted into carbohydrates, ...
(19) Plants that are eaten will pass through the digestive system of a herbivore.
(36) Much of the carbohydrate will be absorbed into the animal's blood system.

ACTORS have been noticed before in the text which talks about the flow of energy in living systems (Appendix 4.6). But this does not deny the fact that the choice of not making any reference to ACTORS again, is an option which suppresses agency and puts more emphasis on the outcome of various processes or in other words the effect of these processes on GOALS. So instead of active structures in which animals eat plants and absorb carbohydrate into their blood system, a sequence of part-whole relations of passive structures shows what has happened to both living and non living organisms. This is one of the main differences between the text the *Carbon Cycle* (Appendix 4.4) and the texts that have been discussed in sections above (Appendix 4.1 and 4.2). In these texts non living, unobservable entities like carbon and carbon dioxide are represented linguistically as GOALS. On the contrary living organisms both observable like animals, plants and unobservable like decomposers are represented in most cases as ACTORS involved either in active or passive structures. But in this text choices at the level of linguistic realisation make other sorts of classifications. And this is due to the context in which this text is placed: every thing-like entity is seen as a source of energy and process-like entities show this flow of energy from one thing to another.

Looking a few pages before the section *The Carbon Cycle,* we notice that it is part of a chapter under the heading *Natural Systems* (see Appendix 4.6). This section begins by representing the various processes involved during the flow of energy in living systems. This is where we will find why both living and non-living participants are taken as GOALS. In order to represent the flow of energy from one participant to another this chapter makes use of three systems of representations: verbal texts, diagrams, and chemical equations. For the purpose of our analysis at this stage we will look at the first two of them: texts and diagrams.

What we notice from the direction of vectors of the three diagrams (Appendix 4.6) is that they do not represent what one participant does to another participant but what goes from one participant to another. If the direction of the vectors were the other way round, pointing for example from secondary consumers to primary consumers, then active material structures would have been chosen in the text, like 'the fox eats the rabbit', instead of passive material structures. But this sort of convention does not show anything about the flow of energy. If both kinds of vectors' directions were used in order to represent both direct agency and flow of energy, then this device would have been rather confusing, given the fact that there should have been two kinds of diagrams which contradict each other because of the directionality of their vectors. Otherwise, another kind of diagram would have been devised in order to represent both processes, but this might have been thought too complicated.

The convention that is finally chosen represents two processes at the same time: energy is transferred from one entity to another and at the same time one entity is eaten by another. The latter have to be realised linguistically in the text as a form of passive material structure, like something is eaten/taken by something else, otherwise diagrams and text will contradict one another. So what we are trying to point out is that choices at the clause level are not only inherently constrained, but in some cases it is the interaction between different systems of representation which leads to choices of certain options.

We cannot pass unnoticed the fact that the chapter *Natural Systems* establishes processes as things from its very first pages. There are mainly two places where we can find large amounts of grammatical metaphor. In the first the text deals explicitly with grammatical processes, given that things which are represented linguistically as nouns *movement, transport, communication, production, removal* are called: "life processes". In the second, processes that have been represented as passive material structures in the text, like *is egested, is excreted* appear later as nominalizations *excretion, egestion.* These grammatical metaphors are needed for the description of more complicated processes in which the nominalized processes participate in various ways, either as ACTORS or GOALS or circumstances. Take for example the process *photosynthesis* in the clause complex:

(37) Sugars are the most commonly made (synthesised) material formed by photosynthesis and the simple of these is glucose.

in which it is the ACTOR of the clause *Sugars... formed by photosynthesis.* Photosynthesis treated linguistically like a thing, is a nominalized process which is also located somewhere, like things do:

(38) This is a process [photosynthesis]that occurs in the green parts of plants.

6.2.7 Material processes of doing, moving and transforming

Another difference between the text *The Carbon Cycle* (Appendix 4.4) and other texts represented above (Appendix 4.1 and 4.2) is that in the former the entity carbon is transformed into other entities by going through various material processes in relation with circumstances of different places. So for example carbon in the atmosphere is only found as a part of the compound carbon dioxide and is never found in carbohydrate molecules. Carbon in living organisms, dead organisms, and non living things is always found in carbohydrate molecules.

A variety of material processes represent how carbon is transformed from being in carbohydrates to being a part of the compound carbon dioxide and vice versa when carbon is transferred from one place to another. In particular when carbon is taken into plants from the atmosphere it is converted into carbohydrates. In plants it can be used in different ways like being an energy store or being used in building plant cell walls e.t.c. If the plant is eaten by an animal then much of the carbohydrates are absorbed and they are either stored as fat or egested as waste e.t.c. But either in plants or in animals the part of the carbohydrates which is oxidized during respiration is released into the atmosphere as part of the compound carbon dioxide.

Thus entities are involved in an interactive system of relationships in which one has an effect on the other. Linguistically, options in representing one of them constrain options for the representations of the rest of them. A specific process demands specific choices for the participants involved and also specific circumstances. But this does not mean that options are hierarchically ordered. Clause complexes in terms of embedded participants and processes, indicate that options are not sequential but emerge as a whole in an interactive system of relationships. As a consequence processes, participants and circumstances cannot be seen separately but each characterises the existence of the other constructing as a whole a package of options which determine options at the ideational level.

Halliday (1994) has developed some more specific categories of participant functions along the lines of the participant functions which are directly involved in material processes: the one that does, mental processes: the one that senses, existential processes: the one that exists, e.t.c. These categories of participant functions represent semantically a close relationship between the process and its participants. For example the 'beneficiary' function in material processes is for the participant to whom goods are given. In the clause "gave the parcel to John", John is the RECIPIENT that is the participant which receives goods (Halliday, 1994, p.145). In the text *The Carbon Cycle* that we are looking at we could say that 'energy' is treated like a thing which is released out of a process and is taken as a 'good' by RECIPIENTS such as plants, animals and human beings. 'Carbon dioxide' is also treated like a GOAL which is either given ('released') or taken between different RECIPIENTS.

Notice also that not all material processes are of the same kind. Some processes are in terms of doing, where one entity does something to another one, like:

(39) The carbohydrate that is not absorbed from the digestive system will be egested as waste.

In that case even if we don't know the ACTOR, we know what has happened to carbohydrate which is not absorbed: it is egested. Some other processes are material processes in which one entity acts in a way that transforms another entity, like for example in the clause:

(17) This gas is taken in through the leaves of green plants and is converted into carbohydrates, ...

the process *converted* shows that the entity *gas* is not the same as it was before the process in which it is involved. The entity (gas) has been transformed into another entity (carbohydrates) even if the text does not specify the nature and the extent of this transformation. On the contrary if we take the process *is taken in* alone, which precedes the one in which gas is transformed, it seems that nothing has happened to the gas in terms of action. The entity is transposed through a medium, which appears as circumstance of place, without being able to say if it is transposed by itself or by another agent. Looking at both processes in a clause complex above, in which one entity is represented as GOAL and two material processes are joined together with the part-part conjunctive element *and,* we come out with the difficulty of deciding whether the two processes take place at the same time or one precedes the other in a sequential order.

We are faced quite often with the problem of deciding whether two clauses have to be taken together or analysed separately in such condensed and technical texts. To take another example, we cannot decide whether we could consider the process *will pass* as a process which shows just transposition or whether transformation is involved at the same time in the clause complex:

(19) 1 Plants that are eaten will pass through the digestive system of a herbivore.

In other cases one and the same process may have two interpretations at the same time. For example the process *release* in the clause complex:

(35) This process releases energy - and carbon dioxide and water as waste products.

seems to involve two sort of actions at the same time: the entity carbon is transformed somehow from being part of carbohydrates in plants to be part of the compound carbon dioxide in the atmosphere. Contextual information which is formed in another system of representation, like the chemical equation following this clause complex, facilitates significantly our effort to identify the process which otherwise remains obscure just from its linguistic realisation.

These findings suggest that linguistic categories such as material processes are very general indications of semantic functions and should always be considered in close relation with knowledge implemented in the grammatical constituents of participants and circumstances. The three linguistic realisations of the ideational metafunction (process, participant and circumstance) have to be seen as the interactive elements of a whole package. It is also the clause complex which is found at various scales at the textual level which indicates the difficulty of identifying the function of a process or a participant by just looking at the clause level. Moreover the fact that the text as a whole interacts with other systems of representations, like diagrams, suggests that contextual information which comes from various systems of representations cannot be neglected because it is conflated with the text.

6.2.8 Grammatical metaphor

6.2.8.1 Defining Grammatical metaphor

As we saw previously processes are not always represented as verb structures but quite often are represented as nominal groups. These nominal groups (Appendix 4.3) might have either a simple form consisting of one noun only, like the nouns *growth* and *reproduction* in the clause:

(40) Some of the carbon that the decomposer has eaten will be used in growth or reproduction by that organism.

or a classifier^thing structure like the nominal groups *repeated uptake* and *repeated release* in the clause:

(41) This repeated uptake and release is part of the carbon cycle.

or a more complicated structure which consists of a head *the decay* a postmodifier, prepositional phrase *of dead animals and plants* and a classifier *dead*, like the noun phrase *the decay of dead animals and plants* in the clause:

(42) Carbon dioxide is also released by the decay of dead plants and animals and by the burning of fossil fuels like coal and oil.

In a scientific text grammatical metaphors are most often nominalizations (Halliday, 1994, p.352). Nominalization is a process (itself) which characterises the historical development of scientific language in which processes become nouns and are treated as nouns. In textbooks and lessons what is happening is rather the other way round: nominalizations for didactic purposes are usually unpacked into processes, but nevertheless they are still treated as such whenever they are thought to be given or whenever a process or a series of processes has to be recalled by name. In the present thesis grammatical metaphors are not only thought to be nominalizations as they are defined in the historical development of scientific language, but any kind of grammatical transformation, thus the unpacking of nominalizations as well.

6.2.8.2 Grammatical and lexical metaphor

The definition of grammatical metaphor makes it clear that metaphors can be considered to be something more than a mere replacement of a lexical selection or wording (Halliday, 1994, p.341). In most of the examples of the grammatical metaphors above, in only a few cases is lexical transformation involved. These are the cases of the nominalizations *photosynthesis* and *respiration* as they are elaborated in the classroom. But even for these cases grammatical transformation is involved at the same time with the lexical replacement. For example *respiration* is not just replaced by other wordings like *breathing*, but grammatical transformation is involved at the same time; animals which breath in oxygen and breath out carbon dioxide, by releasing energy at the same time:

> *T: : No, the oxygen I just breathed in is probably still going round in my blood stream and the carbon dioxide I'm breathing out is from some oxygen I breathed in a little while ago. Right, OK, so the animals breathe out carbon dioxide during the process that we call res / S: res... / T: Respiration [ ] good and that's the process where we release energy from the food that we've eaten by breathing in the oxygen, the oxygen goes all round our bodies in the blood stream.*

Nominalizations do not always need to be accompanied by lexical replacement. For example there is no lexical replacement involved in the metaphor *burning* in the clause below:

(42) Carbon dioxide is also released by the decay of dead plants and animals and by the burning of fossil fuels like coal and oil.

On the other hand for processes which appear as nouns or nominal groups lexical replacement is very rare. Here process-like entities such as: *plants grow* and *carbon dioxide is released*, are represented not as processes but as thing-like entities.

6.2.8.3 Two examples of text structures
Grammatical metaphor in the overall text structure

Comparing the two sections *Soil cycles* and *A cycle of gases* from two different textbooks (Appendix 4.2 and 4.5), we notice that the latter is more condensed in terms of the number of the embedded processes which follow one another and the number of nominalizations and nominalized processes. Two of the most condensed paragraphs are ones which elaborate the nominalizations: *photosynthesis* and *respiration*. In the second paragraph a sequence of anaphoric elements which make reference either to thing-like or process-like entities, constitutes a complicated structure of embedded clauses. This complicated sequence ends up with the nominalization: *photosynthesis*. On the other hand the third paragraph introduces the nominalization: *respiration* and its substitute term: *breathing* in parenthesis, in the beginning so what follows is an elaboration which unpacks the nominalization.

The diagram of the Carbon cycle which is placed at the bottom of the section *A cycle of gases* is also different from the picture-like diagram of the section: *Soil cycles*. Linguistic elements of the former are names of thing-like entities: *plants, animals, carbon dioxide, fossil fuels* and process-like entities. But in contrast with a picture-like diagram, processes are represented as thing-like entities too, that is nominalizations: *respiration, burning, photosynthesis* and nominalized processes: *decay*. Few circumstantial elements accompany either things or nominalized processes, like for example: *CARBON DIOXIDE in air and water.*

Texts also become more condensed without necessarily getting grammatically more complicated in another way: the more highly organised the structure of the textbook is - as it happens with those which are thought to be suitable for the late secondary students - the larger the amount of knowledge treated as 'given', which appears in a number of earlier sections. Things are not re-explained. In particular, for phenomena like the cycles of life which demand quite a lot of given knowledge in order to represent them as a whole, highly organised texts contain many nominalizations often left unpacked because they are considered as given. The extensive use of grammatical metaphor adds to the degree the text is condensed; there are more processes with at least one participant which is a nominalization or nominalized process rather than processes in which participants are single thing-like entities.

6.2.8.4 Some possible implications of the use of the Grammatical metaphor

In the examples discussed in this section (6.2.8) as in many other examples discussed in earlier sections, an action can be represented as a thing and functions at the linguistic level as a thing in relation to other processes and things. Grammatical metaphor breaks the typical ways of saying things, in terms of choices which can be about the selection of process type, the participants and the sequences of group/phrase clauses. The interest of this thesis is in the effect the way of talking - referred to as a metaphorical way of talking - has on representations of entities in specific contexts, of the teaching of environmental science.

The effect of grammatical metaphor on both text and meaning is that an action can be suppressed but the text becomes more 'economic'(in grammatical terms) and the action can now be in a role that it couldn't play before, like being a participant, classified with properties and connected with other nominalized processes. New possibilities for meaning relations are opened up (e.g. one process acting on another).

An effect of grammatical metaphor on reasoning as noticed in classroom observations, is the larger cognitive effort which is demanded from students. Extra (mental) work is needed from students to trace the presence of ACTORS which appeared often long before the nominalized processes in which they are involved and are now absent. The cognitive demand of memorising knowledge in a flexible way so that associations with new knowledge can be possible, is increased with the presence of grammatical metaphor. But probably the most important demand grammatical metaphor imposes on reasoning is 'reading (a text) behind the lines'. An entity represented as a thing and also represented acting as a thing is not a thing but a process. The hearer or reader is called on to 'unpack' the nominalized process and then carry on to comprehend a new meaning by treating it as a 'package' of knowledge, that is a concept-like entity, and not as its linguistic realisation implies, as a thing-like entity.

An indication at the interpersonal level of the more cognitive demands the presence of grammatical metaphor presupposes from the hearer/reader, is that as already stated, texts which contain a large number of grammatical metaphors are addressed to older students. Also classroom observations have shown that the presence of grammatical metaphor fails to pass unnoticed by teachers. The latter are very persistent either in asking students to unpack nominalized processes or to get students used to their presence and role by calling on students to name processes correctly by their nominalized grammatical form.

6.2.9 Conclusion

The analysis shows that aspects of the interpersonal dimension of teaching environmental science are inseparable from aspects of the ideational dimension. For example, texts which are addressed to older students are more likely to contain nominalized processes and nominalizations than those which are addressed to younger students. Aspects of the ideational and interpersonal dimension are also related with aspects of the textual dimension. In addition to the previous example, the extensive use of nominalized processes is accompanied with a textual cohesion which is characterised by embeddedness. These findings are not in contrast with what Halliday (1994) asserts, namely that for any linguistic element choices in one of the three metafunctions affect choices in the other two. They are also in accordance with what Lee (1992, p.11) has argued that there is an interpersonal aspect in grammatical choices such as passivisation. But in the specific context that we are looking at one should ask further the extent to which choices in one dimension bring with them conscious decisions (at any level, e.g. national curriculum, educators and academics, publishers and textbooks' authors, schools' policies and teachers) about choices in the rest.

6.3 Metaphorical representations of entities

6.3.1 Suppressed agency - Abstracted material processes

6.3.1.1. Active and passive structures of material processes

Both linguistic elements and texts in the section *Soil cycles* (Appendix 4.2) consist of material processes in which the two gases: Carbon dioxide and Nitrogen appear always as GOALS. By contrast participants like living organisms and their specific categories like plants, animals, decomposers and bacteria always appear as ACTORS:

(1) Plants can use these chemicals to grow.
(2) Bacteria turn nitrogen into chemicals.
(3) Microscopic life rots down dead animals and makes carbon dioxide gas.
(4) Plants re-use this carbon to grow.

It is also interesting to notice that gases appear as GOALS in passive structures of material processes:

(5) It [nitrogen] gets changed into useful chemicals by lightning, bacteria and some plants.
(6) Carbon is returned to the soil by **decomposers** and to the air as carbon dioxide.

Both active and passive structures of material processes above in which gases are involved are transitive and they all have ACTORS. But this is not the case for all textbook material even for the same topic. Looking at the same topic in another textbook called *Air Ecology* (Appendix 4.5) gases like Carbon dioxide and Nitrogen are again always realised linguistically as GOALS in either active or passive material processes. The variety of ACTORS includes not only subcategories of living things, but superordinate categories, like systems of living things: *oceans* and also nominalizations like: *swirling, burning, decay.* But there are some passive material processes which do not have ACTORS:

(7) This is called photosynthesis and is very important since oxygen is released as a result.

In this case we do not know if the processes packed under the nominalization: *photosynthesis* are the ACTORS which release oxygen or if these processes are not ACTORS but are involved as circumstances in the process which releases oxygen, or if the ACTOR is the same as the ACTOR of the processes which precede the nominalization, that is the *plant,* or if the oxygen itself is both ACTOR and GOAL.

In another case it seems that the ACTOR of the passive structure is reduced to a causal circumstance:

(8) Over millions of years the amount of oxygen in the atmosphere steadily built up because of the green plants.

or the ACTOR might be implied from what follows. For example in the sentence below:

(9) This is when oxygen is taken into the body and carbon dioxide is released in return.

one can not say if oxygen is taken into the animal by itself or because of the animal's action. It is the following sentence which makes reference to the whole processes above with the anaphoric element *this* and the additive elaboration of the conjunctive element *also* which implies that in the same way as green plants are the ACTORS of all these processes packed under the anaphoric element *this,* animals must be the ACTORS for the same processes too:

(10) Green plants also do this when there is no light.

Finally in cases like the one below, ACTORS simply can not be identified:

(11) ...carbon dioxide is passed between the air, plants, animals and the oceans.

Analysing the text *What happens to carbon during decomposition?* (Appendix 4.3) from one of the Nuffield Physics textbooks appropriate for students who are in Years 9 we notice the amount of nominalization the text contains and its highly organised text structure. Phenomena like photosynthesis, respiration, reproduction, decomposition have been constructed in earlier sections and it appears to be assumed that there is no need to go back and recall their meaning. Furthermore these phenomena are seen in a new context of meanings, that is to say, what happens to Carbon during decomposition. So the processes represented as nominalizations are both left unpacked and are involved in other processes as circumstances, like:

(12) Carbon enters an organism either as carbon dioxide during photosynthesis or in its food.

or are placed within nominalized processes which are represented as nominal groups:

(13) There are three ways in which [carbon] can leave the body of an organism (see figures 15.12 and 15.13):

(14) **a** by being released as carbon dioxide - a waste product of respiration...

Carbon and carbon dioxide are found as ACTORS only in intransitive material process. But even in cases such as (12) and:

(15) This carbon dioxide will enter the atmosphere and may be taken in by plants once again during photosynthesis.

apart from the fact that carbon as an ACTOR does not act on something else, we do not know just from the linguistic realisations of the processes if carbon is the agent which moves itself or the affected which is moved. The same sort of ambiguity has been described in section 6.2.4.3 in terms of a MEDIUM/PROCESS structure. The latter can be seen quite clearly when carbon leaves the body of an organism:

(16) There are three ways in which it can leave the body of an organism (see figures 15.12 and 15.13):

The intransitive material process in which carbon is linguistically supposed to be an ACTOR is transformed into three processes in which neither carbon or carbon dioxide appears as an ACTOR again. On the contrary in the first two processes both carbon and carbon dioxide are GOALS in passive material structures without ACTORS:

(14) **a** by being released as carbon dioxide - a waste product of respiration.

(17) **b** by being released as a waste product like urea which also contains nitrogen

The third one is the nominalized process of how carbon enters decomposers:

(18) **c** by entering the decomposer which feeds on the body of the organism after it has died

It is also interesting to see that at the end of this text the dominant passive material structures in which carbon is either released or has been taken in, now themselves become nouns:

(19) This repeated uptake and release is part of the carbon cycle.

Again this is a case of grammatical metaphor which is unfolded from example (12) up to (18) and results in a nominalized form in clause (19); material processes like *take, release* which are developed in the text are transformed into nouns *uptake, release.*

It is also interesting to point at a level of abstraction reflected in language that was not found in the texts (e.g. 'Soil cycles') discussed above. The diagram of the carbon cycle which is at the bottom half of the page (Appendix 4.3) is different from the diagrams of the texts that have been previously analysed. Participants are pictured without being named, except carbon dioxide in the atmosphere and litter and dead organisms below the ground. Processes represented as vectors between participants are accompanied by linguistic elements which are not material processes as in the text *Soil cycles* but either nominalizations such as *decomposition,* like those which are in the diagram of the text *A cycle of gases* or nominal groups composed by a noun and a nominalization. The latter has a Classifier^Thing structure where the Thing is a nominalization and the Classifier represents the agent of the nominalized processes *plant respiration, root respiration, animal respiration.* This is probably due to the fact that processes are not represented as such (look for example in text *Soil cycles*) but as nominalizations, and participants like plants, animals, decomposers and roots are not named (as in text *A cycle of gases*) but just pictured. As a result in order to distinguish processes which are nominalized under the same nominalization *respiration*, named participants in front of it classify the different kinds of respiration.

6.3.1.2 Linguistic realisations of abstraction

As illustrated above, moving from texts which are addressed to young students to texts which are addressed to older students, we find more often passive material structures instead of active material structures. This is a step towards to more indirect material processes. Even if grammatically the same material process can appear either passive or active without changing the participants such as in clauses (2) and (5), passive structures put at the first place the GOAL (e.g. nitrogen), in contrast with active structures which put at the first place the ACTOR (e.g. bacteria). If the GOAL is placed first then this is the THEME of the text, and therefore the entity which the clause is talking about - a grammatical phenomenon called thematization (Fowler et al, 1979, p.208). So if GOALS are the THEMES in a text then the emphasis is put on those entities to which something has happened. On the other hand if the THEMES are ACTORS then the emphasis is put on what the ACTORS can do to other entities, thus actions. As underlined in section 6.2.4.1, the entities which most often appear as

GOALS are observable or unobservable and non-living, while it is observable or unobservable living entities which appear as ACTORS.

Active structures are more experiential, they force us to look at the world through what the ACTORS do. Passive structures force us to look at the world through GOALS, in other words they seem as if they report actions which have happened and are now finished. So passive structures are indirect because they represent actions in some distance by giving first the effect of these actions rather than what causes them.

Furthermore, it is the passive structure that permits clauses without ACTORS. In such structures we know that something has happened to a participant but must recover for ourselves what causes this action. Passive structures without ACTORS are a step forward to more abstracted forms of representing knowledge. Actions are reduced significantly and processes become more nominalized as in cases from example (12) up to (18). From there the next step to more abstracted processes is when the process is transformed into a nominalized process (19). As has been discussed above, in these cases the process is packed into a nominal group which usually has a classifier^thing structure which is involved as a participant in other processes. In other cases the whole process is nominalized under a noun. More complicated text structures in terms of embedded clauses (see section 6.2.5) contain processes within processes, in other words processes within various levels of abstracted forms of process. Thus we can notice different levels of abstraction which are realised linguistically by different forms of abstracted processes. Starting from the more direct actions to processes which involve less direct actions one can see realisations of abstracted actions such as:

-active verb structures of material process: either transitive or intransitive
-passive verb structures of material processes with both: ACTORS & GOALS
-passive verb structures of material processes without ACTORS
-nominalized processes and nominal groups
-nominalizations

We should also notice that the more abstracted the process is the more information is carried by circumstances, such as circumstances of place, time, and cause. It seems that in more technical texts, in terms of the grammatical structure, circumstances take a central role while processes are reduced to the role of participants.

The relation between abstraction and patterns of grammar in science textbooks has been studied recently in a number of studies for different purposes. Martin (1989) in his study of Geography textbooks has discussed the differences between everyday language and scientific texts looking at the grammatical differences. According to Martin, a scientific text is characterised by what he calls 'the grammar of abstraction'. Abstraction is not only attributed to the choices of words which represent concepts and categories of things instead of material entities only, but also to the grammar of the text. The latter codes reality as a set of relationships between things rather than processes (Martin, 1989, p.40). This is realised from the foreground of relational clauses at the expense of material ones and at the same time from the foreground of the nominal groups at the expense of clause complexes (Martin, 1989, p.43).

Schleppegrell (1997) has shown the possible ideological and learning implications of the lack of explicit Actors in teaching materials. Schleppegrell has identified three ways in which the presence of the Actor can be omitted. One is by the use of ergative-verbs. These are what has been described above as a grammatical structure of a MEDIUM/PROCESS in which it is not clear whether the only participant through which the process is (actualised) conceived is an ACTOR or a GOAL. Nominalizations and nominalized processes are another way of excluding ACTORS from the representation of processes. And finally, the use of generic and indeterminate agents such as 'people', 'human' and 'we' has the effect that even if grammatically ACTORS are present they are neither specified nor named.

The ideological consequences of the choices of the three types of grammatical structures above is that the role of specific actors and institutions is suppressed in representations of environmental issues such as *the result from loss of habitat, upsetting ecological relationships and reducing the ecosystem's ability to perform services like food control, water purification and nutrient recycling, is the loss of homes for animals.* The use of non-human agents results in the disengagement of any human responsibility with the processes and causes of environmental problems (Chenhansa, 1998, p.56). Kress (1989, p.57) also has shown that both the retreat into an institutional impersonality and the retreat into individual invisibility have a powerful ideological effect (called 'mystification') due to the fact that sources of power or authority are difficult to detect and therefore difficult or impossible to challenge.

The learning implications of such grammatical choices are striking. Students' responses to textbook materials have shown that concrete agents instead of abstract agents and nominalized processes are more likely to be picked up and elaborated. Furthermore, students attribute explicit agency to texts more frequently than the frequency with which agency is present in these texts (Schleppegrell, 1997,p.59).

Vande Kopple (1994) points out that nominalizations are characterised by the absence of modality and tense. A grammatical form which realises 'things', obscures the time at which an action takes place and due to the disappearances of modality things are represented disengaged from any personal involvement or human judgement.

Vande Kopple (1992, p.343) also stresses the epistemological consequences on the 'nature' of the represented knowledge because of the use of nominalized processes. The latter represent processes as already having happened in the past instead of placing the reader within the process of the actual happening. As a result, processes which are realised as 'things' are reported as a rigid body of knowledge, such as 'facts', which are not supposed to be argued about but should be taken for granted. In that way knowledge is made less negotiable.

As Vande Kopple (1994, p.552) has pointed out, nominalizations and long nominal groups reflect certain choices of expression in science. These are preference for precision, reporting in a form that facilitates comparisons and replication of experiments. These choices for expression adopted in textbook materials may not necessarily be in accordance with the way students think and learn.

6.3.2 How different living organisms are treated

6.3.2.1 Making entities alike

Nominalized processes and nominalizations because of their property of packaging information in a relatively short grammatical form, are often used as the subheadings which classify the differences and similarities between plants and animals. Each subheading can be elaborated with material processes. The material processes in which subheadings such as *feeding, respiration, excretion, growth, movement, reproduction,* e.t.a. from the unit *Living Organisms* (Appendix 4.7) in the textbook Active Science, are unpacked are all active material processes in which animals and plants are the ACTORS. What is stressed by the repeated use of material process in which animals and plants are the participants which act, is that both of them either in the same or in a different way <u>do</u> things. They are involved in processes in which they are MEDIUMS. These processes represent changes that occur in the entities themselves (like growing) and changes in the spatial relations between them and their surrounding environment (movements):

(1) Animals and plants may grow bigger.
(2) Animals and plants are able to move, ...

Plants and animals have also GOALS, most of which are observable:

(3) Animals take in food
(4) Plants take in materials to make their food.
(5) Animals and plants can produce others of their own kind.

Here, the GOALS *food* and *materials* are the affected participants which are transferred into the ACTORS *plants* and *animals* from the environment which surrounds them, because of their action. In the third sentence above *others* are the entities which are brought into being because again of actions of plants and animals. GOALS also can be materials which are the outcomes of processes in which animals and plants are the ACTORS:

(6) Animals and plants produce waste materials which they must get rid of it some way. Human beings do so in breathing out, sweating, and using the lavatory

Plants and animals have, among other things that they can, the ability to act in a way that mixes up both observable and unobservable entities :

(7) Usually, they get the energy they need by combining their food with oxygen.

Their living properties are stressed in processes like the one in the sentence above *the energy they need* which represents them as having needs in the same way that entities, like human beings with intentional properties, do. The same effect is also produced by the processes *search for* and *may seek* in the sentence below:

(8) A plant may search for water or light, an animal may seek warmth.

Plants are the 'makers' in processes which represent how they make their own food. These processes are part of a sequence of various kind of processes in which plants are the entities which transpose other entities into themselves, they are the containers in which these entities are found and the makers of other entities that are useful for the plant's survival and as such have to be stored in it (section: 'Eating sunshine, or eating plants?' see Appendix 4.7).

The nominalized processes and nominalizations which represent the various processes in which plants and animals are involved, are also used as 'slots', 'stores' of information which is readily to be recalled any time it is needed. Their availability or not gives access to information, recalled by questions (the same is found in transcripts):

(9) 1. What are the seven features common to all living organisms?
(10) 4. What is respiration?

Notice also that GOALS and PROCESSES are those participants which are most often called for by questions, probably due to the fact that for the specific section: *Living organisms* emphasis is put on the doer and the actions in which those entities which do things are involved:

(11) 2. What substance makes plants green? How do plants use it?
(12) 3. What substances do plants take in to make their food?
(13) 6. What gases do you breath in and out?

Nominalizations are processes that can be located as such in place but at the same time they can be circumstances of locations in time. So for example respiration is a process which takes place in the tiny cells which make up the bodies of plants and animals, but as a circumstance is a location in time during which other processes are located: energy is released and carbon dioxide and water are formed:

(14) They [animals] breathe in oxygen so that respiration can take place in the tiny cells which make up their bodies.

The subheading ***Eating sunshine, or eating plants*** stresses the differences between plants and animals feeding by using the same verb structure for entities like sunshine and plants which are very different. What is counted as food for plants is different from what is counted as food for animals due to the different nature of plants and animals and to the different nature of processes in which plants and animals are involved. Plants build their own food by taking in materials, some of which are unobservable, and by using energy from sunlight. By contrast, animals cannot make their own food but feed on living organisms, so they take in materials not raw but already processed through other organisms. Nevertheless, paradoxically the choice of the same lexical unit for two very different kind of GOALS, says that, even in a different way, both plants and animals *eat*.

Notice, that even if in some cases differences between plants and animals are addressed explicitly, the grammatical structures that are used for representing them, result in underlying, silent and pervasive similarities. Some of them, such as attributing intentional properties to plants, are also reported in studies which are concerned with students' concepts about plants and animals (see chapter 3).

6.3.2.2 Constructing the invisible

6.3.2.2.1. Making the unobservable observable

Lexical metaphors are often used for making the unfamiliar unobservable world of cells familiar. Looking at the unit *Living cells* (Appendix 4.8) we notice that cells have a membrane called 'skin':

(15) A thin skin called a membrane surrounds each cell.

the substance contained within the cell looks 'like a jelly':

(16) Within it are the jelly-like cytoplasm and nucleus

and cytoplasm is identified as the 'chemical factory' of the cell:

(17) This [cytoplasm] is the chemical factory of the cell. Here, new substances are built up from materials taken into the cell and energy is released and stored.

These lexical metaphors are not the same, not only because they draw similarities from different domains, like the biology of animals and human beings and the domain of industrial production, but also because the unobservable entities are comprehended as having similarities with observable entities which are of a different nature (thing-like and process-like entities). For example the lexical metaphor of a skin-like membrane addresses the similarity between entities which are thought to be as boundaries of different sort of containers. 'Chemical factory' is used as a lexical metaphor which highlights cytoplasm as the location in which various processes take place. But nevertheless, all these lexical metaphors achieve the same effect: they make the invisible visible by making use of concrete visible examples of things and processes. These similarities show how things and processes look in terms of the visible world in which human beings belong and on which they act. So similarities addressed by lexical metaphors afford a set of relationships between unfamiliar entities which can be easily comprehended because they are grounded in sets of relationships from everyday life.

At this point the different effects of the use of grammatical and lexical metaphors should be noticed. Lexical metaphors such as the one described above make salient as clearly as possibly the functions of the participants (e.g. ACTOR or GOAL) and the kind of processes in which participants are involved (e.g. relational or material and if the latter of what kind). Keeping participants and processes present in the text, together with the similarities addressed by the lexical metaphors, both have the effect of representing entities as 'visible' and as 'accessible' to the reader as possible. On the contrary grammatical metaphors such as nominalizations and nominalized processes abstract processes and consequently hide the role of entities and the actual nature of processes, as has been illustrated previously. One can say (with some degree of exaggeration) that while grammatical metaphors make ACTORS and their role invisible lexical metaphors make them visible.

The construction of the invisible can be seen as building up a 'story' (see section 4.5) by creating a cast of participants, a number of roles these participants have and a number of spatial relations between them. The cast of participants: cell, membrane, cytoplasm and nucleus have a variety of roles realised linguistically in terms of identifying and material processes which are not very different from those for entities found in the observable world: Cell membrane is the boundary which defines in/out relations because of its nature: being like a “skin” and because of its role: it is also the participant which controls the flow of substances in and out of the cell, like animals for example which decide what to eat and plants which take in water and nitrates from the soil. Cytoplasm is the place within the cell where a number of processes take place. During these processes new entities are created by the reaction between entities which enter the cell and those which are already there. These processes again are similar to those described under the nominalizations *respiration* and *excretion* in which animals and plants are the agents. Finally the nucleus found in the cytoplasm, is the entity which controls all the processes which take place in the cell. This is presented rather like the 'brain' of the cell which takes all the necessary decisions for keeping the cell live.

It should be noticed here that the shift from the visible to the invisible is a continuum rather than a switch off/on relation, reflected in the spatial relations between the entities and their behaviours. So for example, the chosen grammatical forms which represent spatial relations provide a smooth shift from the visible world of plants and animals to the invisible world of cells where observable and unobservable entities are connected to each other: Cells are the things which are located in plants and animals. Plants and animals are also made of cells which are the places in which other things are located: cytoplasm, nucleus etc. This continuity between the visible and the invisible world involves both place-like and location-like relations realised as circumstances of locations in place. The observable entities plants and animals are the places in which unobservable entities: the cells are located. The cells are also places in which thing-like entities (e.g. cytoplasm) and process-like entities (e.g. chemical reactions) can be located.

However the interaction between observable and unobservable entities is gradually constructed in the text, by introducing cells as the smallest living units from which animals and plants are made up. The size of this kind of living unit is given from the point of view of where the visible meets the invisible: how many cells would fit on the head of a pin. Diagrams of cells, a photograph taken by microscope, and the mention of cells which have a size that is accessible to human vision (chicken's egg as one single cell) give an idea of what these unobservable living units 'look like'.

What is interesting here is that the observable is represented as acting directly on the unobservable. The ontological gap between them is bridged by the grammatical structures. So even if there is a textual effort of highlighting the invisible entities by using illustrations such as diagrams, pictures and models, and addressing part-whole relations between entities; the grammar does most of the work of representing processes as smooth and unproblematic interactions between the observable and the unobservable.

6.3.2.2.2 Making the invisible living

The already constructed similarity between plants and animals in terms of their participation in various processes which are alike for both, like feeding, growth, respiration, movement, etc. shifts towards the construction of the unobservable world of cells as 'living' entities. This is addressed both explicitly and implicitly in the text *Living cells.* It is addressed explicitly because cells are defined as living units and represented as the places where living and growing processes are located. At the same time it is the grammatical forms of processes which make the cell play the role of a living thing. Cells and parts of them are involved in material processes in such a way that they are represented as the ACTORS which do all the job for plants and animals:

(18) This thin skin controls the flow of all ...
(19) The nucleus controls all the chemical ...
(20) Thread-like chromosomes ... store the chemical instructions..."
(21) Cell walls hold plants cells together and give plants much of their strength.

In these examples choices of words which represent processes, like *controls* and *store* and the grammar of material processes which consist of the doer and the affected, work together in order to attach living properties to the unobservable parts (cells) of the observable entities (plants and animals).

Processes that define entities as living are: their ability to act on both what is contained within them and what is located in their nearby surroundings in a way that makes them the agents which take in or out other entities; their ability to process the entities of which they are made, in other words the fact that they can build themselves, and some sort of specialisation in terms of having parts which do certain jobs.

Finally, it is important to say that living entities are represented as acting not by accident but as following some kind of instructions which co-ordinate all actions as a whole in a way that controls the entire life of the living entities. The degree to which this sort of programme-like agency is represented as determinate or indeterminate has an effect on whether it is represented nearer to everyday life sort of ordering where there is some ground for choosing, executing and controlling programme-like actions or is represented closer to a biological view of 'automatic programme-like ordering, where there is a little choice of alternative actions within a programme. The view that is promoted in the specific text *Living cells* seems to be rather contradictory. While relations between entities and sequences of processes seem to leave little choice for entities to alter processes, stress on agency in terms of what entities such as cells and parts of them can or cannot do gives the impression that despite co-ordination of actions, agents are powerful enough in executing their actions.

Looking at the next topic *8.3 Cells and more cells* (Appendix 4.9) we can replicate the same findings: lexical metaphors and grammar work side by side constructing living unobservable entities in the same way as living observable entities have been constructed earlier. For example, an amoeba is a single-celled living entity which has many of the properties multi-celled observable living organisms have:

(22) The single-celled amoeba lives in ponds and damp soil and feeds on microscopic plants...

(23) The amoeba reproduces itself by a process called binary fission. The nucleus of the cell divides in two and the cytoplasm then separates to form two new cells. These daughter cells are copies of the original parent cell.

Later also in the same topic we notice that cells are the ACTORS which build new molecules by rearranging the atoms of incoming material.

Information-like entities, that is the chemical building instructions of the cells have an important place alongside the thing-like entities in the process of building new cells. These chemical instructions have the same material origins as thing-like entities: they are stored in each nucleus in coded form by molecules of deoxyribonucleic acid. It cannot be left unnoticed that when the text talks about chemical building instructions, the agency is shifted to molecules. DNA molecules are the ACTORS which are now responsible for the storage of the chemical building instructions in each nucleus. It is also the same ACTOR which produces exact copies of itself before a cell divides. Again, agency which is brought down to the microcosmic scale raises the question whether it is the same with agency as usually understood in relation to human beings and observable living entities.

6.3.3 Using an analogy to highlight a system of relationships Complexes of participants and processes bound together and becoming a single entity

Three entities will be discussed which are highlighted in textbooks as complexes of participants and processes all bound together as a single entity. These are the structure of living things, the blood system and the distribution of organisms in a habitat. They are all constructed on the basis of an analogy.

In the topic *Living things* of the textbook Nuffield Science for Key Stage 3, Science Year 9, the structure of living organisms is presented as similar with the structure of a building. The text, which is addressed to the reader in the second person, suggests thinking about an organism as a building, built of bricks. In fact the analogy is constructed from the first paragraph of the first topic *Living things* (Appendix 4.10) which belongs in a series of sections under the topic *What is life?* It emerges from the things you are expected to see when you look at a very thin piece of plant material under a microscope. In order to make sense of this first encounter with the invisible world what is suggested in the text is that what you see in the microscope is something like you have seen before, *a wall built from bricks*. This is how 'tissue' is introduced and the entities from which tissue is made, the things which look like the building blocks of the wall, are the 'cells' .

But from this point the analogy of how you should "see" something that you have never seen before is turned to an analogy of how you should "think" about it. The 'building block' analogy helps to resolve the contradictory idea that if all organisms are made of cells then how can it be possible to have such differences in the appearance of organisms. There are two suggested solutions, both driven from the 'building block' analogy, which resolve the contradiction between what something looks like and what is it made of. There are 'various types of bricks' which are used in the construction of buildings, and also bricks are arranged in different ways making different kinds of buildings, like shops and houses. Finally, a further step is taken carried by the same analogy. Different arrangements of bricks make various spaces, like bedrooms, kitchen and lounge connected with corridors, which have different functions. So in a way an entity (organ) functions in a certain way because of the spatial arrangements of the unobservable entities of which it is made.

Looking back at the organism constructed as a whole by the 'building block analogy' we notice that it appears as an inextricable whole-part complex of entities which are involved in various processes. The analogy is unfolded in two steps, starting from what the unobservable parts of the organism as a whole look like, going to how both the observable and unobservable have to be thought about. And of course the first step is realised linguistically in terms of mental processes of seeing, while the latter is realised in terms of mental processes of thinking.

The blood system in the same textbook (topic *All together, now !* see Appendix 4.11) is also constructed on the basis of an analogy. But this analogy functions in terms of how you should 'think' about the blood system rather than of how you should 'see' its components. This role is addressed early on in the text which defines the blood system as a transport system. The definition is elaborated extensively to almost every part of the blood system, which is likened to certain components of the London Underground system, not because they look alike (similar) but because they function in the same way. For example the route the blood follows is made up of tubes. These tubes are not like the tubes the underground train runs through but have the same function as the railway lines have between stations: they carry 'the chemical passengers' round all the way through the body. The analogy is further extended to cover even some very specific parts and functions of the blood system.

The analogy of the blood system as a transport system is realised linguistically by the same kind of material processes which represent what the entities can do in respect to each system. Trains have a route to follow in the same way as the blood has a route to follow through arteries, veins and capillaries. Passengers get on and off the trains not at any point of the route the train follows but at special places, the stations. In the same way food and gas molecules are moved from place to place by the blood system. What is interesting here is that the analogy between how the participants of the two systems behave works so efficiently that lexical metaphors take on the job of addressing the similarities between the two systems. After the first similarities have been established between what entities of the two systems can do in terms of material processes, new entities appear as the outcome of these processes. Food and gas molecules now become the chemical 'passengers' which leave and board the bloodstream. Lexical metaphors like these have a very dramatic effect. Entities like food and gas molecules re-created and are now thought about in a way that they could not been imagined before. In other words the part-entities of the blood system are now re-built with respect to the analogy between the two systems as a whole. When the text talks about specific aspects of the blood system by making use of entities like the 'chemical passengers of the body' it leaves no other choice to the reader than to think about the function of the blood system and its components in a certain way.

The third analogy from the textbook Nuffield Co-Ordinated Science (Appendix 4.12), is between the patchy distribution of organisms in a habitat and the distribution of people in a school during a working day. In the same way as the analogies discussed above it facilitates students' reasoning: if an organism lives in a particular habitat why it is not found all over the habitat, all the time? Again it is not the similarity between the appearance of entities that counts for the analogy but the behaviours of entities in respect to the whole in which they belong. As a result the analogy comes out as a similarity between two systems of relations rather than as a similarity between two entities or between two specific kinds of behaviours in which the two entities are engaged. The similarities between the two systems of relationships are realised linguistically in terms of material processes which represent entities' actions and circumstances of locations in place which show where the entities are found when they behave in a certain way.

Considering the three analogies together we notice that they provide an easily accessible way to recall the ideas. For example to think about the structure of the organism as a building is something that can be easily remembered and whenever it is recalled one can work out all the complex system of relationships which it carries. In this way the analogies become tools for learning, that is they do not only shape together as a whole different entities and the relations between them but they also offer a way in which the entities and their relations can be remembered and recalled as a whole system of relationships.

6.4 Discussion

6.4.1 Why metaphors as parts of constructions of entities and not as parts of genres?

Material processes realise not only explanations, but introductions of terms, definitions and classifications as well. Examples from textbook materials show that entities are introduced or classified in terms of material processes and not necessarily in terms of relational processes or processes of being. This finding indicates that the presence or not of certain kind of linguistic processes is not a 'reliable' indicator of whether there is an explanation or description or classification. As a result, genres such as 'explanations' and 'reports' cannot be seen as clearly distinguished because they are not necessarily realised in different ways. On the contrary, examples from textbooks and transcripts indicate that explanations presuppose knowledge about the entities which are participants in them. But representations of this knowledge cannot be seen as reports - that is separately from the genre of explanation - due to the fact that they are realised more often in terms of material processes which show what the entities can or cannot do, what can happen to them and what they are made of.

Therefore, what is accounted as the framework of study in the present thesis is not an analysis of metaphors based on genres but on the different ways in which constructions of entities are realised linguistically.

6.4.2 Why linguistic representations of entities are not just words

a) *participants*

Representations of entities in nominal groups can draw some very fine distinctions between entities belonging in different categories. So nominal groups can be seen as doing the same job relational processes are doing; defining and attaching attributes to entities. At this point it should be noticed that nominal groups cannot be simply translated into relational processes in order to elaborate what sort of classifications or categories are implied by the group itself. In many cases additional information is needed about the entities which is not present in the linguistic constituents of the group. This finding shows again that linguistic elements - nominal groups in this case

- should not be thought of as realising sets of meaning, such as categories and classifications, in a direct and transparent way. Quite often nominal groups for example carry information which is not explicitly present in their grammatical constituents.

b) *circumstances*

Examples of circumstances in clauses show that circumstances are not just an additional, optional element in the representation of entities. The fact that they are closely related to thing-like or process-like entities indicates that they play an essential role in the structure of ideational processes. Furthermore, circumstances are often the focus of ideational processes, like in questions for example where they become the object of the inquiry. The reasons for choosing specific circumstantial elements and their semantic function should be looked for in the thematic organisation of the entire text and not at the ideational level only. Therefore in the same way as participants, the meaning of circumstances can be silent if they are considered isolated from the process or the participant or the thematic organisation of the text which brought them into being. Finally, the fact that both participants and circumstances are realised by the same grammatical constituents permits them to exchange functions in texts.

c) *processes*

The study of transitivity in representations of environmental science demonstrates that semantic forms such as transitive or intransitive material processes do not determine meaning in a way that cannot be expressed otherwise. In many cases the presence or absence of a transitivity pattern does not say much about the way in which entities are involved in processes. Therefore, the study of transitivity alone should be better not constrained at the clause level. In that way priority should be given not to the semantic forms themselves, but to how entities are involved in transitivity patterns in the text and what this involvement implies for entities' realisations - something that is done in the second part of the linguistic analysis.

6.4.3 Material process as part of the textual metafunction

The last argument above brings us inevitably to the study of the textual cohesion of environmental texts. The study of textual cohesion illustrates how knowledge is implemented in the construction of complicated sets of relations between entities without this knowledge being present at any single clause. Important pieces of knowledge for the construction of an explanation need to be traced back by their references - usually in the form of anaphoric elements and nominalized processes. Also the flexible nature of semantic forms, mentioned above, such as a material process, means that entities can exchange roles, that they can be traced under different semantic functions, making it almost impossible for the reader or hearer to reveal their role by looking at their present linguistic realisation only, such as a specific clause or nominal group.

6.4.4 Material process as part of a multi-modal construction of meaning

The question of textual cohesion (or relations between clauses) will be only partially approached if other systems of representations such as images which interact with language are ignored. An example of a whole unit of a textbook (see section 6.2.6) illustrates that how processes appear in the last section of the unit depend on how entities are introduced in earlier sections. Linguistic realisations of entities in the latter represent choices of how these entities should be classified and taken into account (flow of energy between living organisms) in the construction of new meanings (food webs). Choices of linguistic representations of entities are in accordance with their visual representations. In this case the direction of vectors in the diagram of the food web is in accordance with entities' linguistic realisations, that is as passive material structures. As a result, it is the interaction between different systems of representation which leads to choices of certain options (either about the semantic forms or the images through which entities are realised and represented).

6.4.5 Does it matter if something is represented as a thing or as a process?

In the present thesis the term grammatical metaphor refers most often to the grammatical phenomenon of treating a process like a thing and realising it linguistically as a thing by the use of a nominal group or nominalization. The choice of using nominalized processes in a text has ontological, as well as educational (learning) implications. At the ontological level, process-like entities are represented and realised as thing-like entities, so all the things one can do with thing-like entities one can now do with process-like entities, such as itemise them and therefore quantify them, classify and put them into categories. The learning implications of grammatical metaphors seem to mean extra work for the student since the latter needs to unpack the processes which are hidden in the nominalized processes in order to comprehend in what respect they are treated as 'things' rather than processes.

6.4.6 Is something represented linguistically either as concrete or abstract or is its representation a matter of a degree?

Starting with grammatical metaphors we realise that there is not only one way and one degree to which processes are abstracted. Agency is abstracted according to the degree to which passivity is used to represent processes. In that way representations of processes as such and in terms of thing-like entities are seen as the two opposite ends of realising them and anything between them varies to the degree processes are represented as being abstracted from agency. Passivity as a means of suppressing agency in environmental texts and in representations of science which have a public interest has only recently attracted a number of studies.

Some further implications of the use of abstracted material processes are discussed at the end of the section 6.3.1, from different points of view. What is striking here is that a way of representing grammatically knowledge can have simultaneously epistemological, ideological and educational (in respect to learning) consequences .

6.4.7 How language can bring entities together representing them as similar

In section 6.3.2, representations of entities mainly in one kind of textbook (Active Science) in terms of transitive or intransitive patterns are studied to the extent they represent entities as alike or different. It is noticed that one way of representing entities as similar is by representing them as sharing the same kind of material processes. In that way entities which are generally thought of as less 'active' (e.g. plants) than others (e.g. animals) can be represented as equally active.

Special interest is given to representations of entities which are less accessible to commonsense understanding. The reality of the latter is constructed in relation to more accessible entities mainly in two ways; again by representing both realms of entities as sharing the same kind of transitive or intransitive patterns and by bringing both kinds of entities as interacting participants in the same grammatical processes. In the case of the latter it is the unbroken continuity between the two realms of knowledge and understanding, reflected in their participation in the same grammatical structures, which builds up in an unproblematic way the reality of the less accessible.

6.4.8 Grammatical structures work out analogies below the linguistic surface

In section 6.3.3, three examples of explicit analogies were discussed. Analogies can be focused either on what an entity looks like or how it should be thought of. While the first explores entities in respect to whether they are alike or not the latter explores the extent to which different sets of entities, belonging to entirely different realms of experience function in the same way or not. In both cases what is achieved is that an entity can be understood because familiar knowledge is integrated into the effort to conceptualise it.

Explicit sets of analogies are studied here as discursive constructions rather than models or mappings because attention is paid to the discursive elements which brought them into being. The final product of the analogy is one entity in which two totally different realms of experience (one less accessible and another more accessible) are bound into one. In respect to the latter what is of special interest is that the analogy has a learning value since it can afford exploring more aspects of 'likeness' from either realm and it can be easily recalled since two realms of experience are implemented in its construction.

CHAPTER 7

METAPHOR AS A COGNITIVE PHENOMENON
IMAGE SCHEMA APPROACH

7.1 Introduction

The two most frequent categories of image schematic structures in the context of teaching environmental science, are: the Containment schema and the Agent-structure schema. But there is not anything like a simple image schema, isolated and easily identified in the discourse of teaching (both in textbooks and classroom observations). And this is because entities participate in more than one image schemata, in a number of different ways. Image schemata which are found at the clause textual scale are simpler and easier to represent than those which are found in a piece of text like a paragraph for example. In the same way those which are found in the beginning of a lesson or in the beginning of a textbook unit are often simpler and more easily identified than those which are found at the end.

Metaphors are usually the outcome of multiple constructions of image schemata. These are sequences and complexes of image schemata in which two or more schemata interact. That means that at least two image schemata are found as inseparable, because each participant carries with it functional roles as an element in two different image schemata. The ways in which entities are involved in one schema entails the way in which entities are involved in other schemata.

Therefore, the analysis has taken into account the schematic structures which precede or follow or go alongside the specific image schema which is the object of inquiry. For example, containers act on the entities that are contained or on entities that are found outside, so they function as agents at the same time. Also other agents can possible act on the container.

The fact that there are different structures of image schemata, has driven us to divide them roughly into two categories. These are smaller and larger schematic structures. The latter are made by the former having them as parts. To give an example, carriers can be represented as made up by containers and agents. Cycles also can be represented as made up of a system of sequences of agent structures and containers.

The task of analysing everything in terms of image schematic structures does not stop anywhere. The aim of the present thesis is to provide some examples of choices of image schematic structures used in representing entities and to discuss what sort of meaning relations these choices impose on the represented entities (with a special interest in metaphorical extensions of image schemata). Also, the analysis includes a representation of a multi-modal construction of an image schema (a life cycle), looking at the relation between texts and images in its textbook and classroom representations.

7.2 Agent structures

7.2.1 Identifying an agent structure as an image schema

An agent structure is an image schema in which one entity, the Agent does something to another, the Affected. Everyday examples of agent structures start from the relation between man and the material world. We are accustomed of thinking ourselves as Agents which move objects from one place to another, create things and change or transform them into something else. Things of the material world are commonly thought as the objects of our action; if the latter does not succeed then we talk in terms of the constraints objects impose on action.

Since what an entity can do and what can happen to it in relation to where it is located defines its nature, as argued in chapter 2 and section 4.5, agency is important in identifying and defining an entity. It is noticed both in textbooks and in classroom observations that the way an entity is involved in agent structures makes it seem like or unlike other entities. This is not only due to the type of agent structure but to the degree of agency as well. In the linguistic analysis the degree of agency is described in terms of suppressed or stressed action realised linguistically as passive or nominalized material process on one hand and direct material process on the other (see section 6.3.1), and the kind of agency is described as agent structures of transferring, transforming and bringing something into being (see section 6.2.7). In this part the focus is on schematic realisations of agent structures and their metaphorical extensions, and the effect they both have on meaning constructions.

7.2.2 Suppressed vs. stressed agent structures

As illustrated in the linguistic part of the analysis (section 6.3.2.1) a lot of work in textbooks is devoted to representing plants - which are usually thought to be static since they do not move - as entities which do things in very much the same way as animals. The underlying reason for doing this is to put plants and animals into the same category: living things. In some textbooks this effort is made explicit by suggesting thinking about properties like competition in terms of plants as well as in terms of animals:

You may often observe animals competing directly and actively with each other: for example, two puppies scrapping over a bone or two small children fighting over a toy. It may surprise you to learn that some plants can compete 'actively'. They may do this by releasing a chemical that will deter competitors - or even kill them.

(Nuffield, Co-Ordinated Science, Biology, p.164)

Notice in the extract above that the concept of competition is expanded to characterise behaviours which have the same effect. An animal which is engaged in a fighting with an other animal is represented as having the same purpose as the plant which releases chemicals: both of them are trying to obtain vital resources (like food, water, territory) for their survival:

If the presence of other plants reduces the amount of an essential resource that a plant requires then the plants are competing against each other.

(Nuffield, Co-Ordinated Science, Biology, p.163)

But, the concept of competition applied to plant behaviour is extended beyond its everyday meaning of bodily involvement. The power of action of plants previously thought to be inactive is stressed by representing them as sharing the same agency with living entities that are primarily thought of as active. Like the concept of competition, other concepts such as the ability of movement can be extended metaphorically to cases of plants growing and expanding their territory leaving little place for their competitors.

These cases of metaphorical elaboration of meaning relations are not different to what Black (1962) describes as an interaction theory of metaphor (see section 2.3.2 in Appendix 2). Plants seen as one of the subjects of the metaphor turn out to be more alive than they were thought to be, and concepts such as competition and movement include now cases in which bodily involvement is neither a necessary nor the only part of their meaning.

Metaphorical extensions such as the one described construct new meaning relations. Plants are represented quite generally as acting on their environment - not just in specific cases but generically:

...plants can help to create their own environment and their own soil... These things will all affect what other plants can grow alongside them.

(Nuffield Science for Key stage 3, Year 9, p.17)

Plants' power of action now means that: plants change their own environment, something that only humans are commonly thought of as capable of doing.

It is not only the degree of action of living entities that can be suppressed or stressed accordingly. Non-living entities too are represented as Agents involved in actions in the same way as living entities. Water for example is represented as an agent which 'harms' rocks rather than causing rock's erosion:

Water can also attack some rocks chemically. Rain dissolves some of the carbon dioxide produced by plants and animals. This forms a very weak acid which attacks rocks such as chalk and limestone.

(Nuffield Science for key stage 3, Year 9, p.13)

Other conditions like changes in temperature are represented as causes which can have effects similar to those which Agents like wind and water have:

Changes in temperature can cause rocks to expand and contract. This repeated movement can cause the surface to break off in layers. The rock surface can look rather like an onion peeling.

(Nuffield Science for key stage 3, Year 9, p.13)

Finally, due to the intensive use of agent structures in which it is involved, an entity can be treated like a thing, that is taken from one place to another, gained or lost and stored. This is the case with how energy is treated in the extract of the same textbook below:

If you investigate any energy-using task you will find that the energy used has to be obtained from something else. The energy gained by one thing is lost by another.

(Nuffield Science for key stage 3, Year 9, p.30)

It is interesting to notice how often energy is treated like a thing in relation to observable living or non-living entities. So the repeated use of agency in different contexts has the effect of reinforcing representations of energy as a real thing-like entity.

7.2.3 Unobservable agents act on observable entities and have observable effects

Invisible Agents are given a real status in a number of different ways depending on whether there is any access to them or not. So for example the action of ultra violet rays is traced by their effects. A number of stories brought up by the teacher in the classroom gives evidence of the effect the UV rays have on people and therefore their existence.

(1)

T: *Ozone is a gas that is actually very like oxygen it's a form that almost you can think of as oxygen okay? But whereas oxygen is O_2 it has two atoms of oxygen in each molecule, ozone has three atoms of oxygen. A lot of you have probably heard of skin cancer. Okay. Rolf Harris how many of you have heard of Rolf Harris?*

S1: ...

S2: *Booo*

T: *Okay it's that very dubious song called tie my kangaroo down sport*

S: *Ha Ha*

T: *Right*

S2: *His didgereedoo*

S3: ...

T: *and his didgereedoo and so on*

S: *and animal hospital*

S2: *turtles*

S3 ...

T: *Right. Shhh Shh Rolf Harris was diagnosed a while ago as having skin cancer*

S: *Wohh ... had that*

T: *yes*

S: ...

T: *and I think up to now his treatment for it has luckily been successful okay? He puts his skin cancer down to when he was a child in Australia and he spent all his time running around playing on the beach with only a pair of shorts on.*

S: ...

T: *What is it that the sun gives off if you are exposed to too much of it can cause skin cancer?*

S1: ...

S2: *sun burn*

S3: *the sun, sun*

S4: *UV*

S5: *the sun, the sun*

T: *UV. A... is that what you were going to say? Good. Ultra violet rays*

S: ....

T: *Neither Shhh. If you were going on a beach you can slap sun lotion and all sorts of things*

S: ...

T: *on your body to try and prevent all of the sun's UV getting through to your skin.*
But we've already got something that to some extent does that for us and it is the ozone layer okay?

(Looking at the Environment, Lesson:5)

In this extract the sun is represented as an Agent which gives off ultra violet rays. Skin cancer is caused by the unobservable Agent UV rays. The latter are represented as getting through the skin and as being prevented by things like sun lotion. The ozone layer is another unobservable entity which stops UV rays. In this extract from the way things are talked about it seems that it does not make any difference whether an entity is observable or unobservable but what is represented as important is the roles the entity fulfils in relation to other entities.

Acid rain is another Agent which is known by its effects. A classroom demonstration which shows the effect of diluted acid on marble chips gives evidence of the action of acids. Again as in the previous example the event of weathering together with the Agent which is responsible for it; namely sulphuric acid, are at a scale not easily accessible to the student. Stories which make reference to 'killed forests' and seriously damaged buildings and monuments, also give real existence both to the Agent and its effect and at the same time make the link between what has been demonstrated in the classroom and what happens in the world on a daily basis:

(2)

T *Ah well get it written down, make sure you have written down this time. [] Right I think what I'll do because some of you aren't working very hard girls [] and I would appreciate it if you would listen now please [] and I suggest you don't pull a face like that either [] I'm going to ask you to have a go at a conclusion. [] I'm going to ask you to have a go at a conclusion, think about what it was we were trying to set out to show. [] Has what we have done demonstrated that in any way whatsoever. Has the simple experiment that we have done actually demonstrated to you what it was we set out for it to show. Has it demonstrated in any to you what may actually happen to a building? If so how. Sorry?*

S ...

T *According to this chart yes, because when we tested that with Ph paper with the universal indicator paper it was PH2 according to this chart here and in some extreme cases acid rain might even be up to PH1 so if you had used that type stone to make a building out of, think of it as a type of marble. SO if you had built a building out of a rain and you had been unlucky enough to get that strength of acid rain then that's what would happen to your building.*

The latest generation of environmental problems such as the one mentioned in the extract above involve a complex interaction of entities which belong into different realms of experience. Linguistic representations of these problems go beyond the level of simple structures of material processes and reveal higher structures of textual organisation such as stories and demonstrations.

7.3 A path-link schema made up of agent structures

7.3.1 Constructing a path-link schema

As it is represented, a process need not only be a single agent structure which consists of an Agent and a Patient which is affected in some way by the Agent's action. A process can be represented as being carried on from one agent structure to another leading to a purpose or a conclusion or an effect of some kind. From that point of view a process as a whole is realised not in terms of a single agent structure but in terms of a sequence of various agent structures which follow one another. These structures are realised linguistically as embedded clauses. Instead of a single clause the appropriate linguistic unit is rather the clause's place among other clauses described also as textual cohesion (see section 6.2.5). For example what the teacher describes as a slash and burn type of agriculture is not realised by a single agent structure but by a sequence of agent structures which starts from farmers' actions and ends up with the minerals released from the ash, going back into the soil.

A single agent structure has a very different meaning if it is considered as part of a sequence of agent structures. Going back to the example above, the actions of farmers who cut down and burn trees have a different meaning if they are looked as a part of the slash and burn agriculture and not as a part of a process in which charcoal is formed. This is addressed explicitly by a teacher who is trying to make students aware of the fact that constructing a sequence of actions in a certain way leads to a certain effect:

(3)
T *If you burn them in a very special way, don't all shout out please [] if you burn them in a very special way then you might get charcoal. But if you just let them burn naturally you know you put a match in there and let them burn away what are you going to be left with?*

(Looking at the Environment, 2nd Lesson, p.8)

Notice that in this example the outcome of the sequence of agent structures is that the nature of an entity (trees and woods) is completely changed and the entity is transformed into something else (ashes). The way the example is talked about, even if it refers to any farmer who acts in this way, is represented as if it is a specific instance of a type of farming. This effect is obtained by the use of the second person by the teacher and his preference to use instances of categories of things and processes such as *you put a match* rather than their generic names *burning*. As a result, relations between entities are worked out at a level of a concrete instances which stands for the general phenomenon of farming that has to be explained.

In the same way as single agent structures, sequences of agent structures can be provided by the teacher in the form of a generalised phenomenon. An example of a generalised process which consists of more than one agent structure is when the teacher is dictating a passage that the students write in their books:

(4)
T *In a second. Lets continue please we've had a bit of a break there, can you continue by saying [] just a new sentence [] the earth's [] population [] Helen I don't what to know about what you saw last night [] the earth's population, is now so large [] that we demand [] more and more [] goods [] to be made [] which uses up [] resources [] faster [] than before OK. [] Last sentence [] the result [] is that [] the earth's [] surface [] has been changed [] ...no one's asking questions.*

(Looking at the Environment, 1st Lesson, p.10)

This sequence of agent structures which identifies relations between quantities of entities is the outcome of classroom talk about the need for resources in everyday life.

In another case the teacher provides an instance in order to support the idea that people are not always able to avoid pollution even if they move away from an area which is next to a source of pollution and therefore pollution should be thought of as an unwanted quantity of an entity which is spreading from one place to another. The process of how people, metaphorically speaking, dump some unwanted stuff in others' people places consists of agent structures of transferring entities:

(5)
T *We're not actually, we're not actually [] putting stuff in lorries and taking it up there and dumping it, but when our factories kick out all of this poisonous smoke that goes up into the atmosphere where does it get blown to?*

(Looking at the Environment, 1st Lesson, p.4)

and of bringing entities into being and causing a change in other entities:

T *It gets blown over Scandinavia. When it rains in Scandinavia some of these gases like sulphur dioxide dissolve in the rain to form a weak acid sulphurous acid. When it rains it produces acid rains it kills the trees it makes the lakes become acidic it affects the life in the lakes and so on.*

(Looking at the Environment, 1st Lesson, p.4)

7.3.2 Narratives in the context of teaching environmental science

The last example discussed above has many things in common with the narrative mode of spoken discourse. As we have seen in section 4.5.4, the entities here can be seen as characters in a story. One of the most commonly used modes of representation both in textbooks and lessons is the form of narrative. A narrative is a discrete unit of the written or spoken mode with a clear beginning and end. Natural phenomena and events of everyday life are introduced as stories and reported as stories. Teacher's questions like:

> *Rolf Harris how many of you have heard of Rolf Harris?...*
> *Have you heard of oestrogen?...*

signal his intention to tell a story to students. Similarly if the source from which the story comes from is set up first, it indicates that a story will follow:

> *There was a thing on the radio yesterday...*
> *I watched a programme about...*

Time references signal also that an event will be reported as a story:

> *And in fact when I think of the times when I've been there there's been days, you know those sort of pedalo things...*
>
> *In 1858 it says...*

Entities in narratives are represented as participants in a story having roles suitable to their properties and behaviours. Take for example teacher's talk about the effect the UV rays have on people which is represented in terms of a biographic narrative (see example (1) in the previous section). Material entities such as *skin* and *beach* as well as people *Rolf Harris*, *you, your body* and unobservable entities like *oxygen, UV rays* and *ozone layer* are participants in the same story. What has to be noticed here is that all these entities are treated as equal in the way they participate in the story regardless of whether they are living or non living, observable or unobservable.

Like other narratives found in other discourses in the teaching of environmental science too, narratives at the end may suggest how they should be understood and why. This is a stage often described in the literature as 'evaluation', which shows the significance and the meaning of the actions and how these actions should be interpreted and weighed by the listener. In the example above the teacher at the end generalises the outcome of the story by placing students in the same situation as R

Harris, so bringing the story to a level of a potential outcome for any sort of event which shares the same features with the story just told.

A narrative as a mode of either spoken or written language implies participation. If one narrative has been told, others may be anticipated, triggered off by the first. A second narrative usually acknowledges the first and gives the strongest possible endorsement to the first. Narratives which are students' responses to teacher's story tend to identify with the sort of characters and the actions in which the characters are involved. Narratives also can be instances which exemplify an argument or the other way round they can provide an instance which is later generalised.

In order to see better how one narrative triggers another or elaborates an argument let us take as an example talk between teacher and students which has already been mentioned briefly (see example (5)) at the end of the previous section (7.3.1), from the point of view of the path-link schema. In the first lesson which opens up a series of lessons about the environment the teacher starts the lesson by calling on students to think about the most important things that are absolutely essential for humans' survival. The teacher's argument is that any threat to one of these things would affect people's survival. Air is one of the things that is reported by many students. Therefore, according to the teacher's argument, pollution of the air affects seriously people's lives.

The teacher at this point opens up a discussion by asserting that people do not really have a choice about what they breathe in. Then most of the class argues against that, arguing that people can move from one place to another if they want to avoid air pollution. It is at this point that the teacher intends to take the argument further and tackle the moral issue that people's actions in one place might have an effect on people's lives in other places. This shift of the discussion at the same time takes a turn from the general accounts of air pollution to an instance which is a counter example to what most of the students believe (that one has a choice in avoiding pollution). This instance which is reported by the teacher as a story is about the damage the industrial activity of western European countries cause on natural environments, like the Scandinavian forests and lakes. The main participants of the stories and their behaviours are not just reported by the teacher but are carefully constructed in relation to the direction of the argument he is trying to highlight:

(5)

T *What if [] we'll come back to that in a second but one interesting point Scandinavia, where is Scandinavia what countries does Scandinavia include?*

S *Africa.*

T *If you, we don't need to draw this but if this is, I'm not doing a very good drawing here but [] if that's Britain and Ireland [] ok now then [] which direction is our prevailing wind from our most common wind direction.*

S *South east.*

T *Not quite.*

S *Ok west.*

S *North.*

T *West is closer which side of the country geography, which side of the country tends to get more rain?*

S *West.*

T *It's actually the west side of the country ok shshsh [] if a lot of that is a result of air moving over seas gathering moisture and so on that would suggest that the prevailing wind comes from the east or the west which one?*

S *West.*

T *The west blowing in the moist air off the Atlantic itself ok, in fact [] girls down there will you concentrate please [] in fact it's more from the south west than directly from the west ok, sorry the arrow is barely on there is it. So the wind blows across the country in roughly that direction ok you don't need to draw this. If you look at here on an atlas [] you'll see the Scandinavian counties. Ok. You'll see Sweden Norway and so on [] shs hs sh [] Sweden Norway Finland and so on are actually countries that have [] compared to us very few people. There aren't the great densities of heavy industries and things that we've got. A lot of it is just natural wilderness unspoilt [] what is happening so you might like so you might think getting back to your point that you could move up there countryside nothing around too .. you could live miles away from any cities anybody else but what is happening to a lot of the lakes in Scandinavia? What's happening to them []*

S ...

S *People are dumping stuff in them.*

T *Not quite [] we [] we are dumping stuff in those lakes.*

S *Oh dear.*

S *What we're doing is trying ...somewhere else we're not*

T *We're not actually, we're not actually [] putting stuff in lorries and taking it up there and dumping it, but when our factories kick out all of this poisonous smoke that goes up into the atmosphere where does it get blown to?*

S *Scandinavia.*

T *It gets blown over Scandinavia. When it rains in Scandinavia some of these gases like sulphur dioxide dissolve in the rain to form a weak acid sulphurous acid. When it rains it produces acid rains it kills the trees it makes the lakes become acidic it affects the life in the lakes and so on.*

S *And the poor little animals die.*

T *Ok [] so in lots of ways we're passing our problems onto other countries.*

[Looking at the Environment, 1st Lesson, p.3-4]

The story does two things at the same time; it particularises what was talked about as air pollution, by making reference to specific circumstances, participants and processes and also elaborates the process of how pollution is carried at a distance. We should also notice that all the work the teacher has done in constructing the entities that play an essential role in the story like the direction to which prevailing winds blow and the spatial orientation of countries around Scandinavia gives the status of a real event to the narrative. The story's evaluation teaches students two things: that moving away from a source of pollution does not guarantee immunity and the moral effect an action might have if it is carried out at a distance away from its source (agent). The latter is captured by the analogy between the concepts 'pollution' and 'problem' which results in the effect that passing pollution to someone else equates to passing problems.

As soon as the evaluation emerges from the story, the teacher provides one more example of pollution at a distance. This time the source is a programme in a radio broadcast watched by the teacher yesterday. Notice here the role of media as sources of multi-modal constructions of meaning, in this case narratives. It is one more real instance of an example of how pollution can possibly pass from one country to another. The example at the same time expands the ways of polluting, composing to a case of litter pollution:

T	*Ok [] so in lots of ways we're passing our problems onto other countries. There was a thing on the radio yesterday. They'd been going up and down the west coast of Scotland [] if you've walked; up and down the west coast of Scotland it's quite remote it's quite isolated. Beautiful Mrs ...will vouch for that it's lovely. One of the best places you can go to to ...as well [] they have been one moment, they've been picking litter up off the beaches there. Guess where something like a quarter of that litter has come from?*
S	*Us.*
S	*England.*
S	*No different countries.*
S	*Ireland.*
T	*If you go further towards the west where do you come to? Across the sea*
S	*France.*
T	*No that's the other way this way.*
S	*America.*
T	*America. [] ok and they reckon that something like a quarter of the pollution on the beaches litter being washed up on the beaches had come from America ok. So no where is absolutely immune from pollution from litter damage to the environment and so on ...[] ok you've both got your hands up I'll let you both have your say and then we need to push on.*

[Looking at the Environment, 1st Lesson, p.4-5]

The two instances above of passing pollution are multiple examples of the same image schemata construction; path-link structures of agent structures and carriers - discussed later in the analysis - represented as narratives. We also notice that because the two examples are not equal in the effect they have in teaching. While the first is an exemplified argument the second is an elaboration and expansion of the first towards more generality. The two stories trigger students participation which is realised by narratives coming out from the repertoire of their personal life experience:

S: *Like my nan she lived in the countryside and they've got those like big ...chimney things where all the pollution goes out, so I don't know where she gets that from.*

T *Ok power station. Also some of you might have been, sorry here I am waffling away again some of you might have been out and seen the big, the fields that are full of yellow flowers. Does any know what that plants called?*

S *No.*

S *Buttercup.*

T *It's actually called [] shsh [] it's actually called oil seed rape. Now then [] shsh [] come on [] a lot of the cooking oil and stuff that you use comes that oil seed rape now then a lot of people in the countryside with allergies have horrible summers with hey fever and things like that because of the extra pollen so in a way ....some form of pollution. Pollen in the atmosphere in the countryside that wouldn't otherwise be there. It's there as a result of things that we have done.*

[Looking at the Environment, 1st Lesson, p.5]

It is not accidental that the examples of narratives above have a path-link structure. Representations of entities in terms of path-link schemata provide sets of meaning as packages in a way that one entity or a relation between two entities brings with it other entities or relations as well. An image schema of this kind is often recalled by the final effect of the sequence of agent structures which is realised linguistically by a nominalized process or nominalization. The final effect brings with it the agent structures that make it happen, a phenomenon often called 'nesting' in environmental science.

This is also how narratives are structured. Stories have a plot, therefore entities are participants in the plot. The story is usually recalled by its outcome or the final effect participants' actions have. For example the story in the extract above is recalled as 'the devastation of Scandinavian forests'. 'Packaging' (or 'nesting') of many process-like and thing-like entities under one event-like entity is realised more vividly in those cases of path-link schemata which are represented as stories.

7.3.3 Constructing a narrative/ path-link schema

7.3.3.1 Story's plot and participants

Quite often participants/entities, taken as given either because of the preceding text or because they are assumed to be commonsense knowledge, are inserted in the sequence of the agent structure without being elaborated at all. In the same way participants/entities and their behaviours which the teacher plans to elaborate extensively in later lessons are also just inserted into the sequence. So for example participants like sulphur dioxide and acid rain are just inserted in the story by the teacher, without further elaboration in order for the link to be made between the phenomenon of the poisonous smoke which is carried away from its source by the prevailing winds and the effect on forests and lakes. A few lessons later the focus of the classroom's activities will be on substances like sulphur dioxide and the effect these substances have on various materials.

Sequences of agent structures seem to be suited to the job of explaining how an agency is extended in time or in place. Between the source of the poisonous smoke and its effect, the killing of trees and living organisms in lakes, there are agent structures which describe how the poisonous smoke is carried away from its source, and comes down to the entities that it affects. In this case the fact that the source of the pollution and the affected area are not apparently in contact or in any containment relationship presupposes a number of intermediate agent structures which fill the distance between initial cause and final effect.

A sequence of agent structures can be traced from beginning to end, or backwards. The direction which is followed depends on what is taken as new and what is taken as given in the specific situation. What is taken as new, that is the thing that has to be explained and also the focal element of the classroom discourse in the specific situation, appears at the end of the sequence. In the case of the damaged forests in Scandinavia what needs to be explained is how an unspoilt place of natural wilderness is affected by pollution even if there is no heavy industry next to it. The explanation is unfolded from the beginning to the end following the journey of the entity *poisonous smoke*. If the same sequence of agent structures was followed backwards then the explanation would have started from the damaged forests looking backwards to the initial cause of the damage.

In another case, when the teacher asks the students whether they know what slash and burn agriculture is, the issue in question is what people get from cutting down and burning trees. So the whole sequence of agent structures follows one by one all the steps which lead to the desired effect: the enrichment of soil with minerals:

(3)

T	*Can anyone explain to me slash and burn agriculture? Then if you've done that before.*
S	*You slash it down and you burn it.*
T	*Is that what you, is that what you were going to say?*
S	*Yes.*
T	*Would you like to elaborate on that a little bit?*
S	*No.*
T	*What do you slash down?*
All	*The trees.*
T	*The trees, why do you burn them?*

S *Because you ....*
S *...to make charcoal.*
T *OK you might be able to use you might be able to get charcoal from it. Any other reasons for burning the trees after you've cut them down?*
S *..paper.*
T *Well possibly you would do something else with them if you were wanting paper from them but yes good point.*
S *Would it be to clear them out.*
T *One of perhaps [] one of perhaps the most obvious uses would be simply to get them out of the way to clear the land after they've been chopped down. What are you going to be left with after they've burnt?*
S *....*
S *Charcoal.*
T *If you burn them in a very special way, don't all shout out please [] if you burn them in a very special way then you might get charcoal. But if you just let them burn naturally you know you put a match in there and let them burn away what are you going to be left with?*
S *Ash*
T *Ash ash, now then, shshs, listen [] come on please [] shsh I'm waiting [] when we're ready come on please [] the ash contains lots of minerals so if the ash goes back into the soil it may actually help to enrich the soil [] OK although there are a lot of problems with slash and burn agriculture but that's going into the geographical side which we don't really want to do at the moment, OK*

(Looking at the Environment, 2nd Lesson, p.7,8)

Whatever route is followed on a path made by a sequence of agent structures, you cannot move to the next agent structure unless you pass the one that follows before or after it. This is why the sequence is like a path or a plot of a story from a starting point to an end point. Looking at the two examples mentioned above we notice that what is realised as a destination for the path of agent structures which represents how pollution affects places at a distance is the effect of acid rain on forests and lakes and what is realised as a destination for the path of agent structures which describes the slash and burn type of agriculture is the enrichment of soil with minerals.

7.3.3.2 Intentionality and causality in path-link schema Temporality in a story

In some cases the path imposes a time sequence: one action follows another in time. In the first place some poisonous smoke is the unwanted product of heavy industry, then the pollution is carried away from its source by the act of the prevailing winds and finally the polluted stuff comes down on the earth's surface in the form of acid rain. Obviously acid rain in Scandinavia is formed after and not before gases like sulphur dioxide are released in the atmosphere.

Time sequence and causality go together in cases where the sequence itself is an explanatory chain of cause-effect relations. The latter has the structure of an initial cause which has an effect and then the effect itself becomes the cause of another effect and so on. An example of such cause-effect chains, mentioned also earlier is:

(4)
T *And has been [] ... many places ok []. I want you to do this, I'll be straight down to see you. So sh sh the earth's [] now I want to give you some homework as well so don't put things away. So the earth's population is now so large that we demand more and more goods to be made which uses up resources faster than before. The result is that the earth's surface has been changed and has been badly damaged in many places. We could have said badly damaged in many ways as well. [] The homework quickly as I say, don't put things away because I want to give you homework...*
(Looking at the Environment, 1st Lesson, p.10)

Each agent structure is a cause in respect to what follows and an effect in respect to what came before. The earth's surface has been changed because resources are used faster than before. The latter is due to the need for more goods to be made. More goods are demanded because the earth's population is now larger than before. If each cause has to precede its effect then this specific case of sequence of agents structures (as explanatory chains of cause effect relations) imposes a time sequence as well. It was first the fact that earth's population has increased that resulted in changes at the earth's surface and not the other way round.

Notice here that the way in which the whole event is represented is a matter of choice. Temporality is the option that is followed instead of other ways like for example representing the processes hierarchically or as one evolving from the other. Again this is a feature narratives have. The plot of any story makes its intermediate steps seem unique in a way that if a participant or an action is removed then the story does not make sense or is interrupted. Representing the entire phenomenon as a narrative of escalating action has the effect that the path-link structure is seen as if driven by a plan or a goal that has to be achieved.

Depending on whether the sequence has a cause-effect structure or is a sequence of various agent structures which are related not only causally (but also temporally or spatially etc.) the beginning point of the path can be the initial cause or the source of the sequence and the end can be the final effect or the goal. But there are very few clear cut cases of both types of sequences. Most of the sequences are mixtures of cause-effect relations and agent structures of various kinds. In such cases the starting point of the sequence is used as both the initial cause and as the source of the agent structures, and the end of the sequence is used as both the final effect and as the goal of the path. So for example the action of the farmer who chops down the trees and lets them burn naturally, is the source of a sequence of agent structures and the initial cause of a cause-effect relations which end up with the effect all these agent structures - like the transformation of wood into ash and the release of minerals from the ash which go back into the soil - have on the soil. As a result, intentionality and causality are mixed together in a way that the sequence as a whole becomes a single entity, described by a single word or phrase *slash and burn agriculture* .

7.3.4 Suppressed agency in path-link schema

Agency can be suppressed significantly in the path-link schema if one action follows another without any Agent or cause being involved. This can be realised linguistically as a clause without an ACTOR or a clause which has a passive material structure (see also section 6.3.1). It can also be realised linguistically in terms of clauses which have the structure of a MEDIUM/PROCESS. The use of the MEDIUM function leaves us in doubt whether the participant is the Affected or the Agent (see section 6.2.4.3). Agency between the agent structures is carried by conjunctions like 'because', 'so', 'as a result' ,which impose cause-effect relations between them. In this kind of cause-effect relation a single agent structure can be the cause of another which is the effect. Looking for example at how teacher and students discuss the effect the Greenhouse Effect might have on our lives:

(7)

T: *What what effects might, if the greenhouse effect is really taking place as some people suspect, how might our lives be different in the near future, relatively near future? What might actually happen?*
S: *(...)*
T: *Okay, go on and look for (...) erm, (..)*
S: *No, it's al right (..)*
T: *Okay, I know you don't have to. Right, (...)*
S: *(....)*
T: *Okay*
S: *(....)*
T: *Okay good, if you think about the amount of water that is present as ice at the polar ice caps. If the climate warms up just a few degrees the ice will melt.*
S: *Oo.*
T: *Okay, as a result the level of the sea will increase, low lying islands, low lying areas of coast will become flooded. Can you think of any low lying areas in this country that might risk being flooded. Have*

(Looking at the Environment, 5th Lesson, p.3)

we notice that even if agency within clauses is obscured since we do not know whether the only participant of the process is Actor or Goal or has both roles at the same time:

If the climate warms up just a few degrees
the ice will melt.
Okay, as a result the level of the sea will increase,
low lying areas of coast will become flooded.

agency between clauses is emphatically realised by causal conjunctions between clauses, like 'if x then y', 'as a result...'. In that way clauses follow one another in a cause-effect relation: the warming up of the climate causes the melting of the polar ice caps and the melting of ice causes the increase of the sea level etc. One phenomenon triggers another.

As has been illustrated in chapter 6, conjunction between clauses is one of the ways in which relations between agent structures are realised linguistically. But this does not mean that this is the only way in which relations within a sequence of agent structures can be constructed. Questions addressed by the teacher to the students can carry the agency or cause-effect relation from one agent structure to another. This is for example how a sequence of agent structures concerning changes in the natural environment is built up in the next extract. The teacher keeps asking questions in such a way that an exemplified sequence of agent structures is constructed which is used to challenge the commonsense assumption that keeping something unchanged necessarily means that the natural environment is conserved:

(8)

T	*Conservation is that what you were going to say as well, you were all going to say that were you? OK. So if we are going to try and preserve environment if we're going to try and stop animals becoming extinct plants becoming extinct then we can talk about conservation. OK. now then lets imagine that you go off into a lovely part of the countryside but you find that a farmer out there and they don't do it as much now for various reasons but you find that a farmer out there is about to rip out all the hedges, chop down all the trees in the wood to make a bigger field. [] Is that farmer conserving the countryside by doing that?*
Few	*No.*
T	*So the farmer is changing the appearance of the countryside is he or she?*
S	*Yes.*
S	*Make more*
T	*Was the way the countryside was before the farmer chopped down the trees and hedges the way it has always been or was that a result of change that had taken place earlier?*
S	*No it's a change.*
T	*OK if we were to go back a long long time what might all have the countryside have looked like in Britain?*
S	*Green.*
T	*Green but green with grass or green with something else?*
S	*Green with grass and daisies.*
S	*Trees*
T	*OK there were a lot of trees. most of the countryside was forested OK. So one of the things that we have to be quite careful about when we're talking about conservation is what is it we're trying to conserve? Because most of the places*

that you might go to that you think oh these are lovely they're not like they were 50 years ago. They're not like they were 100 years ago. So you're seeing something as it is today and you're thinking oh this is lovely we've got to conserve it. But do you see what I'm trying to say. That that in itself is different to what it looked like a few years before that a few years before that. It's a res- what you are looking at today is something that has changed anyway over 100s or possibly thousands of years so why do you want to just conserve it in its present state. But if it's gone through 100s of changes anyway to get to that state.

S *...change anymore.*

T *Why not let it keep on changing. What is to say that the next change that it will undergo will necessarily be a bad change.*

(Looking at the Environment, 3rd Lesson, p.2,3)

Questions like:

Is that farmer conserving the countryside by doing that?

So the farmer is changing the appearance of the countryside is he or she?

Was the way the countryside was before the farmer chopped down the trees and hedges the way it has always been or was that a result of change that had taken place earlier.

OK if we were to go back a long long time what might all have the countryside have looked like in Britain?

construct both backwards and forwards a sequence of agent structures which represent the natural environment as being always under change even if human agency is not always involved. We could say that in this case it is human agency which is suppressed. Human agency and change are disconnected so as not to say that every change necessarily needs some sort of human agency in order to occur. At the same time keeping something the same, does not necessarily mean that no agency is involved. So if the countryside is changing anyway then trying to conserve it in its current state demands some agency as well. Finally agency is further suppressed by being disconnected from any kind of intentionality. All these changes which occur either naturally or because some sort of human agency is involved do not mean that they lead to a final nature's intended state:

T *OK good so there might be some examples. But I think the thing that is quite dangerous to do is to assume that because something is going to be changed, it's necessarily going to be a bad change. Because nothing out there is as nature intended it OK although you could argue that we're part of nature but if it wasn't for human beings then every part of the countryside we look at would be different. We've changed everything already. We've changed everything already so why try to conserve it in it's current state.*

(Looking at the Environment, 3rd Lesson, p.4)

In other words what we have here is a long term process realised as an open-ended path-link schema of a sequence of agent structures extended in time. In this path-link schema agency is not necessarily presupposed in order for the process to be carried on. It is rather unlikely for any initial cause or starting point to be traced back whenever there is an attempt to follow the path of agent structures backwards. It is unlikely too that any destination or end point will be found if the path is followed forwards. On the other hand it is certain that some agency is needed if any attempt is made to rest at any intermediate point on the path.

Notice that in cases like some of those above, human intervention is represented as the 'initiator' of a process which triggers a cause-effect relation. Therefore, people are thought of as the primary, responsible agents of what follows in a sequence of agent structure, or in other words the protagonists of the stories. Nevertheless, as mentioned in section 6.3.1.2 the lexical choices for representing the 'initiators', such as the use of the indeterminate *you* or the generalised *farmers* have the ideological implication that agency is attributed to a level at which specific agents cannot be identified. Also in the case of acid rain, the indeterminate, generic *our* as a classifier of the agent *factories* obscures the nature of the agent by keeping us from looking for its identity. In that sense agency is suppressed in the way agents are represented. Furthermore, agency is suppressed by the fact that stories or sequences of agent structures are recalled not by their primary agents, but by their effects in a nominalized form. So the example of acid rain is remembered by its effect *the devastation of Scandinavian forests* and the actions of the farmer has become a type of agriculture *slash and burn type of agriculture.*

7.3.5 Blockage of agent structures involved in path-link schemata

Agency can take the form of active blockage of a process, that is, of counter-agency:
(9)

S ...*I watched a programme about ...and people went round testing the streams where they pumped out more chemicals and everything and fish were like changing from female to male and male to female and having both ...*

T *Yeah that's interesting that's worth talking about. One of the things is that for most of these products if they're toxic it's illegal to put them out but if you have a huge company that products millions of pounds of profit each year then quite often if these companies get taken to court they might get fined £20,000 [] it's peanuts it's like you and me giving 10p away. It doesn't really bother them it doesn't really bother them. It's cheaper for them just to keep on getting prosecuted than to install all the equipment that's needed to dispose of that waste properly.*

S *Somebody said that...illegal robbery is illegal and people still do it.*

T *People still do that yep there are always going to be people anyway who try to get away with things.*

(Looking at the Environment, 3rd Lesson, p.9)

Counter-agency can be traced as a path-link schema of agent structures which has the opposite direction to another path-link schema of agent structures. The two path-link schemata can have the same starting point but then one is heading against the other. That is the case of the causal link which produces the Greenhouse Effect but at the same time a possible 'correcting mechanism': the increasing number of plants like algae, is heading towards the opposite effect, a decrease of the amounts of the carbon dioxide:

(10)

T: *Algae formed the basis for a whole load of food chains. So animals will come along and eat the algae. As a result bigger animals will eat the animals that ate the algae and so on. Some people think the greenhouse effect won't actually really take place and that any changes that we have seen in the temperature of late are just changes that would have taken place anyway. Some people say we haven't been recording the temperature long enough to actually to be able to detect any overall patterns. They think that because there are so much algae around that if the carbon dioxide levels increase slightly, what will happen to the amount of algae?*

S: *It would*

T: *It would increase it, it would use up the extra carbon dioxide. That might be quite a good thing, if there is more algae then what will the algae be able to support more of*

S: *Animals*

S: *Animals*

T: *Animals that eat the algae and so on, okay? So some people say they think that the greenhouse effect isn't really going to happen. If levels of carbon dioxide do increase then the earth has if you like self correcting mechanisms that will bring it back down again. Okay? And there is some dispute as to whether or not the greenhouse effect is a real thing that is actually happening. Right, shhh. Why is, why is it called the greenhouse effect?*

(Looking at the Environment, 5th Lesson, p.5)

So competitive sequences of agent structures can appear not only in cases where human agency is involved almost exclusively (laws and institutions against companies' interests) but also in cases where agency of other living organisms plays an important part.

Besides active blockage, we also find passive blockage. An entity is represented as like an obstacle in a path which either delays or prevents the process from reaching the goal (or destination). This is the case with narratives when the plot has an unexpected twist because of the action of a character against the flow of the events.

The entity itself can be a part of a sequence of agent structures. So the passive blockage is the single thing-like entity where two sequences of agent structures meet each other in an opposite direction. This is not the same as the correcting mechanism above of the GHE, which is presented as if it is intended for the purpose of being opposite to the effect the GHE has. Examples of passive blockage are the ozone layer which allows only part of the UV rays to reach the surface of the earth:

(11)
T: *Anybody like to tell me okay I'm just hesitating because you've answered tons of questions and I'm just seeing if there's someone else here*
S: *...*
T: *Ozone layer. If you're lying on a beach in a hot sunny country*
S: *...*
T: *why is it nice to know that there is an ozone layer up there. What does it do?*
S1: *Ohh I know sir*
S2: *...*
S1: *Sir sir maybe it's erm like if there wasn't any ozone it would be like sun and there wouldn't be anything like c.. erm a lot of shade. 'Cos it blocks all the shade and then ... see the sun.*
T: *Right*
S: *Like you wouldn't get burnt and if the ozone wasn't there then the sun you .... burn*
T: *You are*
S: *burn afterwards ...*
T: *virtually there. Did you want to add something?*
S: *Is it a layer of gas?*
T: *... layer of gas*
S: *.... fair*

(Looking at the Environment, 5th Lesson, p.11,12)

and the algae at the sea surface which block the Sun's light and oxygen to reach the organisms in the sea:

(12)
T: ...So, in no time at all these plants are all flourishing very well but in not time at all so do the algae. And they're growing like mad on the surface of the water, and in no time at all they form a blanket over
S: over the land
T: the whole pond. And immediately that cuts out the sunlight. No sun?
S: No photosynthesis
T: No photosynthesis. The plants down here cannot make food.
S: They don't .... oxygen
T: They die, because they've died they don't?
S: Make oxygen
T: make oxygen to put back into the water.
S1: ....
S: ....chain reaction
T: No oxygen being put into the water means the fish
S: die
T: would die. Also added to this, because the amount of dead stuff at the bottom will now increase very quickly, so will?
S: Nitrates
S2: Nitrates
T: The bacteria
S: .... nitrate ...?
T: Because now there's a lot of food for the bacteria. The bacteria are living things so what will the bacteria
S: ....
T: use up?
S: ... erm

S2: Oxygen
T: They will use up the oxygen. They will produce?
Ss: Carbon dioxide

(Lesson: Nitrogen cycle, p.4)

In the first example, a possible story is invented by the teacher in order to show the effects of a general and rather abstract phenomenon (the depletion of ozone layer) which is found at a global scale. The indeterminate *you* allows the student to consider him/herself part of the story. In the second, an environmental accident which is seen as 'innocent', the accidental leak of fertilisers near the pond, is developed in a dramatic way discussed in more detail in Appendix 5.2. The purpose of inventing a story in this case, is not only to show possible effects of specific kind of environmental accidents, but also to apply knowledge about entities and study their interrelationships in a specific context.

7.3.6 Implications of the use of stories

In this section examples of teaching in terms of path-link sequences of agent structures have been discussed as being similar to stories, narratives. A path-link schema has a structure like a story's plot. The schema like a story can be treated as a single event-like entity, realised linguistically in terms of a nominalized process *slash and burn type of agriculture* or nominalization *the devastation of Scandinavian forests.* Similarly to stories, the structure of the schema can be elaborated with more entities and relations, being expanded to a more complicated and sophisticated structure (like in example (12)) or reduced to a very basic form (like example (11) in relation to example (1)). Therefore, stories and schemata are flexible ways of representing environmental science, affording choices about what should be represented.

A rich source of stories is the recent environmental literature about environmental accidents and catastrophes as well as scenarios of possible disasters. Stories which are invented by the teacher are presented as having dramatic consequences and involve the hearer (student) in the crucial role of the agent (see example (3)) or the affected (see example (11)). The dramatisation of stories does not only attract the attention of the hearer, but makes more convincing the reality of agents and effects.

The value of stories as learning tools, in the context of environmental science, to engage the hearer/reader and keep his/her interest, is the same as what has been recognised as their interpersonal value in studies of narratives in general (Riessman, 1993). An indication that this learning value is effective in the examples mentioned in this section, is students' responses to teacher's stories with stories which come from what they have heard or experienced in their own lives. This has also been another property which characterises a narrative; one narrative triggers other counter or reinforcing narratives.

The effect of using these kinds of stories is to represent their account as the 'only', 'true' versions of what is happening. This has epistemological implications, in respect to what students might think about the methodology of science. As Hajer (1995, p.62) has pointed out, representations of environmental problems in terms of stories - or what is called in environmental sociology as 'story-lines' - impose 'discursive closure'. Complex research work accompanied with all the usual uncertainties and conditionalities is erased in its translation to a plot or story-line.

Note that in most of the examples of narratives discussed above there are no disputes included in the narratives as to whether phenomena 'really are' the way they are represented. Probably the only exception is the GHE for which two conflicting possible outcomes are represented by the teacher. It is only here that the scientific community is represented as not always being in harmony in what it thinks about nature. Arguments within the scientific community are represented as counter sequences of agent structures (see example (10)). But even here nothing is mentioned about how scientists have found a way to explain and represent environmental problems, such as GHE and the depletion of ozone layer.

One of the most important aspect of the stories discussed here is that the relation between the hearer and the story is like the relation between a direct observer of nature and nature. Teacher and students seem to take the role of direct observers of nature, reporting 'authentic' events extracted from nature. The degree to which for example agency is used has an effect on how much what is said looks like a narrative or not. Therefore, how entities are treated in terms of agency structures has a direct impact on whether they are represented as participants in plots which take place in nature or as the objects of scientific inquiry. As Myers (1990, p.153) has pointed out, representations in terms of material processes (and not in terms of nominalizations and nominalized processes) give the impression that the order of 'phrases' corresponds with the temporal or/and causal order of what is happening in reality. So accounts of knowledge about the environment become a narrative of nature. This sort of representation in relation to what has been said above for the specific examples of teaching promotes an objective account of what is happening since the information is there, in the stories, but the connection to scientific activity is lost (Myers, 1990, p.148).

At this point we can distinguish two kinds of narratives. Most of the examples (see examples (3), (5), (8), (9) and (12)) of narratives discussed in the present section are timeless (verb structures in present tense, no reference to a specific time). Such representations suggest that what they describe happens in more or less the same way if similar conditions apply. So for example, in every case in which there is a heavy industrial activity somewhere accompanied by the appropriate weather conditions, it is expected that nearby areas will be affected from some sort of pollution. These kind of narratives are abstracted from reality and treated as objects of science. So it is not accidental that it is such timeless narratives which are represented as if they are the phenomena to be explained themselves.

The other kind of narratives are those which have specific time references (e.g. *In 1858...*) using past tense. These sorts of narratives are closer to how stories are exchanged between people in everyday life and they are like observations to the extent to which they suggest to the hearer to 'see' things as if they took place in 'real' time. While these narratives endorse the reality of what is reported by making reference to specific time and place circumstances, the previous narratives rest their objective effect on the fact that they are reported as 'objects of science', abstracted and generalised. Notice also that in many cases students' personal accounts start with narratives which have specific time or/and place references and are followed by teacher's timeless unfolding of events (see example about allergies caused by pollen and example (9)), or teachers end up with a narrative which is a blend of specific time/place circumstances and a timeless plot (see examples (8) and (12)). The combined effect of the two features of the latter is that they constitute generalised and abstracted accounts of events which occur in a specific context.

In conclusion, examples of stories in this section show that they are discussed in the classroom as if they reflect exactly what happens in the real world. Teacher and students tell stories, as if they were opening a window and watching what is going on in the world. As a result, what is happening in nature is represented as being a narrative itself, particularly when the story which is supposed to stand as an example of the phenomenon to be explained is taken as the phenomenon itself, that is the object of inquiry. In this way environmental science turns to be a narrative of nature and learning is transformed into 'reading' nature itself and revealing its plot abstracted and generalised to some extent from the specific context in which it is looked.

7.4 Containment relations

7.4.1 Introduction

Representations in terms of containment schemata are some of the most fundamental in the discourse of teaching environmental science. Pollution is often described as an agent which either 'escapes' from containers and spreads into others or has to be kept contained and if possibly destroyed for the 'safety' of other entities. Containers impose closure and separation so they also affect the conditions for an action to happen or not. In the following section a whole spectrum of containers is discussed. Some of them are represented in the classroom as man made and others as natural. Some have physical boundaries whilst others they are represented in a way that boundaries are metaphorically imposed. A container shows either where or how something - another entity - can be found or gives a strong sense of a 'within' relation.

7.4.2 Highlighting aspects of containment relations

7.4.2.1 Closure

Under the containment schema - defined as an entity found within another entity (see section 4.4.5) - a large number of containment relationships which vary in scale can be represented, such as being in a pond or a forest and also being in an organism or a cell, in the same way as a large number of our everyday experiences are grounded in containment relationships found at any scale, like being in a box or in a room or in a building.

Containment most of all imposes relations of closure. Entities which are contained have little or no chance to get out. A good example of this sort of containment relation is a teacher's example of the pollution of the Mediterranean sea:

(13)

T: *Think of a sea that's pretty much land locked, land all the way round ...English Channel. Most of you have probably been there at some stage []*

S *Mediterranean.*

T *Mediterranean. Because there are countries all round the Mediterranean it's pretty much land locked if you have a look at a map it's just that little channel at the bottom of Gibraltar North African that the sea can come in and out through most of the stuff that's pumped into the Mediterranean stays there. And in fact when I think of the times when I've been there there's been days,* *you know those sort of pedalo things when I was younger I'd go out on a pedalo and you'd look down in the water and you would see everything floating in the water. Basically all the stuff that people put down the toilets is there floating in the water. Ok disgusting.*

(Looking at the Environment, 3rd Lesson, p.6)

The land locked Mediterranean sea is represented as a container where there is a continuing massive input of pollutants and a very limited output of them. Pollution is represented as a concentration of unwanted entities which have no way out of their container. This aspect of the containment relationship is stressed by the teacher's effort to illustrate vividly what is going on in the container by sharing his personal insight with students. The story-like instance brings the scale that such a container entails to an accessible and therefore manageable level.

The containment relation can also be used for representing theoretical entities and relations which are taken from scientific knowledge. This is the case with the same teacher's explanation of the Greenhouse Effect in another lesson:

(14)

T: *If you are in a greenhouse. Heat from the sun can actually get through the glass into the greenhouse, but once it is in the greenhouse something happens to it. Okay. Which when we get into GCSE and we've actually covered the theory on it we can actually explain a little bit more easily, okay. But something happens to it, that's all you really need to know at the moment. Which means that it cannot get out again so once it's in there it's trapped. It just keeps reflecting around inside the greenhouse like that, it is trapped inside.*

S: *Unless you open the door.*

T: *Unless you open the door and some of it can get out. But the glass can trap that heat so it can't escape again. A little bit will but not much of it. If you're standing outside and heat is coming down from the sun, you will get a small amount of it, you will if you're standing there absorb a small amount of it. What will happen to the rest of it?*

S: *(...) go*

T: *It will go. It will just reflect off in all sorts of directions. Some of it will go back out into space again. Go up through the atmosphere and back out into space.*

S: *It won't because of the greenhouse effect.*

T: *Ah, good, good. Now then. I think we've said this before. We've mentioned carbon dioxide. How many of you when you've been out in the country, have walked along behind a cow and as they've walked along they go phhhh, phhhh, phhhh.*

S: *Well believe it or not I don't actually stand behind cows.*

T: *Ha, ha. Very wise. Very wise. Okay, now then. Gases like carbon dioxide go up into the atmosphere, animals like cows when they let off produce a gas called methane. That goes up into the atmosphere, okay. And there are a number of other gases which go up into the atmosphere will actually act like a big pane of glass. They allow the heat from the sun to come in but will allow it to go only so far and they will reflect it back down again, so they actually trap the heat in around the earth. Heat that otherwise would have been reflected back out into space again is trapped and reflected back down to* *the earth surface so we actually absorbing trapping much more of the sun's heat than we otherwise would be doing.*

(Looking at the Environment, 5th Lesson, p.6,7)

In this extract the atmosphere round the earth is represented as forming a container which has a very special property; entities can get into it but there is no way to get out of it. The difference is that in this case there is no observable entity to form physical boundaries. The analogy between the phenomenon of the Greenhouse Effect and the Greenhouse creates some special properties for what is represented as a container. Reflection caused by glass in Greenhouses replaces the lack of physical boundaries up into the atmosphere *it* [heat] *is trapped inside. ..it can't escape.* Notice here that a physical entity *heat* not so often realised as a thing-like entity in everyday life, is engaged in relations of agent structures which are used for thing-like entities. Heat is here represented behaving like a thing.

Containment represents other types of closed-ness as well. Take for example the teaching of the Carbon cycle which requires the construction of a large number of complicated relations (later discussed as a cycle) between agent structures and containers. In this context the in/out orientation that entities can have in relation to various kinds of containers is emphasised. Carbon dioxide is represented as getting out of the human body and getting into the atmosphere, while oxygen follows the other way round. The direction in which the chemicals are heading in this journey from one container to another is highlighted as important by the teacher. Furthermore, the entire idea of the cycle is grounded in what is transferred and from where (to where):

(15)

T: *Where's the atmosphere?*
S *All around us /*
T: *All around us, OK [ ] How does carbon dioxide get into the atmosphere?*
S *We breathe it out /*
T: *We breathe it out. Just us? /*
S: *Animals /*
T: *OK animals /*
S. *and trees take it in and plants... /*
T: *Alright, let's just do one thing at a time Mitch, animals breathe out carbon dioxide? / S.... / T ..Mitch, that's enough....[ ] Why do they breathe out carbon dioxide, where does the carbon dioxide come from?*
S: *.... /*
T: *No, no the trees are going to do something else in a minute, we'll look at that. Where does this carbon dioxide coming from that we are breathing out?*

(Lesson: Carbon cycle, p.9,10)

As we can see in this extract it is considered as important by the teacher that the students will grasp firmly the idea of where something comes from and where it goes. These relations will be modified later to the extent that they are not represented as discrete entities which are getting in and out of containers but as continuous entities and therefore the question is how much of an entity is transferred and where, in relation to other entities. So now containers, like lungs and the atmosphere, are represented in terms of balanced and regulated inputs and outputs of quantities entities:

T: *We breathe out more than we breathe in. We're adding to the carbon dioxide in the air every time we breathe out.*

(Lesson: Carbon Cycle, p.10)

7.4.2.2 Separation

Containment relations also represent separation. Containers either separate or bring together entities. Entities like dirty water or pollutants which affect other entities have to be contained. Settlement tanks used at sewage works are an example of containment relations which represent separation:

(16)
T: *Has anybody any idea what might be meant by a settlement tank?*
S ...
T *Ok if you get something like sand, lets imagine you put sand in with water and shook it up, the sand would be distributed throughout the water but when you leave it settle because the sand particles are quite heavy they'll fall out to the bottom. Ok and there are other things in that sewage which if you leave it in these big tanks will settle out to the bottom there. IN the bottom of the settlement tanks you get a lot of sludge. The sludge is all this stuff that's settled out that's sunk to the bottom ok. On top of that you get the liquid which is getting to be more and more like water it says that that liquid then goes off to what is called an aeration tank. In the aeration tank there are microbes bacteria and so on. Any pollutants that are left in that water the microbes will feed on ok and get rid of them. As those microbes feed they produce carbon dioxide that carbon dioxide is released into the air in the same way as we when we break down our food our ...carbon dioxide those of you who are still writing I hope that you're following this as well and are not going to ask about it in a moment. So carbon dioxide is given off. [] However although the ;microbes might have fed on the pollutants there will still be things in there ok so again it goes off to a settlement tank in that settlement tank any of the bits that are still in there will have a chance to settle out and then the water will be returned to a river. In the second settlement tank some more sludge will be formed that sludge will go off to something which is called a sludge digester. [] Ok a sludge digester again there are microbes in there different sorts of microbes that will feed on that sludge and they will produce a gas called methane.*

(Looking at the Environment, 11th Lesson, p.5)

Dirty water is passed through a number of containers. In each of them certain entities are brought together in order to interact with each other and others are kept apart avoiding as much as possible any interaction. Therefore, each tank is represented as a container which provides the conditions for certain sorts of agency to take place while preventing other kinds of agents from action. The system of containers here is man made and its role is to prevent the release of man-made pollutants industries into natural containers, like rivers and ponds. In that way human intervention is represented in terms of man made systems of containers which interact with systems of containers given by nature. Thus a container becomes a tool for exercising control on entities. This control depends on what the desirable outcome will be, and is represented in terms of bringing together or bringing apart or removing entities from containers.

But in cases where no care is taken whether pollutants like *rubbish* get in contact with water, pollution carried by carriers like *river* is likely to get into containers like *pond.* As a result living entities *fish* which are found in them are affected. The latter are containers by themselves which now carry pollution even further to other living organisms, like human beings. The conclusion of the next story is that if pollution cannot be kept separated from entities with which interact, then it will be inevitable that pollution will spread and affect various entities since the latter consists of a system of containers and carriers:

(17)

T *It is likely that the water from the stream possibly comes from the marsh and it might run into the pond ok. [] It might be the other way round we'll have to a bit, a more careful look and have a think about that but it is possible that is running from the marsh down into the pond. So if rubbish is burnt, buried in the marshy area. Depending upon what sort of rubbish it is pollution might get into that water. That water would go down in to the pond. It's got a use of the pond though it says it's used largely for fishing and sailing. Again depending upon what sort of pollution it is what*

S ...

T *The fish might die.*

S *...pollute the fish so that it makes humans sick when they eat them.*

T *That is quite possible, even if the fish didn't die they might not be good to eat. What might happen if you were to fall out of your boat into the pond and it was polluted.*

S *You'd die.*

S *you could get...*

S ...

T *Right came up as a rash. You could get poisoned as a result.*

(Looking at the Environment, 3rd Lesson, p.5)

Also the lack of separation can be represented in terms of insufficient boundaries which cannot keep an agent within a container. This is the case of landfill sites which cause various problems to their surrounding environment:

(18)

T: *Well there actually some landfill sites round here I know I've driven past them I'm just trying to remember where they are. If you go past the landfill site, you tend round the outsides of it to see little posts with wire mesh fencing around.*

S *There's one in Ealing.*

T *There's one in Ealing is there.*

S *By the Ealing hospital and they could use them for the parks if they didn't put all rubbish underneath.*

T *Ok what you also tend to find, excuse me, is when the wind is blowing and things like that the rubbish that's in there that hasn't been buried blows around and it sticks to the wire mesh fence so it looks really unpleasant as you go round it ok.*

(Looking at the Environment, 3rd Lesson, p.7)

In all the examples above we notice that containment relations are prerequisite for the occurrence or not of agent structures. Since agency can never take place at a distance, entities which participate in it have to be kept together. This is what containers do. But for entities to be brought together carriers are the entities which link containers, as we will see in the next section.

Containment relations work out in a silent way representations of the nature of entities and their relations. The entities one expect to find in one container, say sewage, are different from the entities which are expected to be found in another container such as a forest. So different kinds of containers create different expectations about the entities in them.

Taking one step further we notice that containment relations in this context work in the same way as the ontological metaphors discussed by Lakoff and Johnson (1980). According to the latter, containers impose boundaries on entities such as physical phenomena making them discrete from others. This is also applied to entities such as processes and life experiences which are metaphorically viewed as thing-like entities, discussed later as metaphorical extensions of containment relations. At this point it is noticed that it is a matter of choice in making meaning in a specific context where the boundaries are set in representing entities as discrete from others. Constructing the ontology of containing entities is an inseparable part of building up relations between entities or in other words in doing science. To give an example, if the atmosphere round the earth is not seen as a container then the GHE simply cannot be explained. Finally, the example of the Carbon cycle above shows that defining a container opens up the possibility for acts of quantification. That is, both the contained entity can be counted as a quantity and the container itself can be seen as having a quantifiable volume.

7.4.3 Containing the invisible

Containers like sewage tanks or ponds and fish are at a level which is accessible to commonsense knowledge. But as we have seen above containment relations like the Greenhouse Effect which are at the scale of the very large and unobservable demand more explanation of how containment can be obtained and can work. These explanations are often in terms of entities taken from our everyday world (e.g. 'pane of glass') which provide good examples of separation. In the same way at the scale of the very small and unobservable separation is again realised in terms of analogues to commonsense knowledge:

Cell membrane This thin skin controls the flow of all the substances which pass in and out of the cell...
Cell wall Plant cells are surrounded by a firm wall of cellulose. Cell walls hold plant together and give plants much of their strength.
(Active Science, p.120,121)

In this little extract, from a chapter of a textbook which is about living cells, discussed earlier in more detail in terms of how language represents the unobservable, we notice that the problem of how boundaries and therefore separation is imposed for representations of containers at the scale of the invisible (to the human eye), is resolved by making use of representations of boundaries found in the everyday world. Skin provides a good example of separation which permits regulated inputs and outputs between the contained and the outside due to our experience of sweating, and walls in building constructions are also a good example of strong boundaries. Separation for cells is concerned also with specialisation. Cells are represented as the compartments in which certain sorts of jobs are carried out:

Different kinds of cells do different jobs. The structure of a cell matches the job it has to do.
(Nuffield Science 13 to 16, Study Guide 1, page: 23)

This is also what the metaphor which resemblances cytoplasm with chemical factories represents:

Cytoplasm This is the chemical factory of the cell. Here, new substances are built up from material taken into the cell and energy is released and stored.
(Active Science, p.120)

In other words, a job which presupposes a number of processes dealing with quantities of materials cannot be done without some sort of specialisation. Furthermore specialisation entails containment relations since not all jobs can be done at the same time and at the same place.

There are plenty of representations of containment relations for which separation and closed-ness is not the most important aspect. In these representations what counts more is that some entities are places in which others are located:

Chemicals from the sea
Some people like to cook with sea salt. The sea is also the source of magnesium and a liquid called bromine...
Chemicals from the air
About one-fifth of the air is a **reactive** gas called oxygen... About four-fifths of the air is nitrogen... The air also contains small traces of a family of gases that includes helium, neon and argon.
(Nuffield Science for Key stage 3 , p.4)

We are used to think of sea and air - apart from being the environment of living organisms - as single entities. The containment relations here represent these entities as sources of many other entities which are part of them. So in a way the containers are defined because of their parts and contents rather than by any sort of separation imposed by boundaries. This is also the case with how ecological niches are represented:

...niches are filled by ...
...was partly filled by a bear-like...
...more successful at filling the niche.
...the vacant niche.
Often it fills the niche so successfully that it wipes out the competition...
(Nuffield Science 13 to 16, Study Guide 1, page: 109,110)

In these examples there is a strong sense of location of a physical place which is represented like a residential area: a niche is a place with the purpose of being filled and living organisms are the tenants which can be so successful in their tenancy that they can become the occupants or even owners of the places. An organism does not just find itself located somewhere, but locations have to be found. Since it has found a place for being 'located', then it is involved in a process for keeping that place. Therefore, containment relationships and boundaries are imposed by a stressed sense of location: an organism can be in or out of a niche. The ideological implications of such representations raise questions about how we think about the concept of property and location as 'social' beings and how we think about these concepts in relation to how we realise our place in nature as 'physical' beings. The next sub-section deals with those kind of containers for which boundaries and separation are imposed metaphorically.

7.4.4 Metaphorical extensions of containment relations: Containers without physical boundaries

7.4.4.1 Sets of relations impose boundaries

The outcome of metaphorical extensions of containment relations can be an entity like a specific kind of environment, say a hostile environment, which is built up as a container entity. The container in this case is not defined by its boundaries but in a number of different ways which make it look as if it has physical boundaries:

(19)

T *Ok a jungle. Now then why might a jungle area be natural. [] Your right in saying that but why. You want to continue seeing as you started.*

S *...I don't know.*

T *Yes.*

S *Is it because there's no machines ...*

T *Ok it's growing by itself. we haven't been out there. We haven't been chopping down things we don't want planting things that we do want building buildings and so on it's unspoilt. It's unspoilt, untouched by human hands ok, a hostile environment.*

S *...*

T *Your house I like it.*

S *My garden.*

T *It's the same hands...a hostile environment?*

S *Is it ...*

T *Ooh it's not I wouldn't have said so. What would happen if one of you er, lets try and think about a good example. If one of you went up to the north pole ok and you didn't have all your coats and goggles and gloves and everything to keep warm. Would it be comfortable being there?*

All *No.*

T *Ok somewhere, good, somewhere where it might be uncomfortable. Where it might even be dangerous for you to live.*

(Looking at the Environment, 2nd Lesson, p.2,3)

Creating a set of relations is one way of imposing boundaries. What one expects to find in one set of relations that makes it unique and different from others, one does not expect to find in another set of relations. An entity is differentiated by sharing some properties in a set of relations along with other entities. So in a way abstract boundaries are imposed between entities which share properties within different sets of relations. The thing-like and process-like entities that are expected to be found in a hostile environment are not the same as the entities that are expected to be found in other kinds of environments. An analogy is that between countries, regarded as distinct places because different laws and customs obtain in them.

The instantiation of each type of environment makes the 'abstract' boundaries more concrete and real. A jungle or the north pole as examples of hostile environments provide a very concrete 'idea' of what is meant by being in a hostile environment. Then the containment relationship is elaborated further by making reference to the entities that one expects to find in a given instance of a hostile environment, thus imposing a within relation between them.

As a result it is not only the entities which are located in a given place that create a 'within container' relationship. The relations that connect the entities together is what it keeps them differentiated from other entities. So in the end being in a containment relation means being part of a certain set of relations; agent structures of various kinds, that bind entities together and of which other entities are not part, thus not contained. To put it simply, in these representations of containment relations being in a container means being in a relation of some kind. The entities that are not supposed to be in the container are those that are not related in the same pattern of relations.

7.4.4.2 Agent structures impose in/out relations

A containment relation can also be created by various sorts of agent structures which impose an in-out orientation. This is how pollution is elaborated. If there is a polluting agent somewhere then one way to prevent its unwanted action is by removing the affected entity somewhere else, for example when people move away from a power station. In that way even if it is not clear whether there are physical boundaries which surround the place within which the pollutant acts, the removal of an entity to a place that is beyond a pollutant's power defines a sort of containment relation. What is within the container is what can be accessible to the agent's agency. An entity that is not reached by agent's action is outside of the containment relationship:

(20)
T: *Living where we do, have we got any choice in what we breathe in?*
S *No.*
S *No.*
T *We've got no choice about it all. [] Unless we move*
S *Yes you have you could move.*
T *We could move if we want to live here []*
S *No you could move to ...*
S *...pollution because you don't know*

(Looking at the Environment, 1st Lesson, p.2)

In the same way it can be the agent which is removed and not the affected, as for example in sewage treatment. As we have seen above the latter has many variations, such as using an agent (bacteria) to destroy the unwanted agent (certain kinds of pollutants). Sewage treatment is an example of physical boundaries as well but this is not the only way in which boundaries and within relations are realised.

In our everyday life too there are metaphorical extensions of containment relations in the same way as described above. In various situations, the containment schema is extended to elaborate agent structures like love or professional relations as Lakoff and Johnson have illustrated (1980). These are often expressed vividly in phrases like "I can't get out of it" implying a metaphorical barrier or boundary to do with being under the power of somebody else, and metaphorical separation such as keeping away from other potential relations.

7.4.4.3 Nominalized processes afford thinking in terms of categories

Aspects of metaphorical extension of containment relations arise also with packaged agencies referred to by a nominal group or a nominalization. Even if teachers explain event-like entities such as photosynthesis in terms of a sequence of agent structures, they later refer to a single agent structure as if it is found within the event-like entity. For example, a photon being absorbed 'in' photosynthesis. Here 'photosynthesis' is represented and treated as a container in which certain agent structures are found. These agent structures acquire a very different meaning and become something else if they are seen outside the event-like entity. The release of Carbon dioxide for example if it is seen outside of the event-like entity 'respiration' is a very different process, for example the outcome of burning entities like fossil fuels:

(21)

T:	*What's the connection between respiration and photosynthesis?*
S:	*They go together /*
T:	*How do they go together? What's the relationship between them / S: ...animals... / T: Animals and plants right / S: animals eat the plants and we eat animals or we eat the plants / T: Right / S:.... / T: Listen listen then, listen / S: .... / T: The plants make food in a process called photosynthesis / S: .... / T: Say it / S: .... / T: say it / S: .... / T: Well done, in a process called photosynthesis which they use carbon dioxide from the air to make that food.*

T *Animals eat the plants so now the carbon dioxide that was used to make the food has been incorporated into that food. Now the carbon's got into us / S: .... / T: Just a minute, why do we need food? / S: .to live... / T: Well be a bit more specific / S: energy /*

...

T: *Is that the only way that carbon dioxide gets into the air these days? / S: ..No.. / T What other ways / S: From factories / T: From factories / S: ... / T: Where else / S: Cars / T: Cars / S: .... / T: Sorry / S: Houses / T: From houses / S: Burning things / T: Burning things, in particular which things? / S: Fossil fuels /*

T: *Fossil fuels. Right. What are the fossil fuels /*

(Lesson: Carbon Cycle p11,12)

Processes, often recalled as nominalizations, like photosynthesis and respiration, represented as containers afford thinking about them as conceptual categories. That means that other process-like and thing-like entities are classified under these categories so the student who studies them knows where to go and look for them. A lot of classification is carried out in that way and some very refined meaning relations are constructed. As a result entities of the physical world are classified together and differentiated at the same time. But what we should notice here is that this classification of entities is not based on a number of abstract criteria or properties that the entities have to satisfy. Respiration is just the nominalized term which stands for the process of releasing Carbon dioxide in the atmosphere and energy when digested food interacts with oxygen in cells. So when the teacher asks what has happened to Carbon during respiration, the answer is not supposed to stand against some abstract criteria (or a formula) that are satisfied or not but against representations of image schemata in which Carbon is involved. These schemata are in terms of agent structures in which an entity is transferred, turned into something else and contained within another entity.

Food webs and cycles of life are also represented as containers in terms of deterministic causal connections in relation to process-like and event like entities. Such representations afford little or no thinking of a plant or an animal which escapes the circulation of matter and energy in the ecosystem. Metaphorical extensions of image schemata work also the other way round; containment relationships either represent or imply certain kinds of agent structures. Entities like the various sorts of ecosystems are represented at first sight as place-like entities which are the containers for several kind of entities found in them. But after teaching, ecosystems are transformed into containers of a very different kind; they are represented as process-like entities so the entities which are thought earlier to be contained within them are now thought to be contained within a system of relationships. All these examples show also that the way an entity is introduced in the first place does not necessarily mean that this is how the entity will be represented later after teaching.

7.4.5 Conclusion

In the present chapter it appears - and indeed is the case - that anything or everything can be seen as a container. If this is so, the question arises of what meaning there is in saying that something is a container. It is a matter of treating an entity as a container or not, for a purpose. There is still a choice - to treat as a container, or not. And that choice is made so as specific meaning relations are addressed to students. As has been illustrated above such meaning relations include fundamental ontological aspects of entities, like what the entities are by imposing boundaries on them and where they belong by setting up categorical relations. The process of choosing what will be represented as a container and how, implies that some aspects of meaning are highlighted while others are hidden, so in other words ontological and learning (in terms of what is considered as valuable knowledge to be transmitted to students and be learnt by them) implications are inevitable.

7.5 Carriers as transportation systems

7.5.1 Identifying an entity as a carrier

In the teaching of environmental science it is often assumed that entities are transported from one place to another. Rivers and rain are seen as having the property of a carrier, due to our everyday experience of running water which can carry both continuous and discrete entities (e.g. silt, sticks). Other entities like the blood stream and prevailing winds are also carriers represented as transportation systems.

In our first example, the teacher introduces students to the idea that quite a lot of entities which surround us in our every day life may carry other entities. As one can see in the following representations of carriers, the property of carrying requires that the carrier is a container or at least a place-like entity for the entity which is carried. Entities like the food we eat and the water we drink can be containers of other entities. Air is more unlikely to be thought of as a container because of its transparent nature; it is more problematic for our commonsense understanding to think of air carrying entities (see also chapter 3) if nothing can be seen in it. This is more obvious when we think about cigarette smoke, since smoke is observable and indicates that something is in the air:

(22)

T *Hands up those of you shshsh [] girls [] hands up those of you who, are concerned about what might be in the food you eat the water you drink ok pop your hands up [] perhaps if you go to the doctors you might be concerned about what's in the tablets the doctor gives you. If that's you, if that's you put your hand up, keep them up [] now then [] now then keep your hands up if you have also wondered from time to time what might be in the air you breathe.*

S *I'm frightened there might be little creatures.*

T *Good I'm surprised at you because I quite often ask that and [] you can put your hands down now. I quite often ask that and people seem to go through their lives worrying about what they eat and so on unless it's something about what is in the air.*

(Looking at the environment, 1st Lesson, p.2)

7.5.2 Non-intelligent systems of transportation found in nature

The teacher's example above opens up new possibilities about entities. It is not only intelligent living organisms which have intentions and desires and can move other entities including themselves, but non living, material entities can do so as well. Prevailing winds are represented as a system of carriers which have a certain direction in moving entities for most of the time. In that way prevailing winds are represented as transportation systems in the same way as lorries carry things from one place to another:

(5)

T *We're not actually, we're not actually [] putting stuff in lorries and taking it up there and dumping it, but when our factories kick out all of this poisonous smoke that goes up into the atmosphere where does it get blown to?*

S *Scandinavia.*

(Looking at the Environment, 1st Lesson, p.4)

The fact that there are representations of transportation systems which are driven by non-intelligent, non-living entities has consequences for what has the power and therefore control over what is transferred. If pollution is carried away by the prevailing winds then it is not located permanently in one place by being contained and static. Entities obtain the potential property of being mobile and being in contact with or mixed with other entities; something which cannot happen without the help of carriers. The consequences of this interplay between the static and the dynamic are represented vividly in textbooks as well:

All terrestrial organisms depend to some extent on water to transport material around their bodies. In general, the larger they are, the more dependent upon this form of internal transport they become.

(Environmental Science, p.68)

Humans must be very careful over what is introduced into the air system. Water and heat are important things carried by the winds around the world, but pollution can also be taken with them.

(Air Ecology, p.14)

In other words, carriers as transportation systems are represented as essential for sustaining life on earth by keeping relations between entities, but on the other hand unwanted entities entering systems of carriers can have a devastating effect by upsetting these relations.

Carriers such as streams and prevailing winds are represented as constant 'flow movement' regardless if there is any entity to be carried or not. They are also represented as if they are 'running effortlessly' by without any agency applied to them either to keep them going or to regulate the rate of flow.

Transported entities are also represented in new ways. Seeds from plants are dispersed by wind or by animals in various ways. And this is because seeds have properties which make it easier to transfer them in one way rather than another, by the wind for example. Such entities are seen as being adapted to what other entities can do for them:

Dispersal of offspring
Plants have no control over where their seeds go, but there is usually some method by which these are carried away from the parent plant...

(Nuffield, Co-Ordinated Biology,p.193)

Dispersal of seeds by wind
There are two ways in which seeds are dispersed by the wind. Study figures 16.5, 16.6 and 16.7 to find out more about this.

(Nuffield, Co-Ordinated Biology,p.194)

Figure 16.7
Structures with "wings" are commonly produced by different kinds of trees. The "wing" may be formed from a bract (a kind of leaf). Otherwise it is formed from the ovary wall, as in the sycamore...
You can see from these examples that plants with wind dispersal either have a "hairy" structure that makes a large surface area or they have some sort of "wing".

(Nuffield, Co-Ordinated Biology,p.195)

In these extracts the relation between wind and seeds is represented as similar to the relation between birds and air. In both cases the transposed entity is adapted accordingly to the medium by which it is transported. But they are different in respect to where the agency comes from. In the domain of living animals the birds are the agents which make use of the medium through which they fly, in contrast with the seeds which depend on the agency of the carrier.

7.5.3 Carrying discrete or continuous entities

Entities like plant seeds are discrete and do not interact with their carrier in a way that the identity either of the carrier or of the transposed is transformed. Other entities like gases are represented as continuous entities. The latter have the property of being mixed with the carrier in a way that the carrier itself is represented as an agent. In cases like this containment and agency are the schemata which are required in constructing a higher structure of image schema such as the carrier. This is the case with acid rain. Rain and sulphur dioxide are mixed so at the end the rain itself becomes an agent:

(5)
T: *When it rains in Scandinavia some of these gases like sulphur dioxide dissolve in the rain to form a weak acid sulphurous acid. When it rains it produces acid rains it kills the trees it makes the lakes become acidic it affects the life in the lakes and so on.*

(Looking at the Environment, 1st Lesson, p.4)

As we can notice in this little extract, rain becomes acid rain from the time when it is mixed with the agent, as the term *acid rain* reveals. As a result if an agency has to be dealt with, then one cannot avoid the trouble of dealing not only with the agent but with both agent and carrier.

On the other hand discrete entities like litter in the sea, because they are not mixed with their carrier, are easier to detect and remove:

(23)
T: *There was a thing on the radio yesterday. They'd been going up and down the west coast of Scotland [] if you've walked; up and down the west coast of Scotland it's quite remote it's quite isolated. Beautiful Mrs ...will vouch for that it's lovely. One of the best places you can go to to ...as well [] they have been one moment, they've been picking litter up off the beaches there. Guess where something like a quarter of that litter has come from?*

(Looking at the Environment, 1st Lesson, p.4)

Continuous entities like sulphur dioxide carried by prevailing winds or rain are unobservable in the sense that one cannot say by looking at the carrier whether the agent is carried or not. That makes it more difficult to detect whether the carrier is a potential agent or not. It is the effect which indicates whether an agent has been carried but this is an observation after the agency has taken place.

Carriers which are represented as 'flow movement' like prevailing winds and rain, rivers and sea give the potential power to entities to be released from one container and spread into another. So at the end the environment is represented in terms of a system of containers and carriers. Agents are seen as transported by various carriers from one container to another. Because of carriers, agent and affected are brought into contact in order for an agent structure to exist. An agent can now be carried at a distance at any scale. Moving the affected away from an agent might not be a solution for avoiding the agency since agents can be potentially moved as well. Carriers are represented in the end as the entities which break the inclusiveness or exclusiveness of containers. In other words they break separation and facilitate or permit interactions between entities. In that way long distances between entities cannot guarantee immunity, as the teacher frequently insists. Therefore carriers can cause or trigger the unexpected to happen.

Another example of a carrier as a transportation system is the blood stream. As the term reveals the carrying of substances is constant, has a certain direction like a stream and distributes entities only where the stream gets, therefore being more predictable than other systems of carriers like the prevailing wind for example:

The blood system is a transport system. You can compare it with the London Underground which moves people from place to place. To do this, there have to be carriages for the people to ride in, and engines to drive the carriages. The trains have a route to follow, and there are special places for the passengers to get on and off. You can look at the blood system in the same way. Here, the 'passengers' are the food and gas molecules that have to be moved from place to place. But what about the rest of the system?

(Nuffield Science Year 9, p.92)

The blood stream is a transportation system not accessible to us even if the blood itself is observable. Moreover the fact that the entities that are contained are unobservable makes it difficult to think how this system works. This is what the analogy between the blood system and the London Underground does, as it has been illustrated in section 6.3.3. It explores the similarities and differences between the two systems of carriers and therefore gives us some insight into a system of carriers by making it more accessible to commonsense understanding.

7.5.4 Properties of carriers as transportation systems

The examples of carriers which are discussed in this section, despite their differences, have some common properties as transportation systems. One of these properties is the fact that carriers impose a certain directionality on the movement of entities. Streams (either natural like rivers or metaphorical extensions of them such as the circulation of blood), prevailing winds and rain move entities consistently towards one direction. In the same way public transportation like buses and trains follow certain directions.

An entity which is carried by a transportation system away from its source follows a route, more or less determined by the carrier. In other words, entities which are in the processes of transportation are not expected to turn back to their departure without any reasonable cause. To do so an agency must act on these entities which exceeds the carrier's agency. For example, since sulphur dioxide is dissolved in rain water and enters living systems as acid rain it is not expected that it will get back from where it comes from initially.

Finally, the consecutive character of transpositions of entities, like for example prevailing winds giving place to rain in transporting sulphur dioxide is not unusual in every day concepts. But what is more interesting here from the point of view of nature is the way one system of carriers gives place to another in order to carry entities which cannot move by themselves. In the case of the Scandinavian forests the shift from one carrier to another is represented in terms of transformation. Vaporised water is transformed into rain therefore sulphur dioxide which is mixed with air will be later mixed with rain as well. This is not really like leaving the train and catching the bus, a scheme which applies quite remarkably for transpositions of discrete entities like pollen grains:

They [pollen grains] are often carried to the top of the troposphere by rising air currents and, if caught by fast-moving winds...

(Air Ecology, p.22)

The case is very different where transportation takes place through processes like a food chain. In food chains entities like pollutants travel from one trophic level to another through agent structures. An affected larva which carries pollutants becomes an agent when it is taken as food by a fish and it affects it. Carriers which are realised as sequences of agent structures are metaphorical extensions of carriers which are realised and represented as 'flow movements'.

7.5.5 Metaphorical extensions of carriers

In metaphorical extensions of carriers the job of the container which transposes like a 'flow movement' entities from one place to another is undertaken by a sequence of agent structures. An effect of an initial action is carried through consecutive processes or events away from its initial action. A food web is an example of this kind of carrier which has not always been thought of as being primarily a carrier. Today it is almost taken for granted even in our everyday life, that food webs should be considered as carriers, especially in cases of health scares such as mad cow disease, but in the past it was rather a shocking discovery that DDT has passed all the way down to the food chain and had been detected in penguins which live in Antarctica. In the following example discussed in the previous section from the point of view of the containment relations involved (see example (17) in section 7.4.2.2) a non-discrete agent is represented as having the property of passing from natural systems into living systems. When acid chemicals are washed into rivers or ponds, irrespective of where they come from, they are carried by one living organism to another. In this case a sequence of agent structures such as a food chain is represented as a carrier which continues the transportation of chemicals from a natural system into a living system.

The phenomenon of inheritance in plants and animals in textbooks is represented as passing of characteristics from one generation to another. In the context of reproduction, inheritance can be seen as a metaphorical extension of carrier in which living organisms are realised as carriers of genetic material. The representation of the process of passing genetic material from one individual organism to another requires that organisms are realised as entities which are made up of smaller units. That is plants and animals are represented as made up of cells and cells contain in their nucleus (DNA molecules) the genetic material which is responsible for the way organisms are and appear. The mechanism of carrying the genetic material from one organism to another starts from when DNA molecules produce exact copies of themselves. At this point, as we have seen above in chapter 3 and section 4.5.3, the use of two lexical metaphors at the same time to describe the nature of the genetic material; as an information-like entity *building instructions* and as a thing-like entity *DNA molecules*, has been blamed as the main reason why people of all ages are in trouble to understand and explain the concept of inheritance.

While inheritance is realised as passing of genetic material from one generation to another, evolution is realised as a variety of organisms carried in long periods of time through consecutive generations. Notice that processes of sequences of agent structures such as adaptation and the survival of the fittest are realised as a nominalized process *natural selection* which acts as an agent in relation to evolution. In other words what is carried in time is species and their characteristics which survive out of a number of agent structures.

Metaphorical extensions of carriers include also cases where things which are not normally thought as being transported are seen as being so. For example an effect itself can be represented as being carried away by an agent structure or a sequence of agent structures:

(5)

T: *When it rains it produces acid rains it kills the trees it makes the lakes become acidic it affects the life in the lakes and so on.*

S *And the poor little animals die.*

T *Ok [] so in lots of ways we're passing our problems onto other countries.*

(Looking at the Environment 1st Lesson, p.4)

Problems here are thought as being transferred from one country to another due to people's actions. The latter are represented as carriers rather than as direct agents. In that way an agency is suppressed since it is different to think of an entity as a carrier of an agency than an agent which acts directly upon the affected:

T *.. you could live miles away from any cities anybody else but what is happening to a lot of the lakes in Scandinavia? What's happening to them []*

S ...

S *People are dumping stuff in them.*

T *Not quite [] we [] we are not dumping stuff in those lakes.*

S *Oh dear.*
S *What we're doing is trying ...somewhere else we're not*
T *We're not actually, we're not actually [] putting stuff in lorries and taking it up there and dumping it, but when our factories kick out all of this poisonous smoke that goes up into the atmosphere where does it get blown to?*
S *Scandinavia.*

(Looking at the Environment, 1st Lesson, p.4)

Agency also can be suppressed when a number of processes are described in terms of relations between carriers and transferring entities:

Temperature, sunlight and the winds carrying water vapour and rain are responsible for the climate...

(Air Ecology, p.18)

7.5.6 Conclusion

In conclusion, carriers break boundaries - mainly imposed by containers - and make agent structures possible. Their semantic function is essentially different from containers, even if they can be containers by themselves, and from agents, even if a sequence of agent structures is seen as carrying something. The concept of carrier is about transferring (movement) and at a more abstract generalised level it is the realisation of making relations, connections between entities possible. That is why carriers have often been seen as the 'mechanism' - often represented as a transportation system - which realises and represents interactions in nature. At the level of what the entities are, dynamic representations of carriers open up the potential of creating or altering entities, thus constructing new entities by working out the ontology of pre-existing ones. The extent to which they are used as means of representation can promote specific ideological aspects about nature, such as seen it as a 'living' organism.

7.6 Cycles of nature: an example of a multi-modal construction of an image schema

7.6.1 Cycles in the context of teaching environmental science

Ecology provides descriptions in terms of cyclic patterns for various phenomena, either natural ones like the life cycle of an organism, or ones caused by humans like the farming cycle. These cyclic patterns can be represented in various ways, either as temporal successions of events, like the steps a farmer has to take during a year in cultivating crops (Appendix 4.13), or as the transformations through which an entity goes in a temporal sequence, like the rock cycle and the life cycle of an organism.

What makes a cyclic pattern found in nature and represented as cycle different from other phenomena is the fact that either a sequence of events returns to its initial event from where it begins or an entity is returned back to where it began. That is why a cyclic pattern as a whole is represented vividly with the image of a continuous cycle to express its closed nature. It should be mentioned here that the experiential basis of the cycle image schema is not supposed to be necessarily grounded in our physical experience. (e.g. day-night cycle) Social, cyclic patterns as well, such as timetables at work (e.g. a school year) provide us with concrete experiences of cycles.

Even if the closed feature of the cycle makes it different from other schematic structures, like agent structures, containment relations and path-link schemata, the latter are implemented in the construction of cycles. The Nitrogen cycle for example is built up by a path-link schema; dealing with it means that one has to appreciate and respect the sequential unfolding of agent structures:

T: Obviously, the object of growing the grass or putting nitrates into the soil, is to get the grass to grow 'cos we need the grass to keep the animals live, so the grass, then, is eaten by the animals so the protein, the plant protein, in the grass is now taken in by the animal, so our nitrogen atoms have gone through the soil, through the plants and the nitrogen atoms now are in the horse's body.. body.. body.. body.

The representation of the Nitrogen cycle in terms of these two schemata transforms it into a more accessible entity. Students can work on it in their minds, talk about it and draw it on a piece of paper. They begin to trace with confidence (and this is where most of the teachers' effort is focused) the intermediate links and paths through which Nitrogen is transferred and transformed, and they begin to use the idea that you cannot deal with the entities as separated and removed from the whole cycle. The cycle is also built as an accessible unit of study without being too vague to deal with. It can be recalled at any time and other entities make sense by making reference to it.

In teaching environmental science, textbooks and lessons can represent the same phenomenon which has a cyclic pattern in different ways, depending on the context and the aims of the teaching. For example in the same textbook *Nuffield Science 13 to 16 Study Guide 1* in the same section *Looking for patterns in life cycles* we notice two different representations of a life cycle (Appendix 4.14). The cycle on the top of the page represents a life time of an organism as a succession of events: creation of a new individual, maturity, reproduction and death. The description of the processes as nominalizations in the diagram forces us to read it as a temporal sequence of events. But the diagram that follows the one at the top of the page demands a different reading. The pictures of an animal *frog* at three different stages of its life accompanied by three different names with which it is called, focus on the transformations that happen to it during its life time. The first diagram does not make any reference to a particular living organism while the second derives from it as an exemplifying instance.

This section deals with the different representations of some of the most frequently found cycles in the teaching of environmental science and the effect these representations have on the meaning these cycles convey. These are the Carbon and the Nitrogen cycle. In analysing the various representations of the two cycles as many as eleven examples of them are used from nine different kind of textbooks addressed to students of various ages, together with two examples of cycles taught in two secondary schools; one is the Carbon cycle taught to Year 7 students and the other is the Nitrogen cycle taught to Year 9 students.

7.6.2 Features of the cycle schema

Looking at the sample of cycles collected for the purpose of this analysis the first thing we notice apart from their variety is that they are all multi-modal constructions of meaning: images and language take part in the construction of each cycle. If for other phenomena the role of images or language is silent in the construction of meaning this is not the case for the construction of cycles. Cycles are at least one of the most explicit cases of multi modal constructions of meaning. Nevertheless, even though an image of a cycle is usually elaborated by a text, and linguistic elements are found all over the image, the latter has a dominant place both on textbook pages and on classroom white boards. It therefore seems appropriate that analysis of a cycle should start from the image without neglecting the linguistic elements and the text related to them.

It is striking what a rich variety of forms are used in making images of cycles. Despite their differences forms can only be of two kinds, either nodes or links (Appendix 4.14). Reading an image as a spatial representation on paper, nodes represent resting places while links represent movements. As a result an image of a cycle as a whole creates a tension because of the recurring pattern of static and dynamic states of affairs. But since the representation on paper is used to describe a phenomenon found in nature another sort of tension is created as well due to the differences in meaning that the means of the representations impose. For example as we will see later, even if nodes represent resting places in an image, linguistic elements referred to them may represent processes and not things.

Nodes can be pictures taken from the real world, usually pictures of animals and plants (Appendix 4.15) or picture-like drawings which resemble pictures but are not specific instances of entities found in reality (figures of cycles in Appendices 4.2, 4.16, 4.17, 4.18). For example a picture of a rabbit is a photograph of a real rabbit (Appendix 4.15), but a picture-like image of a rabbit (Appendices 4.2 and 4.17) is a drawing of a real rabbit indicating that it is just 'a' rabbit. Nodes also can be icons, representing categories of entities, like plants and animals, varying to the extent to which they are abstracted from real entities (figures in Appendices 4.19, 4.20, 4.5). For example the sea can be represented by a crooked line (Appendix 4.21) and a tree can be represented by a figure without any detail specifying what kind of tree it is (Appendix 4.5). Even for icons which have more detail, often animals, one can just sees what sort of animal is involved without being able to say whether it is a goat or a deer (Appendix 4.5). Finally, nodes can be just shapes like rectangles or circles having no visual relation with the things they represent. In this case, the shapes are accompanied by linguistic elements which say what they are supposed to represent (figures in Appendices 4.4, 4.22, 4.23). Links are always represented as lines with arrows at one end and can vary in how thick the lines and arrows are (Appendix 4.3 for example).

Another important aspect of images is the absence or presence of a background and up/down dimension. Most of the picture-like images are placed against a background that is often the horizon or just the sky (figures in Appendices 4.2, 4.16, 4.17, 4.18). Images made by icons or separated pictures are represented without any background (figures in Appendices 4.15, 4.19, 4.5). As we will discuss later the absence or presence of a background is related with the image of a cycle as a whole and it affects the degree to which the cycle is represented as abstracted from the real world or is imposed as a mental construction upon what can be seen in reality.

The up/down dimension is related with the presence or absence of a background when it resembles spatial relations found in nature. While an image with a background always has an up/down dimension in which what is at the top represents the sky and the atmosphere and what is on the bottom represents the ground (or sea) and the underground (see Appendix 4.16 for example) the opposite is not always the case (like in Appendices 4.15 and 4.19). Actually most of the images without any background have an up/down dimension. Even the most abstract images of a cycle made up by rectangles and lines can have an up/down dimension in which nodes like atmosphere are located at the top, and nodes like fuels and carbonate rocks are at the bottom (Appendix 4.4). On the other hand an image which consists of some icons can lack an up/down dimension if priority is given to other features like symmetry for example (Appendix 4.5). An up/down dimension can represent a conceptual hierarchy rather than realistic aspects of the world. Or the two - conceptual and realistic relations - can be implemented at the same time. This is for example in cases where there is a hierarchy of events which are numbered (Appendix 4.22) or in cases where secondary consumers are located higher than primary consumers and producers (Appendix 4.15).

Even if images dominate in representing either the Carbon or Nitrogen cycle, linguistic elements accompany the images in a way that suggests that they provide necessary information for the 'proper' reading of the images. Therefore, it is not accidental that images which are rich in terms of picture, picture-like and icon forms are those which have more linguistic elements in them (Appendix 4.2) than those which consist of very few forms, like rectangles and lines (Appendix 4.4). In cases where quite a lot of information is given in terms of linguistic elements distributed all over the image the text which either follows or precedes the image is not so extensive (Appendix 4.2) comparing with the figure in Appendix 4.4. For the latter it is inevitable that if few words are used in the image these are more likely to be nominalizations, nouns and verbs (Appendices 4.5, 4.21, 4.4, 4.22). On the contrary in the former case, phrases are seen instead of nominalizations (Appendices 4.2, 4.16). We also notice that what images do not represent, language is called on to represent, e.g. if things are not pictured in any way that resembles them then they should be called by their name (see figures in Appendices 4.21 and 4.4).

7.6.3 Cycles representing nature

Four kinds of cycles, represented in the table below, will be discussed:

Cycles represented as:	Images as appear in Appendices
real events	4.2, 4.16, 4.17, 4.18
constructed events	4.15, 4.5, 4.4
selected events	4.19, 4.20, 4.3
invented events	4.21, 4.22, 4.23

(Table 3: The four kinds of representations of cycles and the images which more or less fit in these types of cycles)

The first type is that of cycles represented as 'real events' found in nature. Take for example the cycle in Appendix 4.2. The cycle as a whole is given as a single picture taken from nature, in other words it is represented as a snap-shot of what happens daily in the real world. The picture-like forms of the image - except probably the fire on the right - do not appear specially selected for the purpose of constructing a cycle. The sky on the background and the up/down dimension of the image further represent the relations between the forms of the image as 'natural'. The entire image seems to say: "we don't need to select anything and put it carefully together like pieces in a puzzle, everything we see out there in nature makes sense and is coherent by itself; the only thing is left for us to do is just to describe what we see in the world".

The linguistic elements (many and lengthy) describe what we see in nature. They overlap with an image in a way that does not spoil its realistic effect. Since the forms of the image are too realistic to be mistaken, observable, thing-like entities do not need to be named. Events, like eating, death and burning do not need to be mentioned. What we are informed about from the linguistic elements are the unobservable process-like and thing-like entities. Even for the latter, where possible picture-like images are provided together with their names.

The second kind of representation, that is 'constructed events', is one step away from an image which is supposed to be reality as such. In Appendix 4.15 we notice that all of the observable thing-like entities are pictures of 'existing' entities, thus photographs. The difference from the first category is that where in the first case the whole cycle is given as an instance-like event - in the second case each observable element of the image is instantiated. There is an absence of any background but there is an up/down dimension which is both presentational and conceptual: entities that are found lower than others in the food pyramid are also found spatially lower in the image (e.g. bacteria and fungi). Processes are not represented by pictures but only by linguistic elements and arrows.

Linguistic elements are quite economical when they describe relations among observable thing-like entities and are more elaborated when they represent processes in which unobservable entities are involved. While the two nodes containing linguistic elements represent actions, the arrows represent transfer of substances (N_2) carried by materials (e.g. food) from one thing-like entity to another. Therefore the focus is not on what the pictured entities can do (e.g. foxes eat rabbits), but on where substances are conserved and stored.

Because of these characteristics we can say that this is a category which represents the cycle as a 'constructed event'. What counts in this category is how well the 'pieces' of the 'puzzle' taken from the real world - which is why they are pictured as far as possible - will fit together constructing a 'picture' in a way that does not resemble what we can 'see' in nature but what we 'think' about nature.

Notice also that language takes a step further for decontextualizing the pictured-like entities from their realistic representations; each entity is named (e.g. fox, rabbit, grass). This is obviously not because the reader is unable to recognise what is pictured in each photograph but because the linguistic elements suggest 'reading' the photograph not as specific instances of foxes and rabbits - like saying that there is nothing really special in choosing these photographs and not others - but as any foxes or rabbits. As a result, a rather profound tension is created because of the 'contradictory' use of the two means of representations (images and language); while the pictured-like entities are heading towards to what can be thought of as more concrete and specific (exemplified), the absence of the background together with the linguistic elements are heading towards a more generalised and abstracted schema of a cycle.

Other examples of this category which are less controversial vary to the extent to which they are abstracted and generalised. The figure in Appendix 4.4 for example represents a cycle as a 'constructed event'. But here thing-like entities are further generalised and abstracted from those that can be found in nature. They are represented by their names in nodes which are shaped as rectangles. Their names are categories (e.g. land plants, animals). Links between them are events almost all of them represented in terms of nominalizations which are far from what can be described in what we 'see' (directly) in nature. Despite all these characteristics and the absence of any background the image as a whole still sustains an up/down orientation similar to that found in reality.

The next kind of cycle is of images which represent a cycle as a 'selected event' abstracted and generalised from nature. Representations of cycles which belong in this third category look very much like generalised instances. Observable thing-like entities appear as categories of things due to the use of icons representing them. Nevertheless, icons are placed together in a way that seems very realistic and natural, implying that in nature all the possible things the icons represent are found together in exactly the same way - a choice that makes the use of the up/down dimension inevitable. Therefore the image as a whole seems to select from nature only what is coherent and makes sense in order to represent it (as in Appendix 4.19). Only relevant things are chosen which are joined together in such a way that the whole will be just one event: the cycle. As a result any background information is irrelevant and it does not matter if links overlap with icons. Linguistic elements, depending on how far it is intended to represent the cycle as abstracted and generalised, consist of nominalizations (Appendix 4.19) or short phrases which represent processes (Appendix 4.20). As in the previous category, links have also the effect of representing nodes (these are the icons) as locations and containers from which either Carbon or Nitrogen is transferred and at the same time transformed.

Notice in all these three categories above the tension which is created between the visible and the invisible simply because if the image is intended to picture in any way what can be pictured then unobservable thing-like entities are left with the option of being represented as linguistic elements. As a result the homogeneity of the overall image is broken since links connect elements which belong in two different systems of representations. This tension is resolved in cases where any realistic representation is excluded from the image of the cycle (see figure in Appendix 4.4 for example).

Finally, the fourth kind of cycle represents the cycle as an 'invented event' which is better described as a succession of stages. There is nothing pictured which resembles anything in reality in Appendices 4.22 and 4.23. The image in Appendix 4.22 is not very different in respect to the conventions which are used for nodes and links with most of the images in the preceding category. But the fact that the steps through which Nitrogen goes are numbered and the discussion of the image in the text that follows is structured in terms of these four steps, has the effect that at the end the four stages take the status of the nodes in the overall image of the cycle. As a result, because of the way the image is elaborated, nodes become stages in which processes take place. This effect is very different from what we have seen before in the rest of the images in which nodes are thing-like entities most of them realised at the same time as containers.

The image in Appendix 4.23 which was taught in the classroom (a detailed analysis of the construction of this image as part of a double lesson can be seen in Appendix 3.2) and comes out as an elaboration of another image represented in a textbook (Appendix 4.18) is very much like the image in Appendix 4.22. Each node is a stage at which Carbon is either stored somewhere *carbon dioxide gas in the atmosphere* or transferred *animals breathe out carbon dioxide during respiration* or transformed *burning fossil fuels*. Stages are not numbered here but links show the way in which stages follows one another. In addition, links represent the way in which Carbon is transferred around. But again by placing together thing-like entities and event-like entities the effect that is created is that event-like entities can be represented as containers and agents in the same way as thing-like entities.

7.6.4 Conclusion

In conclusion, the examples of cycles above have illustrated that images have a prominent place in representations of cycles. Linguistic elements provide information about how one can read the images. In many cases of cycles language and images can be seen as co-operating for the creation of the same effect. For example abstraction and generalisation can be achieved linguistically by the use of nominalized processes and reference to categories of entities instead of referring to instances of entities. The same effect can be achieved by the use of images which have little resemblance with reality or few elements which are realistic representations of what one can see, such as the use of links between nodes which are shaped as rectangles. But in some cases tension is created because elements belonging to two different systems of representations (language and image) are linked together in representing relations between observable and unobservable elements for example. Here, language represents what images cannot. But even in this case choices can be made to resolve the tension by excluding any image-like representation from the cycle.

Regarding both images and linguistic elements, different examples of cycles from a variety of textbooks have been studied from the point of view of how they realise the relation between the phenomenon and its representation. In doing so, four types of cycles have emerged, which are not to be understood as strict categories, but as varieties in the degree to which a cycle is represented as a mere picture of reality or as an entity constructed by scientists.

7.7 Discussion

7.7.1 What is an image schema?

In section 7.2, schematic realisations of agent structures represent agency in a similar way as linguistic realisations such as transitivity patterns, illustrated in the linguistic part of the analysis, represent relations of agency. In particular, examples of agency as they are applied to plants and animals as well as non-living entities in textbooks and in lessons show that the image schema of an agent structure is neither a category nor an instance of a category. It is rather a property shared by many instances and realised in different ways since the latter do not necessarily belong in the same category. For example competition is realised differently among instances of animals and plants since both belong in different categories. So schemata such as agent structures are not supposed to be only prototypical properties shared by most or all members (instances) of the same category only. As a result the ontological implication of the use of the image schema of agent structures, is that categorical relations between entities are worked out at the level of their instances even across different categories.

As has been pointed out in the section concerning agency, because of their role underlined above, image schematic structures (and in this case agent structures) permit shifts of categorical relations from one category to another. To give an example, plants are represented as being more active than they were thought of before, with concepts such as competition and movement which were primarily thought of as being attached to active living entities such as animals being applied to them. In that way it seems that metaphorical elaboration of entities in terms of agent structures of image schemata are close to Black's (1962) accounts of the interaction view of metaphor.

7.7.2 Path-link schemata or narratives? What is their value in teaching?

Sequences of agent structures show that one should be careful in considering a single agent structure as a unit of analysis. An isolated agent structure can have a different meaning if is seen among other agent structures. Path-link schemata and narratives seem to have the same structure; actions follow one another in a sequence which has a beginning and an end. The structure of the story grounded in stories told in our everyday life makes it a useful tool for teaching. Students know that the story is expected to have a cast of participants, and a beginning and an end. They are motivated because they know that stories are meant to be interesting, and they are able to participate by responding with their own stories. All these reasons probably explain why stories represented as narratives are so often chosen by teachers in order to represent issues and phenomena of environmental science.

The fact that a story seems to be a valuable tool for representing science means that the ontological, epistemological and learning implications of its use should not be overlooked. Stories which are represented as being what is at issue to be explained are at risk of being misinterpreted by students as being reality themselves. Representations of phenomena such as acid rain in terms of narratives can be thought of as having a structure identical with the structure of narratives. This narrative-like structure imposes boundaries on the phenomenon such as an end and a beginning as well as a structure; a selected choice of a sequence of agent structures. If students think that this structure is the same as that of the phenomenon, then misconceptions are very possible. This implication brings with it an epistemological consequence about what should be taken as a scientific way of reasoning. In the absence of alternative stories or any accounts of where these stories come from or other ways of representing the same phenomenon, it is very likely that science is seen by students as working on the basis of 'single', 'true' stories which emerge directly from nature. Following from that, both teacher and students are in danger of falling into a naive realism which also dictates what learning should be; stories are seen as a window looking into nature, revealing nature's plot.

7.7.3 Containments, carriers, cycles: ontological, epistemological and learning implications

Representations of entities in terms of containment relations are about imposing boundaries on entities. These representations have ontological implications about what the entities are thought to be, or can or cannot do. Also these constructions constitute the ways in which entities are realised since they reflect choices about what can be meant and how, with epistemological consequences. Forests and ponds are represented as if they are units of study which emerge from the world 'naturally' without it being our choice to pick them up as such and study them. But even if the reasons which are hidden behind what is apparently seen as obvious choices are silent, they not only imply that the scientific way of studying the environment is not very alienated from the way 'we perceive' it in our everyday life, but also show how the environment is supposed to be studied in schools.

Metaphorical extensions of containment relations and nominalizations are very similar in respect to what they afford and how. They both treat process-like entities as thing-like entities and that explains why so often metaphorical extensions of containment relations are represented linguistically as nominalized processes (e.g. photosynthesis). Things like objects have clear edges and can be touched in a way that one has a very good idea of distinguishing them as discrete entities. The same is not true of processes. It is usually our action which imposes artificial boundaries on processes, so as to speak, knowing when a process stops and another one begins. According to Piaget and the main stream of cognitive psychology our early interaction with the physical world (called 'sensori-motor' knowledge) seems to have a priority in our cognitive development in relation to more abstract domains of knowledge. This is more or less what Lakoff (1987) claims: that image schemata have an experiential basis grounded in our preconceptual structures of kinesthetic image-schematic structures. The similarity between the two is vividly reflected in Ogborn (1994) and Lee (1992). Therefore, treating our interaction with processes in terms of acting on object-like things seems to have an experiential basis which serves a fundamental need; to clarify entities to ourselves by representing and realising them as discrete as possible.

As has been illustrated in this chapter imposing boundaries and representing entities as discrete objects is widespread. Ironically, even if one expects that these kinds of representations make the comprehension of entities easier, it also obscures the complexity and artificiality of many of these constructions.

Finally, we should not pass unnoticed the fact that these representations have a silent ideological implication. Imposing boundaries on entities such as the Mediterranean sea and keeping them separate from others in order to illustrate pollution probably does not work in the same way if environmental science is to be looked as part of an interdisciplinary study which includes geography and economics (e.g. the effect of industry and economic relations on the sea without the former necessarily being in the region of the latter). In particular, economics can provide a view of Mediterranean in which boundaries are not realised in terms of a closed sea, but as a part of a wider web of economic relations. As a result, representations of entities in terms of containment relations which shut off alternative ways of representing entities can possible mislead students by reproducing a naive, everyday realism which turns a blind eye to the fact that conflicting interests can create different points of view about whether one entity is seen as separate from others.

The arguments above apply to some extent to all schematic representations. The case is clearer with containment relations because they are primarily concerned with setting up the ontology of entities; that is making them discrete. The issue of how entities are represented schematically and what are the possible consequences such representations carry with them applies also to carriers and cycles.

The extent to which carriers are used as means of representation promotes specific ideological aspects about nature (e.g. as a 'living organism'). Notice also that representations in terms of carriers depending on the scale at which they are applied are heading towards two opposite directions (often mentioned in the literature of environmental science): at the scale of whole living systems emphasis is put on stability (e.g. 'blood system', 'air system') while at the scale of the parts the possibility of dynamic relations carriers can afford is illuminated (e.g. water carrying pollutants next to a marshland area). As one can see here choices of where the emphasis is put on can highlight and at the same time hide specific aspects of meaning relations. In other words, what is chosen to be said carries with it always an aspect of what is, deliberately or not, chosen not to be said (or remain silent).

Different representations of cycles can have different implications both ontological and epistemological at the same time. The former are about the nature of the represented entity (e.g. carbon cycle) and the latter are about how knowledge about cycles can be achieved. In order to show these implications different representations have been grouped together in respect to whether and to what extent they represent the cycle as a natural entity or as a theoretical entity.

To give two examples, cycles can be represented as being 'pictures' taken out of nature that have to be read in a certain way. Such representations are about relations which reflect relations in nature. They also imply that what can be represented is what one can see in nature. This naive realism represents cycles as 'natural' entities which can be approached by an almost 'photographic' relation between the 'viewer' and the object of his/her inquiry. On the other hand cycles represented as 'constructed events' imply that they are theoretical entities which are made up by 'real pieces' these are entities taken from nature as they are and arranged in a way that fits what we think about nature. This view subscribes a more active role to scientists since cycles are not simply made by what we see in nature but by how we think about it. At the same time the reality of the cycle is grounded in the real status the pieces of the cycle have since they are extracted from nature as 'they are'.

7.7.4 Ideological implications of the use of image schemata

7.7.4.1 Agency carried at a distance might have an ethical effect

As it has been discussed in section 7.2 agency in environmental science can raise ethical questions. The ethical issue of affecting people or other populations of organisms which do not cause environmental damage or pollution is raised quite frequently in lessons about environmental catastrophes. The question often implied in representations of the latter is why the environment of a certain population has to suffer damage for which it is not responsible.

In the examples given the issue of pollution is looked at from either the biocentric or the anthropocentric point of view. The latter presents environments as properties which belong to certain populations; the Scandinavian environment belongs to the Scandinavian people, who are affected when 'their' environment is affected. The biocentric view gives some respect to nature itself, so when a pond is polluted and the fishes die it does not mean that this is bad for human beings' interests only (they cannot make use of polluted fishes as a source of food). Apart from the fact that life is destroyed which is attributed a value more important than that given to inorganic matter, the whole balance of a living system - the pond in this case - is seen as being upset (see example 17).

Phenomena like the GHE and damage to the ozone layer which have effects on a global scale, are represented as having different effects on different people; countries which are below sea level will be flooded and populations living closer to the poles are more at risk of developing skin cancer (see example 7). It is also interesting to notice that the temporal distance between the causes of these phenomena and their effect is stressed in their classroom representations; generations of populations today are affected by what other people have done in the past:

The ethical issue which is raised by agency at a distance, either temporal or spatial, implies a rather peculiar mixture of anthropocentricism and biocentricism; causality in nature is seen as circular, so it is expected that the agents will pay the cost of their action, so that in a way the effect goes back to them and affects them. Agency as an ethical issue also raises the question of whether relations between human beings and between human beings and nature have to be thought of as competitive or symbiotic.

7.7.4.2 Deep Ecology: Does nature teach us how should we think about it ?

Various examples of sequences of agent structures given in the classroom are trying to modify students' way of thinking about nature and how they think about their role in respect to nature. In most of the teachers' examples causes of catastrophes are represented as single decisions of humans which were taken without thinking in terms of a sequence of agent structures but rather in terms of single agents. Teachers' example of the diseases caused by the appearance of bacteria in seas because of insufficient sewage works and the appearance of pollutants in water supplies because of untreated waste disposals in seas, rivers and lakes are represented as caused by single agents such as factories.

The teaching of the Carbon and Nitrogen cycle seems to aim to reinforce the concept of a sequence of agent structures and to promote the idea of the closed-ness of the entire ecosystem. At the same time part-whole interdependence is emphasised; a faulty part or a removed part causes destruction of the whole. The repeated patterns of sequence of agent structures, the frequency with which nesting is used to represent various phenomena, the emphasis that is given to the feedback loops of causal relations and the fact that what is taken as a unit of study is never an isolated part of a whole system, construct a holistic view of nature. In that way what is counted as valuable is the contribution of the part to the whole and not the part itself. Thus unobservable parts take a very real value because of their participation in the whole, in the same way that observable parts participate. The ideological implications of almost all textbook and classroom representations of cycles are: to think environmentally is to think always in respect to the whole and to take the whole as the fundamental unit in the study of the environment.

7.7.4.3 Ecocentrism versus technocentrism

Concerning human action, most of the examples one of the teachers provides support the argument that new technologies are not the solution for every problem caused by pollution or by the exploitation of nature's resources. The teacher states explicitly that peoples' attitudes and behaviours have to be changed if we wish to develop a sustainable environment. Therefore, following his argument, new policies applied by laws must be addressed to that end, for example by forcing industry to install all the necessary equipment in order to dispose of toxic waste properly (see example 9). He also claims that domestic waste can be reduced significantly if peoples' consuming attitudes change in respect to packaging for example.

This ecocentric approach to environmental problems has its roots in the holistic view of nature which as we have seen above is constructed at various levels in many different ways of representing nature. As a result the teacher speaks as if nature teaches us how to think about it and our relation with it, and that this way of thinking should be the basis on which any approach to environmental problems has to be grounded. The previous section (7.7.3) has illustrated that representations of environmental science have certain ontological implications about the nature of the represented entities. What has also been shown is that ideas about the nature of entities carry with them implications about how we can think and learn about them. In the present section (7.7.4) what have be seen as ideological positions (e.g. ecocentrism) implied in classroom talking have ontological (e.g. environment realised as the set of relations between the whole and its parts) and epistemological implications (priority of sequences of agent structures over single agent structures) as well.

CHAPTER 8

WHAT DO THE METAPHORICAL WAY OF TALKING AND METAPHORS IN TERMS OF IMAGE SCHEMATA AFFORD AND HOW?

8.1 Introduction

Two analytic approaches (S.F.L and image schemata) are used in the present thesis for the study of metaphor in the teaching of environmental science. Both approaches can be looked at from two points of view; how each metaphor works, (that is the first and second research question) and what it can afford (that is the third and fourth research question).

8.2.1 What the two approaches: Systemic Functional Linguistics and the Image Schema approach, have in common in respect to the findings of the present study

According to Lakoff and Johnson, image-schematic structures are relatively simple structures that constantly recur in our everyday bodily experience. These structures are directly meaningful because they are directly and repeatedly experienced (like moving in and out of rooms) in contrast with conceptual, abstract structures (like the concept of cell in Biology) which are indirectly meaningful. Conceptual structures arise from basic - level and image-schematic structure usually by metaphorical projection from the domain of the physical, everyday, bodily experience to the abstract domain (Lakoff, 1987, 268).

But, according to Halliday, grammatical metaphor occurs if the natural correspondence between how things are and behave in the world and how these things and their behaviours are realised linguistically is violated. So if we talk about an action not in terms of a material process but as if it is a participant, realised grammatically as a nominalized process, then we have a grammatical metaphor. Because of the interrelation between context, semantic form and language, how we talk about something has an effect on how we treat it and how we are engaged with it. So the action can be treated now not as an action but as a thing which can have properties and it can be a participant which is involved in other actions.

As has also been discussed in chapter 4, while these two accounts of metaphor seem to agree that there are different realms of experience and that metaphor occurs when reference to one can be made in terms of another, they are different in respect to what they think metaphor is about. For S.F.L nominalizations as well as the rest of the grammatical metaphors consist of unusual ways of representing either familiar or unfamiliar entities. On the other hand, representations in terms of image schemata afford familiarity for abstract concepts since their schematic representations are grounded in directly understood concepts.

But this difference between the two analytic approaches is rather a matter of what is accounted as a unit of analysis. Grammatical metaphors as far as they are concerned with the ideational metafunction are about representations of process-like and thing-like entities as they appear in single clauses. Image schemata are multi-modal constructions, so they are not meant to be analysed as they appear in single clauses or even in the linguistic mean of representation only. Take for example the containment schema. Its linguistic representation in the examples discussed in the present thesis exceeds the level of a single clause. Representations of containers also are not bound to any specific ideational process or to the presence of a circumstance or a participant.

So while 'photosynthesis' is a nominalization from the point of view of S.F.L because a process is represented by a noun, from the point of view of the image schematic approach representations (both linguistic and pictorial) of 'photosynthesis' can realise the latter as a container in which different things happen or as a path-link schema of agent structures in which one agent structure follows another like walking along a path from one destination to another. Both kinds of image schemata represent 'photosynthesis' in relation to what we know or is familiar to us since both containment and path-link are grounded in well understood and familiar experiences. What constitutes a choice for S.F.L is whether the entity photosynthesis will be represented as a thing-like, or as a process-like entity. For the image schema approach, choice consists whether first of all photosynthesis will be represented in terms of an image schema, and if so of which kind.

Representations of environmental science in teaching can be looked at from the point of view of what we already know about what the world is - in this case the environment and issues related with it - and how it can be represented in school science. In this case grammatical metaphors are representations of entities against our expectations of what the world should look like, while image schemata are rather representations of entities which resemble representations of other entities.

The view adopted in the present thesis is to look at how entities are represented in relation to how other entities are represented in the same or different texts or images. This view instead of opposing what is represented with what is expected to be represented, studies how various representations are at work and then looks at similarities and differences in the way in which the same or different entities are represented.

To give an example from the analysis, in some texts entities such as animals or plants are represented as being more active than in other texts. The extent to which animals or plants are represented as active or not is not only something that can be realised by a single representation (e.g. material process or agent structure) of a plant or an animal, but from a number of repeated representations of these entities which despite their variety are heading in the same direction; to represent them as Actors which are doing several things. Furthermore, it is not only that there are several representations at work in which in one way or another plants and animals are Actors, but the fact that other entities are related to these Actors as Goals. The extent to which such representations constitute choices among others is evident when we look at other texts in which plant and animal action is suppressed due to the use of passive material structures. Also the extent to which animals and plants are represented as similar is not because the text says so, but because they belong to the same kind of material processes and share the same sort of Goals.

As has been argued in chapter 4, the focus of the linguistic approach is not on the lexicogrammar, namely words and their syntactic relations in clauses, but on how semantic forms realised by words and clauses function in making meaning. Participants like Actors and Goals are neither mere grammatical forms (like nouns) nor sets of meaning. They are semantic forms - that is to say forms which have certain functions in a specific context. Actors for example are the participants which are most likely to be realised as nouns and have the semantic function of doing, acting.

The same sort of arguments as above are relevant for the image schema approach. Image schemata are neither pure forms, such as slots which can take any value of some kind, nor pure meaning relations. Metaphors seen as metaphorical projections of image schematic structures are not mere comparisons between concrete, rich images or between things. Metaphorical projections of image schematic structures onto abstract concepts as the image schema theory claims, create new meaning relations between entities. For example when the same agent structures that are used for representing animals are metaphorically projected onto representations of bacteria which are unobservable, and students have no immediate experience with them, then the two entities are brought closer in that bacteria are thought to be more like animals.

Moreover shifts across various schematic structures at the level of the basic level categories build up meaning relations which are very different from mere mappings from the source (image schematic) onto the target (abstract) domain. Take for example the schematic structures which represent two basic level categories: human beings and animals. As discussed in Appendix 5.2, the agent structures that deal with the 'self' engage it in very much the same sort of agent structures that represent animals. As a result the 'self' is objectified since the distance between the subjective and the objective 'self' is expanded while the distance between the 'self' and the rest of the natural world is reduced.

Much of the work in the classroom is, as stated above, at the basic level of image schematic structures. In consequence, the discourse can be analysed as chains (or other more complex structures) of related image schemata. 'Abstract concepts' do not appear in the discourse as such, but as represented at this basic level. To give one more example, the concept of cycle can be represented either as a path between intermediate links which are meant to be place-like entities, physical locations in which an entity is found (e.g. Carbon) or as a temporal sequence between events which are meant to be 'resting' places like physical locations but without having a spatial, physical dimension. Both schematic representations are grounded in our everyday experience with the spatial and temporal dimensions of the world around us. What is interesting here beyond the mere metaphorical projection of the image schema of cycle onto the scientific view of cycles of life is to look at the effect on the meaning of the latter by choosing either type of schematic representations.

Therefore, metaphor in the present thesis is seen as a shift of functions at the level of the semantic forms which affect how the entities that they represent are realised. This view of metaphor is different from those accounts which describe metaphor as only an ornament. It is also different from those other approaches which see metaphor as only to do with structures of meaning relations, and neglect the linguistic effects of substituting one set of terms for another, on fundamental semantic relations (for example an action *breathe* represented like a thing *respiration*).

Semantic forms (both linguistic and schematic) impose generic meaning on different entities. So for example both cells and human beings are - in different ways - containers because they are represented as such repeatedly by accounts of containment schemata. This is due to the semantic function of the containment relation which the containment schema imposes. Therefore, the same semantic functions apply to various sets of meaning. It is a more general level of meaning construction but at the same time a very basic one in which certain meanings apart from all their differences are grounded. Semantic forms for both approaches are relatively few and certainly not infinite; however one can see no upper limit to numbers of differences in meaning.

Differences in the choice and use of semantic forms suggest that shifts of the status of entities (within or between domains) can be noticed in the discourse of teaching environmental science. For example the extensive use of passive material structures, in which cycles of life (Carbon and Nitrogen cycles) are realised linguistically in textbooks addressed to older students, suppresses agency significantly in contrast with those textbooks which are addressed to younger students and are full of active material structures instead of passive ones.

The choice and use of certain forms and not others entails certain constructions of meaning and shuts off others. Going back to the example above the entailed meaning for younger students is that agency is needed almost all the time in order to keep the cycle going on. On the contrary the entailed meaning of the cycle for older students is that little or even no agency at all is needed. Looking at the entailments of the schematic structures we notice that for the younger students there is more stress on the idea that it is the same entity (CO_2) which can be traced everywhere round the cycle by travelling from one place-like entity to another. On the contrary the entailments of the schematic accounts for the older students suggest that transformed entities (Carbohydrates, CO_2) are involved in processes which are found at different stages of the cycle. Notice here the difference mentioned above, between a cycle as a journey in which departure and destination are just intermediate resting places and a cycle as a construction of temporally oriented processes in which the spatial dimension is suppressed.

8.2.2 Summary and Conclusion

In conclusion, the basic means of meaning are not infinite. Choices from the set of available means (semantic forms) have an effect on representations of meaning relations. Nevertheless meaning and semantic form do not always have a simple referential relationship of one to one correspondence. In some cases one semantic form can mean what another semantic form is used to mean. For example agency sometimes can impose containment relationships as well. The semantic boundaries between the functions of the semantic forms are not clear cut, therefore the latter turn to be multi-functional; noun phrases realise thing-like as well as process-like entities and agent structures realise actions as well as containment relations. As a consequence the same set of form-meaning relation can be open to various semantic, interpretations.

What is considered as metaphor in this study are the cases in which certain choices and uses of semantic forms either linguistic or schematic have an effect on meaning in a way that something (an entity) is like something else or it behaves in similar ways to something else. Differences in the representations of entities in which metaphor is involved show the implications of metaphor on how meaning can be further constructed. In other words metaphor creates a 'picture' of how to think about an entity. In that way a metaphorically constructed meaning has already imposed constraints on what can be considered as part of it or not.

How does meaning meant for a certain purpose; namely the teaching of environmental science, have an effect on what the world (social and natural) is thought to be. To give two examples from the analysis:

The world is not only what it looks like, but involves also quite a lot of things that we cannot see because they are invisible to us. Metaphor brings the invisible world closer to the visible one because it represents the unobservable in the same way as the observable: unobservable entities are represented as if they behave in more or less the same way the things and processes that we can see behave and function. The continuity of the observable to the unobservable bridges the gap between them in our understanding of the world.

The various semantic forms can be used to produce a 'realistic' picture of the world as we observe it in our everyday life. In particular the semantic forms that represent the Carbon cycle might give some phenomenological accounts of its spatial and temporal dimensions. But in other cases they can impose on our phenomenological world a conceptual world in which the spatial place is replaced by a conceptual place and in which the boundaries of thing-like and process-like entities are not clearly imposed.

The last two examples above suggest ways of looking at the implications this study can have for research in environmental and science education, and also the teaching of environmental phenomena, concepts and issues.

8.3.1 Representing the unfamiliar as familiar and the familiar as unfamiliar. Two sides of the same process ?

Image schemata such as agent structures and containers, provide the opportunity of representing unfamiliar thing-like and process-like entities as familiar. Entities that are less accessible to commonsense reasoning either because they are unknown, or unobservable or because they are only manipulated under controlled situations, are represented in schematic structures as if they are involved in relations grounded in our everyday experiences. This is also what representations in terms of material processes do. Unusual entities are talked about in material processes as if they are not problematic and are being understood in the same ways familiar entities are understood. Both kinds of representations develop gradually a sense of familiarity with such entities and as a result the status of the latter as 'real' entities is endorsed since they are engaged in everyday experiences and practices which are taken for granted as just obvious. Therefore, image schematic and linguistic choices in the context of teaching environmental science seem to have an important role in bridging the gap between commonsense and scientific knowledge. This role is accomplished by representing scientific entities as similar with everyday entities and by representing the relation between both as continuous.

However, the distance between commonsense and scientific knowledge can be decreased in order to achieve purposes other than familiarity. Familiar entities can be talked of or can be part of metaphorical extensions of image schemata in such a way that they are alienated from the commonsense context from which they initially came and are now represented as scientific entities. I will now argue that achieving familiarity or unfamiliarity with entities should be thought of as two opposite directions of the same process. In other words the process of achieving familiarity with scientific entities at the same time results - to some degree - that 'alienation' with some commonsense entities can be possible. Two aspects: resemblance and continuity, of the process of achieving either familiarity or unfamiliarity concerning both kinds of representations (grammatical structures and image schemata) are discussed below.

8.3.1.1 Resemblance

Constructions of image schemata such as agent structures and containment relations as well as realisations in terms of material processes can bring entities from different domains together by representing them as having similar behaviours and properties. This is something that can be achieved either more explicitly or more implicitly. While in the former way the presence of the two domains from which the entities come are both present, in the latter sometimes not only the presence of the one of the two domains is silent but also the presence of the supposedly familiar entity is silent too.

To give few examples, in section 6.3.3 an explicit representation of the blood system as a transport system is discussed. As has been argued, in this representation both domains (biology and transport) and systems of entities (blood system and underground, rail system) are present in the analogy. The analogy, described by others as a model or mapping, is analysed here as being worked out by the same kind of material processes which apply to the description of both the blood and the underground system. It can also be well analysed through showing that the same kind of image schemata apply to both systems. Lexical metaphors, such as 'chemical passengers' realise the blood system as being bound with the generic entity 'transport system'.

To give another example, the explicit analogy between balloons and cells highlights a similarity between the two entities with the prospect of making the latter more accessible to students' understanding, in the following piece of a textbook:

In Unit A3 you learned that molecules are on the move all the time. If there is little water on the outside of a plant cell, the water molecules will soon escape and plant will wilt (see figure 4a). But if there is a lot of water on the outside, more molecules will be trying to get into the cell than are trying to get out (see figure 4b). So the cell takes up lots of water and gets hard, like a blown-up balloon.
(Nuffield Science, Y9)

Analogies like the one above are grounded in similarities between schematic structures which belong to different domains. In this case, what is explored is the extent to which one schematic structure, the containment property of changing the capacity of what can be contained, applied to cells, is grounded in the experience we have with an object taken from everyday world.

Many approaches to metaphors and analogies which study them based on the way they are marked out at the linguistic surface, will pass unnoticed the fact that in the extract above agency is stressed to the extent to which unobservable entities such as molecules are illustrated in respect to what they look like and how they function:

molecules: are on the move all the time
escape from the plant cells
are trying to get into a cell
or are trying to get out of a cell

Molecules are represented as having intentions and as involved in movements like familiar living entities (e.g. animals), so a strong sense of agency is attributed to their behaviour, analysed either as agent structures or material processes in which molecules are the Actors.

Another example of an implicit resemblance between entities in which more than one domain of experience is used for their construction concerns the representation of cells as if they are the workplaces in which various jobs have to be done, and as if they are the containers in which things are stored and have parts which do several jobs (see sections 6.3.2.2.1 and 6.3.2.2.2). In these examples even if lexical metaphors are implemented in the representation of entities, the domains from which the analogies are drawn are not addressed explicitly. Regardless from which domains the analogies come from, resemblance is found between what is observable/accessible and what is unobservable/less easily accessible. So the latter are involved in schematic structures and in material processes in the same way as the former.

Representations analysed in terms of image schemata and grammatical structures afford representations of the unknown and unobservable in terms of what is known and observable, but at the same time familiar entities are seen in unfamiliar ways and previous beliefs about the nature and behaviour of entities are challenged. For example, entities such as Nitrogen fixing bacteria and decomposers are represented as observable living agents:

T: *They need to be broken down and bacteria etc. will break down the waste and they will be called the decomposers so waste is broken down by decomposers. Aren't we lucky we have the bacteria around the place, otherwise we'd be walking to school in the morning knee deep in dead cats, dogs, mice, rats, hedgehogs, etc. but you know that if you see a dead animal or whatever it is in the hedgerow after a period of time it's only the bones left.*

The fact that decomposers here are represented as agents in a relation of solidarity with humans; they do a job for us that we cannot do, without elaborating more the way in which the process of breaking down is realised, implies living properties to their nature. This example also shows that both what is said and what is not said about the way the entity acts, produce further inferences about how its (nature) ontology is understood.

One should also notice that what the teacher is trying to do is to challenge the commonsense belief that all bacteria are of the same kind and that they are all bad for humans. Even though the teacher's point of reference is the indeterminate 'we', which results in attributing some familiarity with bacteria's behaviour, students are called to think of themselves and consequently their lives as being dependent on what unobservable entities, which are represented as living, do. What the teacher implies is that without the bacteria we would not have been able to cope with a number of carcasses around us. He would later challenge more misconceptions about bacteria and disintegration by attributing for example the 'terrible' smell of dead animals to the release of special chemicals by bacteria in order to break down the dead organisms. Resemblance affords here both familiarity and unfamiliarity. The nature of bacteria is elaborated in a way that makes them familiar, but at the same time the 'self' is seen from an unusual angle and prior beliefs about them are challenged.

Entities which are discussed in the classroom for the first time are introduced by the teacher in relation to what students already know about them. For example the concept of the environment is introduced by a number of instances of different kinds of environment. Every instance of an environment is represented first of all as a physical/spatial place in the example (19) discussed in chapter 7.4.4.1

T *What does the word urban mean in the connection with the word environment?*
S *Is it ....*
T *Hands up first. Yes.*
S *Is it a type of place.*
T *It's a type of place. What type of place though might it be describing? Yes. [] Sorry.*
S ...
T *I did...it's the water it's the water. Yes? [] I'm going to have to .... next one next one you answer the next question...*
All *Towns.*
T *Towns and cities and built up areas and so on ok we can refer to as urban environments ok [] now then the next one.*
S *Rural.*
T *A rural environment ok now then here is your change a rural environment is. [] the countryside ok. Out in the countryside []*
S *What's urban?*
T *Towns and cities. A domestic environment?*
S *Dogs and cats.*

There is little thought whether a certain environment like a marshland area or a river can be thought of as a single unit or not. Therefore what is implied from the way different kind of environments are talked about is that what is accessible to the human scale is seen as an appropriate unit of study and in addition, if necessary, relations between units can be addressed.

But the study of each environment, even if it is identified at a first glance as a familiar place-like entity with spatial/physical dimensions, shifts to the sort of place-like entity where certain sort of interactions between entities occur. The natural environment for example is thought to be the sort of environment in which human agency is not involved at all. On the other hand an urban environment is one in which human beings intervene in every possible way, therefore it is an affected environment which in some cases is highly polluted:

T *Ok a jungle. Now then why might a jungle area be natural. [] Your right in saying that but why. You want to continue seeing as you started.*
S *...I don't know.*
T *Yes.*
S *Is it because there's no machines ...*
T *Ok it's growing by itself. we haven't been out there. We haven't been chopping down things we don't want planting things that we do want building buildings and so on it's unspoilt. It's unspoilt, untouched by human hands ok, ...*

T *Urban environment. A word or a phrase that would describe that environment. Yes.*
S *Horrible.*
S *Pollution.*
T *Pollution polluted ok, it's likely to have quite a lot of pollution there.*
S *Very busy.*
T *It's very busy [] you might come up with things like densely populated a lot of people in a given area. [] ok*

The fact that an environment is defined by actions that take place within it and its interactions with entities of other environments and not by some intrinsic properties of the physical location as such is also supported by the teacher's argument (later in the same lesson) that nothing can guarantee that a certain sort of environment will remain as it is totally unchanged; a natural environment can cease to be natural if people intervene and use it for growing crops for example. What has been talked of before as a type of place, a physical location with a sense of closure separated from other types of place, has now turned into a set of relations which impose separation on the entities involved in them. So what was first represented as a container realised as physical location has now been represented as a container realised as a set of relations.

Students are called on to think about different types of environment not on the grounds of what they are expected to be from the commonsense point of view; that is physical locations, but as containers of a very different kind; it is the set of actions which entities are able to carry out on other entities or which can happen to them that define what is 'in' or 'out' of a type of an environment. Inevitably, the new way of thinking about types of environment 'alienate' students from the commonsense way of viewing an environment. As has been observed in the specific classroom situation, the extent to which thinking about environments in a new way is promoted depends not on the mere acknowledgement from the teacher that environments can be seen from a different point of view, but from a range of discussions and activities carried on with students in which the different realisation of the concept of the environment is worked out.

As far as resemblance is concerned, it is noticed that a set of relations even defining what a natural environment is has as a point of reference human actions. In that respect the metaphorical extension of the containment relation in terms of relations of agency is elaborated not from a specific scientific point of view but from a commonsense point of view, very much in the same way metaphorical extensions of containment relations, in terms for example of people who see themselves as trapped in some kind of relation or situation (e.g. drug addiction), are realised in everyday life. So in this example as in the previous one it is noticed that resemblance can be silently heading towards two opposite directions at the same time; unfamiliar entities are made familiar and familiar entities are seen in unusual ways.

Resemblance brings scientific, abstract entities and commonsense entities together at a level where a set of relations are grounded in everyday experience. At this intermediate level between what is abstract and what is concrete, described by Piaget as an empirical abstraction and by Lakoff and Johnson as basic-level categories and image schematic structures, the nature of entities and their relations with other entities are worked out most of the time, both in the context of textbook representations and classroom talk. From the image schema point of view adopted in the second part of the analysis of the present thesis (see chapter 7) resemblance is evident by the fact that both scientific and commonsense entities share the same schematic structures. In other words the same image schemata (grounded in everyday physical experiences) are the hosts for both abstract and concrete entities. As far as Systemic Functional Linguistics is concerned (see chapter 6), the same grammatical structures (e.g. material processes) are the host semantic structures for representing both abstract and concrete entities. One should be careful here not to misconceive this intermediate level described above as a domain which consists of mere concrete entities. Neither image schemata nor grammatical structures are forms or meaning relations. They are also neither abstract nor concrete. They are semantic forms abstracted from the everyday physical experiences in which they are grounded and they are applied as representations of meaning to entities which come from various contexts. Therefore a description of resemblance as working the abstract within the concrete is rather naive since it characterises only one side of what is happening while it ignores how commonsense entities are represented. Moreover, this description polarises the abstract and the concrete leaving nothing between them while reinforcing us to categorise entities and representations in either category .

In respect to resemblance, metaphor either looked from the point of view of the grammar or from the point of view of the image schema, affords both familiarity and unfamiliarity in the context of teaching environmental science. To give a final example from the representations of cycles, people, animals and plants involved in the Carbon cycle are abstracted from the concrete properties and relations which they have in our everyday world. They lose their uniqueness by becoming physical objects made of tissues and cells connected through circulation of substances. But then the discussion of arrangements and functions of parts is grounded in actions and relations which are very much the same as the concrete relations and actions in which we are involved in our everyday world. The blood stream is described as if it carries substances to parts of our body in the same way that goods are transported among countries.

8.3.1.2 Continuity and recurrence

Another way of representing the unfamiliar as familiar is by engaging the former as a participant in schematic or grammatic structures in which the latter is involved as well, without drawing a line between the two. Continuity means unnoticed, smooth shifts between entities which are found at different scales and are different in terms of whether they come from science or from everyday life. In that way continuity as well as resemblance affords that the ontological distance between entities is decreased or increased accordingly.

Both in textbooks and in classrooms, continuity between entities, like resemblance, is not represented as an exceptional, rare case of representation in contrast with what is supposed to be a regular (literal) way of representing entities. On the contrary both resemblance and continuity are repeatedly used in transmitting desirable meaning or sets of meanings. The same schematic or grammatic structures for the same entities are repeated across different contexts and instances, so in a way a viable and convincing way of thinking is promoted and gradually established.

As discussed in section 6.3.2.2.1, both what is visible and invisible is part in the same grammatical structures of material processes in representations of the structure and functions of plants. Grammatical choices represent observable entities acting directly on unobservable entities. Also circumstances which realise spatial relations represent as unproblematic the fact that unobservable entities are located within observable entities. These representations which treat the invisible in the same way that we talk about the visible in everyday life, make more unlikely the chance of bringing the ontological differences between the two realms of experience to a conscious level. Therefore, continuity in grammatical structures results in familiarity with entities which are less accessible from the commonsense point of view, because the represented nature of these entities is based on representations which keep their differences with familiar entities silent (see also Appendix 5.1 and 5.2).

Image schemata provide a set of relations in which what is known, easy to understand and/or observable is connected with unknown and unobservable or difficult to understand entities. At the end it is not just the fact that in a single image schema one unobservable entity is connected with observable entities or that it is involved in those kinds of relations which have an experiential basis, but that the same entity is found in more than one image schemata which are somehow connected to each other. Associations of image schemata like sequences of agent structures afford shifts at the level and the scale at which a phenomenon is studied without causing a breakdown between realisations of meaning which have an experiential basis and realisations of meaning which have a scientific basis.

It should noticed here that the attribution of real existence to entities is a multi-modal construction. In the example of the Carbon cycle it is the classroom talk assisted by drawings on the board and in books which does most of the work. But in other examples very carefully planned demonstrations or the very detailed setting up of experiments in relation to classroom talk, do the same work. The teacher who demonstrates the effect sulphuric acid has on marble chips in a test tube, first of all is making the process observable and then elaborates it with language; 'eating away', 'disintegrating' etc. The demonstration becomes later the visual representation which stands in place of the unobservable process of weathering.

Among the means of multi-modal construction of entities representations in terms of narratives should be included. Resemblance and continuity often work together at the basis of how a narrative-like representation realises a phenomenon. One of the most important aspects of the path-link schema - discussed earlier in section 7.3 - is that it represents a phenomenon as a narrative of nature rather than as a narrative of science.

This is realised by the temporal order of agent structures which follow one another as if they occur naturally and not hierarchically.

Nominalization and nominalized processes as grammatical choices which abstract agency to some degree, are heading towards the opposite direction. Such representations lack any resemblance between how a phenomenon is represented and how it can be experienced from a commonsense point of view. Under nominalization a number of process-like entities and interactions between entities are silent but they can be made explicit if the packaging of information the nominalization entails is revealed.

8.3.2 Conclusion

In this section certain choices of linguistic and schematic representations have been discussed as functioning in the same way and leading to the same realisations of meaning. Metaphorical ways of talking analysed either as grammatical structures or image schemata afford both familiarity with unfamiliar entities and some sort of alienation with or distance from familiar entities. Resemblance and continuity bring into a relation of interaction entities which belong into different realms of experience. As has already been illustrated, this interaction reflected in entities' representations has implications for how the nature of entities is represented and realised, and the status that is attached to them, particularly the extent to which they are represented as real, and what is it considered as commonsense or scientific knowledge. Before we discuss further these implications in the final last chapter, it should be noticed here that resemblance and continuity do not impose boundaries between what is supposed to be commonsense and what is supposed to be scientific knowledge. On the contrary, it is mostly in a silent way that the ontology of both is worked out - in the teaching of environmental science - in a way that resemblance and continuity realise the relation between the two realms of experience as one of unbroken and unquestioned continuity.

CHAPTER 9

CONCLUSIONS

9.1 Overview

Two different points of view have been used in the present thesis for the study of metaphor, one concerning more with language, that is Systemic Functional Linguistics and the other concerning more with cognition, that is the image schema approach. Following the two approaches metaphor is seen as a choice of an option for representing meaning relations against other options. So for example from the linguistic point of view choices such as nominalized processes and their implications in constructing meaning are looked at against others such as direct material processes. Also from the image schematic point of view the implications of the use of certain kinds of schematic structures and their metaphorical extensions are exemplified against other possible kinds of representations.

In answering the first two research questions:

How do the image schematic and Systemic Functional Linguistics apply as analytic approaches in the context of teaching environmental science? and

What does the application of the schematic and linguistic analysis in the specific context suggest for their semantic functions: clause types and image schemata?

we noticed that both kinds of semantic forms as they are used in both kinds of analysis (chapters 6 and 7) seem to be very valuable and powerful in realising entities at the ontological level. This is due to the fact that the same semantic form (e.g. material process) can realise different entities (e.g. animals and plants), which suggests that semantic functions (e.g. agency) work out categorical relations between entities (e.g. the category of living organisms).

The analysis also has shown that in order to understand what the semantic functions mean for the entities to which they are applied (e.g. the semantic function of agency, a material process, has in realising decomposers' behaviour) the way in which semantic forms are looked at is very important. It would have been a very constrained or even distorted picture of what the entities are if analysis was restrained at the level of a relation between a single entity and a single semantic form only in a single case of representation. On the contrary looking at how an entity is represented for example at different places in the same and in different texts, we realise how important it is to take into account textual and interpersonal aspects in the construction of meaning as well as the relation between language and other means of representations. Thus, in answering the third research question:

How is the content of environmental science realised linguistically and schematically?

it has been argued that entities are not just either concrete or abstract but depending on how they are represented they can be seen as being abstracted to a degree. Also patterns of transitivity have proved to be a very valuable tool in looking at entities since they underlie both implicit and explicit accounts of metaphors, the way in which the reader is treated in texts and talking and the way in which unobservable entities are realised. From the image schema point of view, agent structures are not only the realisations of single actions, but looked at as sequences then they constitute the realisations of narratives.

Considering both approaches, in respect to the second and third research question, it should be once more emphasised here that neither linguistic nor schematic choices are always apparent at the linguistic surface. It can be easier to identify entities represented as containers with physical boundaries, rather than metaphorical extensions of containment relations in which agency imposes boundaries. It can also be easier to identify nominalizations rather than entities which are represented as active in the same way other entities act, due to their persistent appearance as Actors in material processes. But what is the case for both 'easily' and 'less easily' identified representations is that they constitute semantic functions which contribute decisively to the meaning of the represented entities and are not mere words or phrases. Therefore, metaphor is not something that can be counted on the basis of a single word or phrase. Metaphor is seen here as a discursive property that is the effect on the represented meaning by the use of specific semantic forms (either linguistic or schematic) which can appear at different places in the text or talk. Because metaphors are not signalled as such their presence often becomes silent for the educator, the learner and even the investigator in many cases.

In respect to metaphor, the main purpose of the present study has been to show what is the effect on the transmitted meaning in choosing specific linguistic and schematic representations of environmental science, in the context of teaching environmental science. This purpose, formulated in the fourth research question:

What is the effect of the choices and use of certain semantic forms on how contents of environmental science are represented?

is investigated at the level of exemplified accounts of teaching which illustrate what are the possible implications of adopting specific choices against others.

In order to accomplish this purpose, the present study has focused on how aspects of environmental science are realised in their representations and what implications these realisations have for the nature of the represented entities (ontology), how knowledge about entities can be made possible (epistemology) and what is supposed to be learnt and how (learning). To give an example, treating the unobservable in the same way as the observable has an emergent ontological and epistemological implication in the sense of how the unobservable entities are realised; that is as similar to observable and therefore approaching the unobservable from the point of view of the observable is not thought of as problematic but is taken for granted.

I believe that the epistemological and learning implications should not be seen as if the latter are determined by the former. But failure to keep them distinct both in textbooks and in classroom representations either because there is a reason to do so or not, has the result that what has a learning value is often implied by what is taken as epistemologically acceptable and correct.

From the framework outlined above, and the implications different choices of representations can have, discussed in sections 6.4 and 7.7, it appears that this study does not support a view that there is only one way of representing environmental science either because it is the only or more 'natural' way to talk about such contents of science or because there is only one 'correct' (either scientifically or educationally or politically) way of representation which is the appropriate one in this context. Therefore, metaphors are not seen as deviations from how things are supposed to be represented or as additional persuasive elements towards a better and more effective representation. On the contrary, metaphor is seen as variety both in the way a representation works and what it can afford. That makes problematic any definition which sees metaphor as a single phenomenon.

9.1.1. Representations and metaphors

Representations of environmental science can be seen as taking part in the 'conflict' between the everyday world of commonsense reasoning and the scientific world of science. According to Halliday representations which are closer to the former are called 'dynamic' (or doric) due to the large extent to which transitivity patterns are used to make reference to everyday happenings, while representations which are closer to the latter are called 'synoptic' (or attic) because they characterise the impersonal and abstract way in which knowledge is reported in a scientific context (Halliday, 1985, p.97).

Nominalizations and some metaphorical extensions of image schemata such as 'photosynthesis' which is seen as a container because it is represented as a single entity, that is a 'package' to which entities are seen as either belonging or not, can be seen as synoptic representations. On the other hand, image schemata which are grounded in everyday experiences such as containers with physical boundaries ('a pond') and representations of agent structures with the use of material processes unfolded nearer to the way in which actions are supposed to be experienced in reality (e.g. one material clause following another without any embedded processes), can be thought of as closer to the way things happen and are reported in everyday life, that is, the dynamic mode of representation. But notice that in respect to the specific examples discussed in the previous chapter, representations are not seen as belonging either in one mode or another in an exclusive way which presents the relation between the two modes (synoptic and dynamic) as a 'conflict', but most kinds of representations discussed in the present thesis, have an effect on representing entities which is to some degree dynamic and to some degree synoptic. Also when it comes to the question of what sort of implications representations which are nearer to one mode or to the other have, that is the fourth research question, then we notice that in different ways they come to the same end.

In particular, dynamic representations have an overall structure similar to the structure of stories. A strong element of agency is almost imposed or at least projected on how nature is represented. This view implies that what we can see in the natural world is patterns of agency which resemble the plot of a story. That sort of representation can facilitate learning by reducing the distance between learner and scientific entities by putting the latter in the structure of an everyday context. Therefore, how things happen comes to be taken for granted because they are grounded in patterns of happening and doing which are experienced as obvious in everyday life. The use of nominalization on the other hand works in the opposite way; agency is abstracted from the accounts that are attributed to nature which also come to be impersonal, and therefore the distance between the 'knower' and the objects of his/her inquiry is now increased. As a result knowledge about nature is represented as being objective leaving little or no space for questions about how this knowledge can be possible. So the implication of the use of nominalizations and story-like representations is the same but for different reasons; knowledge about nature is represented as being objective either because nature is as obvious as the everyday world is or because the process of making knowledge and knowledge itself is implied to be objective.

These findings are also in accordance with how knowledge about the environment is represented in the media. According to Stocking and Holstein (1993), scientific claims are reported in the media at face value with relatively little attention to their constructed nature nor to their unknowns and uncertainties. So in that respect environmental communication is primarily an objectivist scientific discourse. But while scientific information is represented as objective knowledge, the environmental discourse which carries this information is dramatised in order to represent causes and effects as real and important.

The 'objective' character of linguistic and schematic representations of environmental science in the examples of lessons and textbooks discussed in the present thesis, is silent for both cases of representations, but for different reasons. Image schemata are grounded in everyday experiences so they are taken for granted without any need to be justified. Grammatical structures (such as agency patterns) also construct and work out relations between entities at the level of semantic functions without being marked at the linguistic surface. So they are taken as the natural way in which things are talked about. Finally, nominalizations appear as 'packages' of scientific knowledge which are too objective to be challenged or further analysed as choices of representing science.

9.1.2 Metaphorical representations of knowledge

As was shown in chapter 2, definitions which are about the ontology of entities such as 'pond' and 'forest' are not the same in ecology and in everyday life. Nevertheless, in section 7.4 we have seen that the teaching of these entities often follows a naive approach in representing and realising them as if they emerge from commonsense thinking alone. Such representations grounded in everyday, containment relations impose boundaries on entities and represent them as different and separate from others in an oversimplified way.

One can easily recognise the tendency for entities which have made their way in commonsense knowledge to be discussed in textbooks and in classrooms as parts of our everyday exchange of meanings in order for students to achieve familiarity with them and only a few aspects of these entities are elaborated from the environmental science point of view. The fact that entities such as 'pond' or 'forest' are parts of our everyday life and vocabulary and should be seen as such does not mean that the way these entities can be talked about can be taken as obvious and unproblematic.

The question about how the nature of entities, that is their ontology, is represented and realised in classrooms is related with the acknowledgement that the same entities can belong in different categories depending on how they are looked at. It also points to the idea that if the reasons for classifying entities in one category rather than another remain silent, then it is to be expected that students will bring their own reasons for distinguishing categories and as a result misconceptions underlying their reasoning are never made explicit.

The implications of the use of misunderstood categorical relations by students in a way that very seldom makes them aware about their underlying patterns of reasoning are increased by the fact that categories of entities are often silently shifted towards different realisations. These shifts of categorical relations are often due to their linguistic representations (e.g. plants represented as 'acting' in a very similar way as animals are represented doing things). Metaphorical extensions of image schemata also work in the same way (e.g. types of environment defined as containers due to agent structures and not because of physically imposed containment relations).

As discussed from the point of view of metaphor in chapter 8, both linguistic and schematic representations work out constructions of entities and their relations at the ontological level mostly in a silent way. In respect to how knowledge is represented, representations in terms of grammatical choices are taken for granted as the 'only', 'natural' ways to talk about things. That propagates a view about language as a transparent medium of meaning which overlooks the fact that grammar is a system of options. Ironically, representations which use patterns of image schemata grounded in commonsense, everyday experience promote a naive objectivism. This is due to the fact that even metaphorical extensions are not questioned as such since they are grounded in everyday experiences which are taken for granted. Therefore, their implementation in reasoning is not considered as a matter of choice but (rather) as a matter of natural necessity; in a way that this is how things are. So almost no questions are raised in textbooks and in classrooms about why something is represented in one way and not in another and therefore what is the effect of its representation on its meaning.

Concerning objectivity, an interpersonal aspect which characterises the relation between 'knower' and knowledge is whether nature is objectified or not and to what extent, not because it is represented directly as such to the reader/hearer, but because the latter is addressed in such a way which implies objectification. This can happen in different ways (as has been illustrated in Appendix 5.1 and 5.2), either because the reader him/herself is objectified if he/she is represented as being part of nature so the latter is taken as an objectified entity, or because the reader's relation to nature is seen as an instrumental relation in order to guarantee objectivity.

Interactions between entities are valued as very important in environmental studies as has been discussed in the review of the literature of environmental science (see chapter 2). And this is because different views or paradigms in ecology (e.g. mechanistic vs. organic) study relations between entities differently and as a result different accounts of nature emerge. In section 7.3.3 it has been shown that interactions between entities reflected in sequences of agent structures provide a picture of nature which looks like having the structure of a story. Interactions between entities become reports of stories' plots. The fact that narrative accounts of nature are not explicitly stated as such (either in textbooks or in classrooms) and in most cases only one unquestioned plot is provided for each phenomenon adds to the effect that one way of looking at nature is propagated silently in teaching.

Also, in the examples of teaching of the present thesis it is hard to find any accounts of why an entity treated as a unit of study is chosen to be so. Again commonsense understanding dominates and any reasons for making choices are silent.

Representations of relations between a living entity and its environment in textbooks and in classrooms constitute a mixture of approaches towards nature. Take for example the representations of cycles. On one hand in such representations there is a lot of emphasis on circular systems of cause-effect relations in contrast with linear causality. But, on the other hand many of these representations reflect a naive objectivist view about nature dressed up as an organic view of nature. This is due to the fact that these representations are seen as if they are directly extracted from nature itself. Moreover, since no mention is made of the fact that representing patterns of relations between entities is part of a specific methodological approach in environmental science, they reflect the latter as being theory-free, natural science (not only by name but also by method) even if cycles are represented as being constructed or invented by scientists.

The issue of continuity between the observable and unobservable reflected both in grammar and in schematic relations as well as the issue of the interaction between the two either seen in clauses or within the same schematic structures, while endorsing the existence of the unobservable or theoretical entities and making them more accessible to the learner, leaves silent the issue of their construction as scientific entities (constructed and used within a specific scientific paradigm).

9.2 Implications

9.2.1 Teaching and learning

The present thesis advocates a view about metaphors as parts of representations of environmental science which is different from what predominantly has been thought about metaphors and their role in an educational context. Exemplified accounts of how this different view about metaphors can be seen at work, in real terms, in natural and not artificially created situations, have been provided. In analysing these examples, an effort has been made to find how one can best describe what is a metaphor and how it functions in a specific context while pointing at the same time to the possible ontological, epistemological and learning implications choices of certain sort of representations can have. The implementation of this sort of thinking about metaphors reveals some general current fallacies which are pervasive not only in what is considered as the value of the use of metaphor in science and environmental education, but also in general accounts about the role of education itself.

So far as metaphors and analogies are concerned, it is rather unfortunate that from the very beginning when metaphor attracted scholars' attention, various pedagogies grounded in psychological and educational studies have created the expectation for educators and teachers that metaphor and analogy are useful 'tools' for learning. What is implied by the use of the term 'tool' is that metaphors are 'tools' of thinking which can be 'activated' for additional assistance in the process of teaching outside of the 'regular' way in which things are represented. This view picks up only explicit accounts of metaphors and evaluates them superficially at the level of the linguistic surface of mere 'words' or 'concepts', ignoring what lies below the linguistic surface. The current difficulty of studies in making convincing any causal connection between students' misconceptions, their consequent failures in attainment and what look like 'peaks of floating icebergs' above the 'sea surface', indicates that one should wonder what is hidden below the linguistic 'surface' of 'good' or 'bad' metaphors.

The 'iceberg' fallacy is closely related with the fallacy - reflected even in early Halliday - that there is a 'natural' way of talking about things. The latter view not only represents language as a transparent mean of representation but underestimates the semantic function of other means of representations (e.g. images) as well. It is because of this view that metaphors are seen as deviations against the regular way of talking. As far as the latter is concerned, it is not realised as choices among options of means of representation. This view, which propagates a 'naive' realism, since according to it, it does not matter how something is represented but has also no interest in what is the effect of what is not represented. On the contrary in the view adopted here what is represented and what remains silent both have equal value because both reflect choices of what is meaningful or not in a specific context. The question is not whether there is a natural or direct way to talk (represent) about things, but whether a particular situation is encoded as an agentive or as a non-agentive event for example. The latter is often a matter of perspective and interpretation, rather than an 'objective' property of the situation as Kress has pointed out (1979, p.19-20). In other words what we are looking at is a matter of choice in meaning-form relations.

Another 'myth' which is perpetuated in environmental education is the value that is attributed to experience as an effective way of learning. Teachers are advised to provide situations in which students can have an immediate experience with entities, something that is reflected in the rhetoric 'teaching about and for the environment, within the environment'. Curriculum proposals sound naive in suggesting that whatever promotes an experiential relation as such is effective and therefore to be welcomed in teaching, as if scientific entities can reveal themselves to students without any sort of representation intervening between entities and students. Again this 'myth' is grounded in the fallacy that representations are 'neutral' in respect to what they represent.

The classical concrete - abstract dichotomy in cognitive studies is also reflected in educational studies. The latter due to their denial of the role and value of representations, attribute concrete or abstract properties either to mere words or to concepts and things. The present thesis argues that it is neither the 'things' which are themselves either abstract or concrete nor their representations themselves, but it is the way representations are used which realise entities as more abstract or concrete to a degree. As has been emphasised, representations such as image schemata and certain grammatical structures are semantic forms; representations of entities which are abstracted from the experiential basis in which they are grounded.

Finally, it is now taken as a necessity that both studies and curriculum proposals in environmental education should take into account in their frameworks at least the basic dimensions of the main theoretical, epistemological positions or stances or paradigms which are currently present in debates about the nature of environmental science. But most studies fail to show how these paradigms are materialised in the actual processes of teaching or how the latter can be constructed in a way that can be directed towards one or the other theoretical position. Attempts to illustrate how the latter are reflected in teaching often become anecdotal accounts due to the fact that studies lack any systematised and coherent framework, so that the value of their isolated examples which exemplify how paradigms can be possibly realised is very limited. As a result quite often curriculum proposals suffer from what Napoleon has called the 'syndrome of generals'. Curriculum developers insist on the application of their proposals like the generals who implement their strategies and act as if their strategies really take place, without having a good sense of what actually happens in the battlefield.

The view about representations and metaphors which is worked out in the present thesis can be very valuable in teachers' training. In particular, the role of representations as a non-transparent medium of meaning relations can be underlined concerning real classroom situations. Teachers might re-think their role as educators if they realised the possible implications specific ways of representing environmental science have, such as the use of material processes or nominalizations. Furthermore, their training should aim at a better understanding of how different kinds of representations (either schematic or linguistic) at different scales (from an ideational process up to a narrative) are co-ordinated towards the transmission of specific meaning relations. Studies concerning the effect covert representations of environmental science have on what and how students think about the environment and issues related with it, could not only underline the importance of representations but also make teacher training more effective.

In addition, the study of written materials such as textbooks, which are either available for teaching or as popularised accounts of environmental science, is valuable not only for identifying possible causes of misconceptions and difficulties in understanding, but also in constructing materials according to the interests of various groups of people and suitable to the age range to whom they are addressed. In respect to the latter, similarities and differences between texts which are addressed to students of different ages, raise questions about the differences in the text structure and the linguistic realisations of abstraction, as well as how participants such as Actors and Goals are represented and how language can be seen as part of an interactive system of relationships between different systems of representations. Studies of text materials need to distinguish overt cases of metaphor in which both entities which are represented as similar (or different) are present in the text, from covert cases in which one of the entities might be presupposed by the text, but because it is not present in it we do not know what this entity is. In other words, studies about metaphors in texts should not treat them as if all of them are overt cases of metaphor.

9.2.2 Limitations and further work

In both kinds of analysis the limitations of studying a single semantic function, let us say material process, isolated from others and disengaged from its wider context which can be from a piece of text up to a chapter or even an entire textbook or series of textbooks - as far as we are concerned with textbooks - have been explored and recognised. Further work can provide more detailed accounts of higher structures of semantic functions as higher organisations of meaning and their relations with lower structures of semantic functions. There are many open questions which can be further studied concerning specific contents of environmental science. In particular, a question arises about how far a higher semantic function, such as a cycle, is determined from the arrangement and the direction to which lower semantic units e.g. single agent structures and containers, build up meaning relations, e.g. connections between entities in which entities are constantly transferred from one 'place' to another. The same question arises from the linguistic point of view since as has been pointed out and exemplified in section 6.2.5 and in Appendix 5.1 choices of ideational processes depend on decisions made about the text structure (textual dimension) and to whom the text is addressed (interpersonal aspects).

Further analysis based on both kinds of representations (linguistic and schematic) about the same contents exploring at the same time differences and similarities in the way the two approaches are applied, is interesting specially for cases in which writer's or speaker's motivations and intentions are either not clear or are seen as obvious (e.g. transmitting pieces of knowledge about cycles to a specific audience). The present thesis has been exploratory to the extent to which the two approaches can be applied at looking metaphorical aspects of taught environmental science. As a result, the two approaches have been seen as rather complementary and their similarities have been the primary focus of study. More research on semantic forms such as narratives from the point of view which is suggested in this study will be valuable given also the extent to which they are used in primary schools and in representations of environmental science which are of public concern (e.g. TV documentaries with a narrative style about the life of wild animals).

The present thesis is limited so far as its outcomes are related loosely with the recent work of studies in environmental education and the philosophical and epistemological aspects of environmental science. Even if where ever it has been possible, causes of students' misconceptions due to how specific contents of environmental science are represented to them, have been discussed, as well as the limitations of various kinds of studies, there has not been any effort to connect in a systematic way all these areas of concern (philosophy, studies and representations) since this has not been the scope of the present study. Further work in this area is of special interest because it might be expected to illuminate the importance of representations in the realisation of knowledge about the environment in a way that issues concerning students and public misconceptions will be looked at differently. Furthermore, the study of representations can make it possible for investigators and educators to see how wider philosophical aspects are 'materialised' in the actual process of teaching.

The present study can be criticised on the basis that it is grounded in examples - sometimes used as 'best' examples - to exemplify arguments. Because of that, one can argue that the outcomes are of limited value since they depend too much on specific contexts and would not be able to be generalised to other contexts. This is true as far as context is concerned but one should bear in mind that the aim has not been to provide generalised accounts of the teaching of environmental science. The exploratory character of the study is attributed to the construction of a point of view and the exploration of two approaches as they are applied in a context (teaching of environmental science) for the study of which they have not been initially intended. So what matters, is not the examples themselves and categories of them but how representations work in different examples and what their implications are. Therefore, what might be seen as weakness is the potential for new studies for deepening and widening the investigation of metaphor not only in the context of environmental education but also in the context of science education and public understanding of science.

In respect to the latter, the issue of representation has been the interest of many studies (see for example Hannigan, 1995) from mainly a sociological point of view. What has been described in the present thesis as an intermediate level of representing which is neither concrete or everyday, nor abstract or scientific, has found its way into sociological accounts of the public understanding of science as a 'discourse coalition'. The latter means that a variety of discourses, some of them nearer to the way things are represented in everyday language and others nearer to representations of scientific reports, are brought into one and the same text whose ideological task is to provide some resolutions to the different interests and points of view the different discourses carry with them.

An interdisciplinary approach to matters of public concern which implements the ideological implications representations have along with the ontological and epistemological ones would be very valuable. From a sociological point of view what has been underlined not only here but in many other studies is that language is not a transparent medium in representing knowledge, but has also another important aspect. Representing knowledge to non-experts as experts' knowledge in a way that the former have no access to it, implies a greater level of dependence of non-experts on experts in making decisions for the interest of both. On the other hand, the attempt to represent popularised accounts of knowledge which rely too much on everyday knowledge is in danger of providing a distorted picture of reality to non-experts by keeping them away from the complicated nature and making of recent knowledge about the environment and issues related with it, knowledge on which directly or indirectly we rely on even in our everyday life (e.g. mad cow disease and genetically modified foods).

There is not really any straight answer either from a philosophical, epistemological or sociological point of view, to the question of whether representations of environmental science to the public should be drawn more from scientific or commonsense knowledge. But what one can say here is that making people aware about the way knowledge is represented has probably equal value to the value of the content of that knowledge. People are used to ask what something is (e.g. a cause or an effect) and how far it is true or not, but very rarely ask how something has been talked about and whether what we know about it is due to the way it has been represented to us. A naive realism underlies the false assumption, reflected in language and in cognition, that if something is true 'it can speak by itself' irrespective of how it will be represented.

However, it is rather recently that people have become aware about the importance of how knowledge is represented since the appearance of global environmental problems such as the Greenhouse Effect and the depletion of ozone layer has shown that these issues can not be reduced to simple answers and their representation to the public has become a real burden for those in whose interests it is to do so - from governments, media and non-governmental organisations down to science teachers in classrooms. The intense attention which issues, such as CJD and GM-food which apply to the immediate interest of the public (what one can eat), have attracted in the media, raise serious questions about who is representing what, how and for what purpose.

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APPENDIX 1

AN IMAGE FROM A NEWSPAPER ARTICLE

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APPENDIX 2

EARLY AND CONTEMPORARY APPROACHES TO METAPHOR

2.1 Introduction

There have been two alternative approaches to metaphor in the recent debate in the fields of linguistics, philosophy of science and psychology: the constructivist view which recognises metaphor as an essential characteristic of the creativity of language and scientific thinking and the non-constructivist view which sees metaphor as deviant and parasitic upon normal usage (Ortony, 1979, p.2). The latter derives from the traditional view which sees reason as literal, as primarily about propositions that can be objectively either true or false. The former derives from the view which takes imaginative aspects of reason (metaphor, metonymy and mental imagery) as central to reason, rather than as a peripheral to the literal. In particular, this view sees metaphor as a dynamic cognitive process and as a dynamic cultural process changing the language we speak and write, in contrast with the traditional view which takes metaphor as a static grammatical category (MacCormac, 1985, p.6).

In the constructivist view of metaphor, two divergent perspectives can be identified, related with what is to be counted as a metaphor. One of them claims that the concept of metaphor and the concept of model include within their sense the concept of analogy. There is an implicit assumption here that analogy is a more fundamental and simple concept than metaphor or model. The second perspective investigates metaphor as a phenomenon of its own without any kind of reduction into another concept (analogy, model or similarity). The latter approaches vary to the degree to which they define and represent metaphor as fundamental to language and reasoning. To give an example, some theories argue that the whole language is metaphorical. It is very difficult for theories which adopt this position to escape from some kind of circularity, such as the assumption that theories of metaphor presume basic metaphors. So according to this point of view, it is almost impossible to distinguish between the literal and the metaphorical.

Notice that the term 'constructivist' comes from the relatively new tradition in cognitive psychology and education, which stresses the individual as an active participant in the process of comprehending and understanding new knowledge.

Therefore, the distinction between constructivist and non-constructivist accounts of metaphors is raised within that recent tradition which is opposed to the view that individuals are passive recipients of knowledge.

Today, one can say that most of the studies about metaphors recognise the role of the latter in understanding and reasoning, so they are in one way or another constructivist accounts. But, they still vary in the degree to which they think that:

- metaphor is either primarily about words or concepts or categories of things
- there is a metaphorical process which can describe metaphor as a cognitive process (e.g. mapping) and can be generalised across various examples of metaphors
- what the metaphor affords is what it is about having ontological, epistemological, ideological and learning implications
- there is a learning value to metaphors which are used in an educational context

In the first section (section 2.2) of this review, issues related with the definition of metaphor will be put in their historical context. It is important here to elicit early approaches to metaphor and their disputes because they are the bases in which new theories are grounded. There is also one more reason to do so. Recent studies of metaphors often fail to realise explicitly their influences from early accounts of metaphors usually because they take the latter (early accounts) for granted. The next section (section 2.3) investigates two divergent theories: comparison and interaction theories which although both recognise the cognitive value of metaphor, they use different approaches to investigate it. Section 2.3.2 provides also some linguistic, pragmatic and semantic accounts of metaphor. Thereafter, the main epistemological theories of metaphor and their influence on what place is given to metaphors in science are discussed (section 2.4). One can realise here that metaphors, analogies and models are seen as closely related with what is counted as scientific explanation. Finally, in the last section (2.5), a short review represents the research literature on children's ability to comprehend and produce metaphors.

In the following review about early and contemporary approaches to metaphor, Lakoff's and Johnson's accounts, metaphors in Systemic Functional Linguistics, as well as recent studies of metaphors in the context of science education are not included, but references to them are made wherever is thought appropriate to do so, since they are discussed extensively within the main part of the thesis (see chapter 4).

2.2 The history of metaphors

2.2.1 Ancient and medieval years

Early on, it was natural for the pre-Socratic philosophers in ancient Greece to use figurative language when they tried to express the insights of myths and poetry for their predecessors (Johnson, 1981, p.4). As a result, their philosophic fragments were based on a huge network of interrelated metaphors. Plato, well known as the master of metaphor, also used figurative language to convey his most important philosophical convictions. At the same time, he attacked what he called 'uneducated imitated' poets whose misuse of language leads others away from truth (Johnson, 1981, p.4). It is on similar grounds that he criticised sophists "who care nothing for truth and who make trifles seem important and important points trifles by the force of their language" (Phaedrus, 267a-b). For Plato, figurative language (and also metaphor) was a tool that helps to effect persuasion and puts formidable power in the hands of anyone who masters it perfectly. He also believed that figurative language should provide true accounts of that to which it refers, otherwise its use is misleading. This is why he condemned rhetoric which he saw as belonging to the world of the lie, of the 'pseudo'.

Although from the point of view of Plato, rhetoric is without doubt philosophy's enemy, Aristotle's accounts of rhetoric constitute an attempt to establish philosophically, the connection between the validity of rhetoric and that of philosophy (Ricoeur, 1978, p.11). It could be argued here, that the first definition of metaphor was established by Aristotle because of his attempts to institutionalise rhetoric from the point of view of philosophy. This shift took place when he developed the link between the rhetorical concept of persuasion and the logical concept of the probable. According to Aristotle, both in rhetoric and philosophy, the kind of proof appropriate to discourse is not the necessary but the probable (Ricoeur, 1978, p.11). It is at this point, where the power of persuasion and the concept of probability meet for the first time, that metaphor is seen both as essential in reasoning, (the latter realised not in terms of certainty), and as a representational device since metaphor is linked with the power of persuasion.

Aristotle's well-known definition of metaphor is given in the Poetics:

> "Metaphor consists in giving the thing a name that belongs to something else; the transference being either from genus to species, or from species to genus, or from species to species, or on grounds of analogy."
>
> (Poetics, 1457b, 6-9)

As it appears from this definition, metaphor has the following features: first, it seems that metaphor is something that happens to the noun, so it is primarily about words. Second, its is not surprising that it is defined in terms of movement, a change with respect to location, since metaphor /μεταφορά/ in Greek means movement (Ricoeur, 1978, p.11). And the third characteristic is that metaphor is the transposition of a name which Aristotle calls "alien" (allotrios). Allotrios means a name that belongs to someone else; in other words, the transfer of a name to some object to which the name does not properly belong (Ricoeur, 1978, p.20). According to Aristotle, the structure of metaphor is the transfer of the meanings of words and its function has two aspects: a rhetorical function and a poetic function. In rhetoric it is the art of inventing or finding proofs, but in poetry, its aim is to comprise an essential representation of human and its appropriate method is to speak the truth by means of fiction fable, and tragic myths (Ricoeur, 1978, p.13).

In Aristotle's accounts of metaphors, as represented and discussed by Ricoeur (1978), one can notice that even if metaphors are associated with words, they are not about the words themselves as purely linguistic elements but about shifts in the meaning of words. These shifts can take place either as categorical relations - that means alternations of the relations between categories and their instances (this is what transference from genus to species and from species to genus means) - or shifts of meaning at the level of instances which belong into the same category (from one instance to another or what Ricoeur has translated as from species to species). Also metaphor can take place as a transference in meaning relations from one domain of experience or knowledge to another, grounded in analogy. The latter means shifts in meaning across categories and their instances which belong in different domains. It is remarkable to notice the extent to which our thinking about metaphors in cognitive psychology today is based on these early accounts about metaphors. It is not accidental that Aristotle was thinking - if we interpret correctly what he wrote - about shifts in meaning relations in terms of movement, changes with respect to location across and within categories and domains of knowledge and experience. As is well known, his thinking was dominated with the task of defining different realms of knowledge as separate domains by making detailed taxonomies and categorisations of entities in terms of superordinate and subordinate categories. Therefore, changes in how things are defined and their meaning relations with other things are realised, were thought of - as indeed are realised in more or less the same way today - as re-locations within and across taxonomies. That also explains why, in Aristotle's definition, realising entities as being either of the realm of species or of the realm of genus has a prominent place, since in his systematic taxonomies entities are either instances or categories.

The argument above also explains the element of surprise that the use of metaphor entails. ' Allotriosis' - that is seeing things in new ways and not as they are expected to be - with entities is the result of transferring them to different categories or domains from the ones in which they are thought of as 'naturally' occurring. Finally, Aristotle's accounts of how metaphor functions tell us what the metaphor is about, what reasoning with metaphors can afford. Interestingly enough, metaphors are devices to persuade us about the extent to which things, ideas or beliefs are real. There is a cognitive value attached to metaphors since they provide the means of inventing or finding proofs, that is representing something as true and consequently real. But these means of representations are not to be looked at in any sort of propositional language but in the very means with which people communicate with each other in their everyday life and pass ideas, beliefs, values and knowledge from one generation to another; these are narrative-like kinds of speech (fiction, fable, tragic myths).

Later on, during the medieval years, metaphor followed two main opposite streams. Medieval rhetoricians took it more as an embellishment that gives force, clarity and charm to language than a powerful tool which provides proof through persuasion. Rhetoric was clearly distinguished from logic and then reduced to a style of speech. As a result, metaphor under rhetoric in medieval years became a stylistic device without any important cognitive function, separated from serious philosophical argument (Johnson, 1981, p.9).

On the other hand, medieval theology leads to a more favourable appraisal of figurative discourse. St. Thomas Aquinas claimed that if human beings grasp many intellectual truths through sensible likenesses, then many spiritual truths might be known by means of comparisons with material things (Johnson, 1981, p.10,11). Both eastern and western theology have always been preoccupied with the almost impossible task of defining two very different realms of experience: the material world and the world of spiritual entities. Figurative language has often been the only available way to express relations between the two worlds. Theologians even today are strongly divided between those who believe that what the bible says should be taken as a metaphor and those who read it and take the meanings of the words they read literally. Finally, comparative religious studies identify sort of structuring metaphors which shape believes and values in different religious.

2.2.2 Post-medieval years

In the post-medieval years, metaphor was ostracised with the growth of science. Empiricists' attack on metaphor took place both on the cognitive and linguistic level. Thus it claims that:

a) The human conceptual system is essentially literal. Therefore, literal language is the only adequate vehicle for expressing one's meaning precisely and making truth claims which together, make possible correct reasoning by the philosopher.

b) Metaphor is an ornamental deviant use of words, which accounts for its tendency to confuse and to deceive and,

c) The meaning and truth claims of a metaphor (if there are any) are just those of its literal paraphrase (Johnson, 1981, p.12).

It is apparent from these claims that the empiricists struggled to set 'clear' criteria about what is 'scientific' and how scientific knowledge can be achieved. But it should be noticed that in the first claim the demolition of metaphor did not take place only on the grounds of science. Empiricism spoke not only on behalf of science but on behalf of 'the human conceptual system' which must be characterised by 'correct reasoning' which makes truth claims. It is interesting here to note that the growth of science in the post-medieval years until the end of the scientific revolution, made people believe that almost every realm of knowledge can be realised in the same way as a science is realised. The high value that was given to science and consequently to the ways (methods) with which the achievements of science can be made possible has influenced the way people perceive human knowledge and understanding in general until the present time. The pervasive character of this influence of what is thought of as scientific knowledge and reasoning to human knowledge and reasoning in general - including commonsense reasoning - is best reflected in J. Locke's writings:

> Since wit and fancy finds easier entertainment in the world than dry truth and real knowledge, figurative speeches and allusions in language will hardly be admitted as an imperfection or abuse of it. I confess, in discourses where we seek rather pleasure and delight than information and improvement, such ornaments as are borrowed from them can scarce pass for faults. But yet, if we would speak of things as they are, we must allow that all the art of rhetoric besides order and clearness, all the artificial and figurative application of words eloquence hath invented, are for nothing else but to insinuate wrong ideas, move the passions and thereby mislead the judgement, and so indeed are perfect cheat; and therefore however handable or allowable oratory may render them in harangues and popular addresses, they are certainly, in all discourses that pretend to inform or instruct wholly to be avoided and, where truth and knowledge are concerned, cannot but be thought a great fault either of the language or person that makes use of them (Paul de Man 1978 p13).

In contrast with the empiricist view Kant argues, in his discussion of genius and imagination in the Critique of Judgement, that artistic genius is the ability to generate aesthetic ideas when there is no set of rules or concepts or algorithm to guide this creative activity. By "aesthetic idea" he means

> "that representation of the imagination which induces much thought (viel zu denken), yet without the possibility of any definite thought whatever, i.e. concept, being adequate to it, and which language, consequently, can never get quite on level terms with or render completely intelligible"
>
> (Critique of the Faculty of Judgement p.175-6).

While Kant's remarks have opened a view about metaphors 'in thinking from scratch', when there is not any solid background knowledge in which one can ground his/her efforts in constructing new knowledge, the fact that he opposes 'reliable', well established and organised knowledge from knew knowledge which only rests on imagination and not on any firm criteria or rules, devalues metaphor from any serious cognitive accounts.

Nevertheless, Kant's accounts of metaphors in terms of 'schemata' are very near to what Piaget has described as 'empirical abstraction' and what Lakoff and Johnson have described as 'everyday metaphors' and 'image schemata'. Kant has been concerned with the distinction between schematic and symbolic hypotyposes. The term "hypotyposis" here is used as the iconic element in a representation, that means it makes present to the senses something which is not within their reach, not just because it does not happen to be there but because it consists, in whole or in part, of elements too abstract for sensory representation. In the case of the schematic hypotyposis, schemata, are objects of the mind. On the other hand, in the case of the symbolic hypotyposis, symbols as objects of reason contain nothing that belongs to the representation of the object. That means no sensory representation would be appropriate for them (Paul de Man, 1978, p.29). Kant cites several examples of metaphorical terms, like those which have to do with grounding and standing e.g. "to depend", "ground", "to follow from", used in philosophical discourse. All of them are symbolic hypotyposes, according to Kant, because they are a mere translation from a reflection upon a represented object into an entirely different concept, to which perhaps no representation could ever correspond (Paul de, Man 1978, p.25). This is also how everyday metaphors are discussed by Lakoff and Johnson; what Kant sees as symbolic hypotyposis, Lakoff and Johnson describe as metaphorical extensions of image schemata that turn into pervasive, everyday metaphors. Without having any intention here to provide extensive accounts of the similarities and differences between Kant, Piaget and Lakoff and Johnson, one should notice a fundamental difference that while for Kant basic dimensions of reasoning such as schematic hypotyposis are apriori, for Piaget and for Lakoff and Johnson they are experientially constructed.

Nietzsche is the first philosopher of the later post medieval years who breaks down the clear distinction between literal and figurative language. He points out that our common ways of speaking about things inevitably involve transposition, transformations and distortions because the full nature of things is never grasped into consciousness rather the manner in which we stand related to them (Cantor, 1982, p.71). Thus, all language is a mixture of the literal and the figurative, since every linguistic utterance has some element of the customary in it and some element of the novel. What is regarded as literal at one moment may become figurative at another and vice versa. The interplay between literal and figurative meanings extends the range of meanings of words, bringing wider and wider realms of experience. So refusing to accept literal and figurative meaning as stable categories, he instead treats them as the basic principle of man's historical development (Cantor, 1982, p.75).

Man's development under Nietzsche's point of view appears to be an unusually complex process because he sees two contradictory tendencies at work in history, a tendency for man to spiritualize his ideas, and to literalize them. Therefore all meaning is a result of human making, of shaping and reshaping his ideas. These are some early relativist accounts of metaphor, because according to Nietzsche to claim that there is no real knowing apart from metaphor is ultimately to claim that all truth is a human creation (Cantor, 1982, p.78).

2.3 Theories of metaphors today

One can discriminate two kinds of arguments in later accounts of metaphor. There are those who take metaphor as an elliptical simile without any significant cognitive function in it and those who clearly distinguish simile from metaphor, arguing that the latter is not cognitively reducible to the former. The first view is the comparison theory of metaphor and the second the interaction theory of metaphor.

2.3.1 Comparison theory

According to the comparison theory, the meaning of the metaphor is a literal set of relevant similarities picked out by the context of the utterance. The simplest and most widespread version of this view has been that the nature of metaphor is essentially a comparison between objects that are literally disparate. Obviously, this view sees metaphor as an ornamental linguistic devise constructed on the principles of analogy and seeming to be concerned primarily with the comparison of similarities between two or more objects. The exact nature of how far metaphor depends on similarities has varied from author to author. So others have claimed that metaphors are comparisons based on analogy or proportions and others have gone beyond this position arguing that metaphor is little more than implicit simile (Ortony et al, 1978, p.921).

However, there are three interesting arguments which have come from the comparison view and have opened new pathways for the later investigation on metaphor. The first is Bréal's claims that the use of metaphor is not just a characteristic of the genius but a common linguistic tool very important for language change. He described the language change through the distinction between "novel" and "frozen" metaphors. Every metaphor started as "novel", which means that it is original to each person who uses it. Many of the "novel" metaphors become integrated into the language overtime and survive as "dead" or "frozen" metaphors or what Lakoff and Johnson in their accounts call as 'everyday metaphors' (Ortony et al, 1978, p.922).

Embler took Bréal's ideas and went further to give a more cognitive account of metaphor. He asserted that metaphor is not just a linguistic tool useful for language change, but it is also important for the creation of new meanings. Thus it has an important role between thought and speech where their limits are often fuzzy and vague. Then according to his argument if a metaphor is not reducible to the literal language it has meaning of its own.

Finally, Campbell took one step further and he presented a theory of metaphor as comparison in which every metaphor is an implicit oxymoron. Oxymoron is defined as a juxtaposition of two concepts that have opposite meanings. He insisted that the power of metaphor comes from its inability to be paraphrased. Campbell believed in the cognitive and linguistic power of metaphor to create new meanings for different individuals at different times (Ortony et al, 1978, p.922).

Although the three arguments above have pointed to new ways of looking at metaphor, comparison theories in general suffer at least in two points. They assume that because similarity often plays a role in our comprehension of a metaphor, it is also the essence of the meaning of the metaphor. Second, they have interpreted superficially Aristotle's definition to an extent that they are unable to see other aspects of the act of metaphoric comprehension except similarity and analogy (Johnson, 1981, p.27).

2.3.2 Interaction theory

The interaction view approaches metaphor functionally rather grammatically, so it goes beyond the comparison view that although metaphors can be merely substitutes for literal discourse and although they can be comparisons between objects, the psychological interest of metaphors really involves more (Ortony et al, 1978, p.923). The two more distinctive figures who have built and shaped what we call today an interaction theory of metaphor are I. A. Richards and M. Black. Their views are discussed in the present section.

From 1936 Richards set the fundamental ideas of the interaction view which has criticised both the positivist's account of the use of language and the mere comparison view on metaphor. Against the empiricist/positivist objectivism on the appropriate use of language in science, Richards claimed first of all that there isn't any objective world which could be described by any kind of objective language. He argued that our world is a projected world, with the characteristics which we give to it from our own life. As he said "we receive (from this world) what we give" (Richards, 1936, p.108). Metaphors produce the exchanges between the meanings of words in language. These meanings are super-imposed upon a perceived world which is itself a product of earlier or unwitting metaphor (Richards, 1936, p.108).

It cannot be passed unnoticed that in these accounts of metaphors the role of language is emphasised as a means of representing the world. According to Richards, we cannot possibly have immediate access to reality without a mean of representation intervening between us and the world. Therefore, what the world is (for human beings) is what can be meant (by us) about it. Richards made reference to language at the level of words, so the unit of study which is adopted here is single words. Metaphors have a dominant place and role in what is found between us and the world, thus in representations. Notice also that metaphor - as in Aristotle - is not about the words themselves but about exchanges in the meanings of words. The process of referring to the world through language does not start or end in a sort of 'God's eye view of reality', therefore, there is not only one referential relation between representations and world in terms of a 'single, true and correct' reference. New representations transform and replace earlier representations of the world. These early 20th century accounts show that a view about metaphors often presupposes a view about language and its relation with the world. Richards' view about language is very near to what recent sociolinguistic theories (Halliday 1994 and Kress 1979) claim against the traditional view which sees language as transparent and neutral to what it represents.

Richards continued the disruption of the traditional cognitive/emotive dichotomy (Richards, 1936, p.95) but he took a big step further: he was the first to set up the problem profitably for both the later generations of philosophers of science and psychologists. He saw the role of metaphor as crucial in the relationship between the changes in the meaning of words and the world.

Against the mere comparison view, he went beyond the oversimplified connection between metaphor and similarity, analogy by discussing the operation of metaphor in ordinary discourse. His main position, which will be the doctrine of the interaction view until today has been that:

> "when we use a metaphor we have two thoughts of different things active together and supported by a single word or phrase whose meaning is a resultant of their interaction".
>
> (Richards, 1936, p.93)

Richards called the two ideas which are active together in metaphor the 'tenor' and the 'vehicle'. The 'tenor' is the underlying idea or principal subject which the 'vehicle' or figure means (Richards, 1936, p.97). The 'vehicle' is not normally a mere embellishment of a 'tenor'. Both of them - 'vehicle' and 'tenor' - in co-operation give a meaning of more varied powers than can be ascribed by either meaning which is not attainable without their interaction (Richards ,1936, p.100). In some cases, there are some common characteristics which belong to the 'vehicle' and 'tenor'. These common characteristics Richards defined as the ground of the metaphor. So we can make a very broad distinction between metaphors which work through some direct resemblance between the 'tenor' and the 'vehicle' and those which work through some common attitudes which we may take up towards them both (Richards, 1936, p.118).

Richards investigated an extreme case of the latter, when we put together two things belonging to very different orders of experience. In such cases the mind works as a "connecting organ" by connecting any two things in an indefinitely large number of different ways. This position reminds us of Campbell's comparison view which described the metaphoric operation as an implicit oxymoron which is defined as the mind's effort to juxtapose two concepts that have opposite meanings. Moreover Richards tried to answer the question, which of these indefinitely large numbers of different ways to connect two concepts or things the mind uses. According to him, there might be a larger whole or aim which is used as reference for these choices (Richards, 1936, p.125). As the two things put together are more remote the tension created is greater. That tension is the spring of what Kant said "more thought". Mind's effort to connect the two things is increased and as a result sometimes the peculiar modification of the tenor which the vehicle brings about (Richards, 1936, p.127). Many years later, Robert Davidson talked about the same thing as the cognitive distortion which is the necessary cost each time when metaphors and analogies are used in learning (Davidson, 1976, p.138).

Richards' analysis of how metaphor works, shows that it is not necessary for the 'tenor' to be present linguistically. The presence of the latter can be implied by the 'vehicle'. Moreover, the distinction between metaphors worked out on a basis of direct resemblance between 'tenor' and 'vehicle' and those which rely on some common characteristics between the two, invites us to consider that probably not all metaphors are of the same kind, but they can vary in their appearances from less silent to more silent metaphors. Also, the fact that 'vehicle' and 'tenor' in some cases can come from a very distinct realms of experience, suggests what is identified today (see Ogborn et al, 1996) as the possible function that metaphors can have: to bring entities from different domains of knowledge and experience together or apart. Richards has gone a step further suggesting that entities which come from different realms of experience are decontextualised from the context in which they occur initially and are recontextualised in a context which can sustain both entities. The latter context can be seen as the 'school science' in which both scientific and commonsense entities co-exist, or, what sociologists and discourse analysts refer to as discourse coalition concerning the discourse of representing environmental science to the public.

Entities are transferred from one domain to another with the potential that in the new context in which they are relocated they can be closer to very different kinds of entities. This process constitutes a choice and as such is not accidental but is motivated from a purpose. In these accounts metaphor is discussed in respect of the person who creates it and of what he/she is trying to achieve by its use. It is probably the first time that metaphor is seen as a choice in relation to interpersonal aspects of making meaning in similar ways Halliday and Kress discuss language in general and metaphor in particular. What Richards describes as tension created by bringing two remote entities closer to each other is similar to what Aristotle has described using the term 'alotrios', the possible effect metaphor can have. In Richards' accounts, interaction is the product of that 'tension' created due to the fact that a specific 'tenor' cannot be expressed or represented literally by a specific 'vehicle'. The fact that the 'tenor' and not only the 'vehicle' can be modified in resolving the tension between them does not only justify why Richards' accounts constitute an interaction theory of metaphor, but also reminds us of the more recent accounts of metaphors according to which (Ogborn et al, 1996) transformations of displaced entities are likely to occur.

Finally, as Bréal claimed, Richards insists that the metaphor is a very common phenomenon in language. According to him, we cannot get through three sentences of ordinary discourse without it. Even in the rigid language of the sciences, we have great difficulty in eliminating or preventing it. Literal language is rare outside the central part of the sciences. Any word may be at the same time both literal and metaphoric, just as it may simultaneously support many different metaphors, may serve to focus into one meaning many different meanings. According to his theory, if we cannot distinguish 'tenor' from 'vehicle', then we may provisionally take the word to be literal. If we can distinguish at least two co-operating uses, then we have metaphor (Richard, 1936, p.119).

Notice here that for Richards metaphor is neither for poetic language nor for rhetoric only but is an inseparable part of everyday language. Even if his linguistic unit is the word it is not taken as one correct and true reference of an object in the world, but it can carry more than one meaning. He also raises the concept of a context, so words are used and take their meaning within a context. Thus he gets away from the classical 'dictionary' view about the meaning of words.

Twenty six years later Max Black's essay, "Metaphor" (1962) is perhaps the landmark by which, according to Johnson (1981, p.19), we may orient ourselves in attempting to understand recent work on the subject. Black as well as Richards tried to answer the question: How do we identify metaphor? At the beginning of his work on metaphor, Black pointed out that any adequate theory must explain how we are able to recognise metaphors and distinguish them from other types of speech. Black seems to adopt Lowenberg's view that because there may be no syntactic or semantic deviance at the level of the sentence, an adequate account of metaphor can be given only at the level of the utterance in its total context (Johnson, 1981, p.22).

The main issue which is raised here is that the metaphorical statement as such does not involve any rule of violation, because there can be no rules for "creatively" violating rules. And that is why there can be no dictionary of metaphors. As he pointed out, any attempt to be more precise about the identifying and individuating criteria for metaphorical statements will be embarrassed because the same metaphorical statement may appropriately receive a number of different and even partially conflicting readings (Black, 1979, p.25). These arguments raise metaphor as an issue of interaction between a speaker and a listener so the question how something can be identified as a metaphor is strongly related with how a metaphor can be interpreted.

Black replaces the two major components of Richard's interaction view 'tenor' and 'vehicle' , with the 'primary' and 'secondary' subject of metaphor. The metaphorical utterance works by selecting or suppressing features of the 'primary' subject by using features from the 'secondary' subject. The main difference from Richards' components is that the 'secondary' subject is not merely an individual "thing" or "idea", but a system of relationships. Therefore for Black metaphor is neither primarily about words nor about single entities but it is about 'relations between relations'. In particular the metaphor works by "projecting upon" the 'primary' subject a set of associated implications" of the 'secondary' subject in the following three stages:

> "a) the presence of the primary subject incites the hearer to select some of the secondary subject's properties; and
> b) invites him to construct a parallel implication-complex that can fit the primary subject; and
> c) reciprocally induces parallel change in the secondary subject."
>
> (Black, 1979, p.27)

It seems that Black with his analysis of how metaphor works attempted to explicate Richards' striking image of the "interanimation of words". In other words, Black attempted to rationalise metaphor by arguing that we can identify it and it is not an unconscious event whenever it appears. So metaphor now is not represented as 'the flash of the genius', that means an instant event, but as a process (often called metaphorical process in more recent accounts) which consists of stages or steps.

He also put the interaction of subjects as a creative production in the mind of both the hearer and speaker. Both of them are led to engage in selecting, organising and projecting. As a result, this kind of interaction involves a shift in the speaker's meaning of words belonging to the same family or system and the corresponding hearer's meaning (Black, 1979, p.29). The reason for this shift in meaning is the need to do so because the available literal resources of the language are not always enough to express our sense of the rich correspondences, interrelations and analogies of domains conventionally separated. As we saw earlier this is because metaphorical thought sometimes embodies insight expressible in no other fashion (Black, 1979, p.34). But for Black this does not mean that the metaphor belongs to the realm of fiction and is merely being used, as some writers allege, for some mysterious aesthetic effect. Black's thesis on metaphor survives any critical argument that metaphor is a device of language which does not belong to the realm of truth because he grounded his argument in analogies of structure (partly created, partly discovered), the interactions between the two systems of the primary and secondary subject. The analogy between the two systems which Black saw as a kind of isomorphism renders explicit insight into the systems to which they refer thus generating a view about "how things are " in reality (Black, 1979, p.41).

Epistemological accounts of science today - as will be shown later - give serious accounts of what Black refers to as a power of metaphor to generate a view about "how things are" in reality. Also, the description of the 'metaphorical projection' is near to what Lakoff and Johnson describe as basic-level conceptual structure embedded in our everyday bodily experience which is metaphorically projected onto abstract conceptual structures in order for us to make sense of the latter.

Much of the recent literature on how metaphors work consists of attempts to go beyond Black's groundwork to explain more fully the mechanism by which a metaphor creates new meaning and generates insight (Johnson, 1981, p.28). Black's mechanism of how metaphor works and its terminology has met with criticism. That is neither fully explanatory nor fully explained. An important point of criticism of the interaction view on the linguistic level is that it necessarily involves two nouns so inevitably suggests some kind of comparison between them. On the contrary, Richards' 'tenor' and 'vehicle' may be co-present in one word, or phrase (Martin et al, 1982, p.94).

John Searle (1995) has provided a lot of work from the pragmatics point of view - the study of speech acts and the context in which they occur - to give a more complete explanation of how relevant knowledge is brought to bear in understanding a metaphor. Searle has set again the question of how metaphors work in terms of the speech-act distinction between word or sentence meaning (vs. what the word or sentence means literally) and speaker's utterance meaning (vs. what the speaker means by uttering words or sentences with literal meaning). So, the question is how can a speaker utter a sentence of the form "S is P" and means metaphorically "S is R"? In this case, three questions arise. The first is how does the hearer know to look for a metaphorical interpretation? Second, what categories or principles allow the hearer to compute possible values of R and the third and most important, what principles guide the restriction of the range of possible Rs to get the precise meaning of the metaphor? This issue has been identified as one of the main problems of the metaphorical use of language in most of the recent studies on metaphor. If anything is connected with anything without any restriction at all, then the cognitive value of metaphor is seriously limited and so its educational use is also in doubt.

Searle offers several principles which are relevant to the three questions above and supported by specific examples (Johnson, 1981, p.33). There are two interesting points in his principles for our further investigation of metaphor. First, he distinguishes metaphors from indirect speech acts by suggesting that whereas in indirect speech acts the speaker intends to convey both the sentence meaning and the indirect meaning in metaphors the intention can only be to convey the latter. Furthermore, the metaphorical utterance is divided into the simple and the open ended. In the former, the speaker says "S is P" but means metaphorically that "S is R", while in the latter the speaker says "S is P" but means metaphorically an indefinite range of meanings, "S is R_1", "S is R_2", etc. In both cases, utterance meaning is arrived at by going through literal meaning (Searle, 1979, p.122). The character of some kind of metaphors to have an open ended meaning is discussed by Richard Boyd in his analysis based on what he calls theory - constitutive metaphors in science, theory which will be discussed in the next section.

2.4 Metaphors in science

Richard Boyd gives a central role to metaphor in the scientific enterprise. He recognises its task of introducing terminology and modifying usage of existing terminology, in such a way that linguistic categories describe significant features of the world (Boyd, 1979, p.358). He divides metaphor into two categories. Those which, because they are employed often by a variety of authors and in a variety of minor variations, become "frozen" into a figure of speech or a new literal expression. Literary interaction in metaphors meet what Bréal calls "frozen" metaphors or what Black refers to as "dormant" metaphors. This kind of metaphor seems to lose its insightfulness through overuse. On the other hand, what Boyd has introduced as theory-constitutive metaphors have the characteristic to be open-ended. Thus, they invite us to explore the similarities and analogies between features of the primary and secondary subjects, including features not yet discovered or not yet fully understood (Boyd, 1979, p.363). Boyd offers as examples in this category, metaphors in cognitive psychology, for example the mind as a computer machine metaphor that is drawn from the terminology of computer science, information theory and related disciplines. Such metaphors have provided much of the basic theoretical vocabulary of contemporary psychology, for example the view that consciousness is a "feedback" phenomenon.

Theory-constitutive metaphors as their name suggests are useful for a theory construction in the relatively young sciences. The metaphorical language of the latter is fundamentally pre-theoretical and lacks the explicitness and precision characteristic of scientific theories. What Boyd describes under the name theory-constitutive metaphors is very close to not yet discovered similarities or analogies between the literal subject and its secondary subject. Again, as Black was criticised earlier, for the same reasons we could say Boyd's approach is very near to the comparison view because he reduces metaphorical processing into an analogy not yet fully constructed between the two (primary and secondary) subjects.

Despite this criticism, Boyd goes further to set the metaphor in scientific realism. According to the latter, knowledge of general laws in science is almost impossible without some knowledge of unobservable entities or powers. The problem that is raised here is how the knowledge of unobservable entities or powers could be possible. This knowledge is possible if reference of natural-kind terms (like "water") and of theoretical terms in science might be fixed "causally" rather than by definitional conventions as naive realism demands. In other words, the aim of science is how to accommodate the linguistic usage to as yet undiscovered causal structure of the world. Roughly speaking, this is the task of arranging our language so that our linguistic categories "cut the world as its joints". The accommodation of the linguistic usage above is started whenever we

> "introduce terminology for substances and fundamental magnitudes by appealing to situation in which we believe they are exemplified prior to our discovery of their fundamental or essential features".
>
> (Boyd, 1979, p.367)

Thus, because such accommodation cannot be accomplished by explicit and conventional definitions, it appears that nondefinitional procedures for accommodating language to the world such as metaphorical comprehension are essential to knowledge. The acquisition of new knowledge and also the exploration of new areas of inquiry require that linguistic usage be modified so as to mark newly discovered causal features of the world. Boyd characterises this modification of language as dialectical and he claims that it is essential to the process of accommodation of language to (newly discovered features of) the causal structure of the world (Boyd, 1979, p.382).

Thomas Kuhn, the leader of the theory of scientific revolutions agrees with Boyd's assertion that the open-endedness of metaphor has an important parallel in the process by which scientific terms are introduced and thereafter deployed (Kuhn, 1979, p.409). He also claims as both Black and Boyd claimed that the end product of the interaction between the primary and secondary subject of every metaphor is not some kind of definition or a list of characteristics shared by the two subjects. This dissatisfaction of the criteria that a traditional empiricism and objectivism have required to declare the meaningfulness of natural-kind terms, doesn't mean any loss of functional precision of the scientific language (Kuhn, 1979, p.413).

The essential role of metaphor must be seen in his theory of how scientific knowledge is processing. The emphasis in his theory is placed on the evolutionary character of scientific progress, where a revolution involves the abandonment of one theoretical structure and its replacement by another incompatible one. This view gives important place to the sociological characteristics of scientific communities.

Very briefly, the process of the scientific knowledge is described by Kuhn as an interchange between periods when scientists articulate and develop theories in their attempt to account for and accommodate the behaviour of some relevant aspects of the real world - what he calls normal science and periods when scientists try to resolve substantial difficulties which make their theories problematic and develop crisis in theories main streams. The discontinuous change from one stage of normal science to the new stage of normal science constitutes a scientific revolution. Almost everything which is involved within a period of normal science is characterised as paradigm. Every paradigm corresponds with every stage of normal science and is made up of the general theoretical assumptions, laws and techniques for their applications that the members of a particular scientific community adopt (Chalmers, 1982, p.90).

Kuhn states that scientists who live in different rival paradigms are "living in different worlds". They have completely different sets of standards and metaphysical principles so there would be no logically compelling demonstration of the superiority of one paradigm over another. In Kuhn's words these differences between rival paradigms make them "incommensurable" (Kuhn, 1970). There are no inductive procedures for arriving at a perfectly adequate paradigm. So theory change between two paradigms is accompanied by a change in some of the relevant metaphors in the sense that their referents which occur in both are a function of the theory within which those terms appear. There is neither any neutral algorithm for theory choice nor any neutral language into which both of the theories, as well as the relevant data, may be translated for purposes of comparison (Kuhn, 1979, p.416). At this point, one can see the main differences between Kuhn's and Boyd's accounts of metaphor. Boyd talks about one real world still unknown but toward which science proceeds by successive approximation. On the opposite side, Kuhn is very sceptical of a sequence of theories which are getting closer and closer to a true description of what the world is really like. He takes as an example, the history of optics where we find that a beam of light is described, first as a stream of particles, then as a wave and then as something that is neither a stream of particles nor a wave (Chalmers, 1982, p.156).

Harré's argument about the role of scientific metaphors follows his basic ideas of the nature of science which are referred to as referential realism. The principle underlying Harré's referential realism is that our experience stands over against an independent largely unobservable real world. Harré's realistic accounts are also very close to Boyd's and Hacking's theories.

Scientific realism takes the entities, states and processes described by correct theories as real. This is also the purpose of the scientific work - to get close to the truth. As it appears from the definition above, we talk about the real existence of entities which is established through correct theories. Thus, it might seem that if you believe a theory is true, then you automatically believe that the entities of the theory exist. According to Hacking (1983, p.27) realism can be divided into two categories: realism about entities which recognises the existence of some "good" theoretical entities and realism about theories which demands scientific theories to be true.

Scientific realism is often related with causality. In many cases, theoretical entities are supposed to have causal powers. For example, the 'direct' proof of the electron derives from our ability to manipulate them using well-understood low level causal properties (Hacking, 1983, p.24).

The strongest evidence for scientific realism is the experimental work. And this is because, as Hacking pointed out, "entities that in principle cannot be 'observed' are regularly manipulated to produce a new phenomena and to investigate other aspects of nature. They are tools, instruments not for thinking but for doing" (Hacking, 1983, p.262)

Referential realism according to Harré, constructs a form of scientific realism that needs only a weak system of epistemic concepts, but a strong notion of reference. This kind of realism is based on the distinction between three epistemic realms which briefly are:

a) the realm of common perception

b) the realm of beings which could be observed given certain historical and technical contingencies (e.g. 'genes' and 'cells') and

c) the realm of beings which for a variety of reasons is beyond all human observational capacity (e.g. cognitive objects with mathematical properties)

Harré structures his thoughts about the nature of science in what he calls policy realism. Policy realism is summarised into the thought that

> "if a substantive term seems to denote a being of a certain natural kind (and some special conditions are satisfied by the theory in which that term functions) it is worth setting up a search for that being".
>
> (Harré, 1986, p.59)

What is interesting in respect to the third epistemic realm, is the adoption of terms through the metaphorical trope because of the lack of any literal vocabulary. According to what Harré calls as "the displacement theory" a term is taken from a well established context of use and is used in a new context to express a belief for which there is no existing vocabulary.

Harre also claims that explaining, in scientific discourse and in any of the three epistemic realms described above, is essentially a linguistic activity which does not stop at the level of words and phrases, but additional elements are needed for a complete analysis, such as sentence connectives (Harre, 1960, p.7). According to Harre, there is nothing like one simple type of explanation which can be identified as a distinctive genre, generally adopted by science, but a variety of different kinds of explanations e.g. linear explanations, explanation in detail, hidden mechanisms, explanatory theory, analogical/metaphorical explanations. Explanation is a complex activity which involves other kinds of activities like descriptions. Transformations of explanations into descriptions and descriptions into explanations is a very common phenomenon in science, when, for example, an explanation is used as a description in order to support another explanation. For example, the structure of fish is explained in terms of the ecology of the sea where the latter is taken as a description in order to explain the former (Harre, 1960, p.8).

Harre is concerned specifically with the role of metaphors and analogies in the construction of the generic entities and events which have explanatory power. He notes that the connections which establish the relevancy of facts to one another are often complex, so that if they are to be of any use in facilitating understanding, which is a requirement of an explanation over and above delimiting the area in which we can find a cause, some simplification of the relevant facts must be made. The most direct way, and that commonly adopted in environmental science is to represent a structure or a process or an environment schematically, so that only the most important features are brought about (Harre, 1960, p.85). What Harre calls schematic explanations are very near to how image schemata are treated in the present thesis. In particular, schematic explanations are based on the concept of the analogy/metaphor in two ways:

1) schematic explanation as an analogue of a complex natural phenomenon. So, for example, a particular model of the carbon cycle is an analogue, one of the many possible ways to describe the carbon cycle in the environment.

2) analogies/metaphors facilitate an understanding of a phenomenon which is not familiar by the use of the familiar implications of another similar phenomenon (for example elaborating pollution at a global scale in terms of a well known case of a local pollution).

But even if Harre addresses the importance of the role of metaphors in schematic explanations he does not provide any further accounts of how metaphors facilitate schematic explanations.

The last epistemological theory which will be discussed here that identifies a prominent role for metaphors and analogies in science is the theory of "mild realism" adopted by Mary Hesse. According to this approach, theories represent real structures, not literally, but by means of metaphor and analogy, because no universal literal reference of concepts can be defined. In particular, theories can express the relative clustering of things and their properties, by picking out the essential properties that produce a theoretical classification which best fits present evidence. It is important here to draw the distinction that theories have real reference, but the concepts to which they refer are family resemblance concepts and the relations referred to are based on analogical and metaphorical relations between things and systems of things. (Hessé, 1988, p.337)

Scientific concepts share with linguistic metaphors the property of shifting both reference and sense with context. A major problem in such creation of new meaning in science is that how meaning change takes place is dependent upon under what constraints metaphoric meaning shifts. If everything is to be combined with everything without constraints - that means "anything goes", then how can communication between scientists become possible? To answer this question, Hessé uses Rosch's theory about categories.

Wittgenstein had speculated that categories were structured by what he called "family resemblances". The basic idea of "family resemblances" is that categories may be related to each other without all members having any properties in common that define the category (Lakoff, 1987, p.16). Rosch first tried to establish the idea above by empirical research. According to her results, prototypes are conceptualised in everyday language which is structured by cue-properties. These properties are frequent within a category and relatively infrequent outside it, so they are not objective in the world independent of any being. She refers to them as interactional properties which form clusters in our experience derived from our physical and cultural environment. The latter consequently means that the boundaries of a category are not uniquely determined and also that any radical change in the perspective of a culture or a theory upon the world categories may dissolve and reform, as in an ideological or a scientific revolution. (Hessé, 1988, p.323)

Turning back to Hessé's question: How the meaning variance in science happens in such a way that communication becomes possible, the answer is given to what she calls a "nearness" of meaning which is a function of a variety of variables e.g. similarities and differences between members of basic categories, synonymy, inclusion, contrast, structural analogy, paraphrase, empirical association, cause and effect relations etc. forming a complex network. This network is not just a "free-floating" system of socially accepted coherence, but is tied down at various and varying points by empirical reference in particular cases, that is, at the reference points that permit language to be learnt and communication conducted (Hessé, 1988, p.324)

Scientific categories are like the family resemblance concepts of cognitive categories. Both of them are relatively stable in local contexts, but are not fixed or are their boundaries clearly defined so that they are not immune to radical revision in theory change. Therefore, in science, the world of theoretical entities and causes as well as the everyday observable world is ordered by some clustering of objects and properties in the same way as it has been described above, according to Rosch.

Hesse has argued that the deductive model of explanations should be modified and supplemented by a view of theoretical explanation as metaphoric redescription of the domain of the explanandum. This model describes explanation by dividing it into two parts: the explanans (that which explains) and the explanandum (that which is explained).

M. Hessé uses M. Black's analysis of primary and secondary subject associated with the explanandum and the explanans. In her accounts of how a scientific theory is constructed, the primary system is the domain of the explanandum, describable in observation language and the secondary is the domain of the explanans described either in observation language or the language of a familiar theory (Hessé, 1980, p.112). She argues that the secondary system cannot be imposed apriori upon any primary, and vice versa that any secondary system cannot be the source of metaphors for any primary. This is why the associate's ideas both of the primary and secondary system are changed to some extent by the use of the metaphor in a way that the two systems are seen as more like each other: they seem to interact and adapt to one another.

The association of the ideas of "metaphor" and of "explanation" doesn't mean that all explanations are metaphoric and vice versa, that all metaphors are part of explanations. The introduction of a metaphoric terminology is not itself explanatory. Metaphor becomes explanatory in the theoretical explanations because the role of the latter is the introduction into the explanans of a new vocabulary or even of a new language. The touchstone in this view which associates metaphor and explanation is that

> "there is one language, the observation language which like all natural languages is continually being extended by the metaphoric uses and hence yields the terminology of the explanans".
>
> (Hessé, 1980, p.122)

Again these accounts, as others before, seem to say in slightly different words what Lakoff and Johnson say about the metaphorical extension of everyday-experienced image schemata on to abstract concepts and categories.

2.5 The study of metaphor in cognitive psychology

The theoretical framework which the researcher uses to define what is to count as a metaphor both influences the type and process of the research task. In particular, tasks are:

a) either comprehension or production studies,

b) either linguistic or extra-linguistic studies.

The age of the participants is also an important factor as in the hypothesis, whether the metaphorical comprehension and production is constructed through age-stages or not.

Although the difficulties and complex character of the research on metaphor, the child's ability to comprehend and produce metaphors is not only of theoretical interest but of practical importance as well, particularly in reading. If, as Richards pointed out, we cannot get through three sentences of ordinary discourse without at least one metaphor, then we can see how important the role of metaphor is in the acquisition of language. Then it appears that the study of metaphor in cognitive psychology has important consequences in educational psychology. As is well known, the primary concern in educational psychology is with the processes underlying the acquisition of knowledge. And because what people learn is learned through the medium of language, it follows that knowing how metaphors are processed and what constraints exist on their comprehensions is bound to contribute to our understanding of the learning process (Ortony et al, 1978, p.937).

The first major problem in the research is that the definition of metaphor influences seriously any kind of results. For example, it is a different thing to take metaphor as similarities or proportionalities or proverbs. One should bear in mind that traditionally, the study of metaphor has been predominantly undertaken by scholars of philosophy and literature. And as has been illustrated in the sections above, there is more than one theoretical perspective and every perspective derives from more than one theory. So the metaphor has been slow to find its way into psychology. One can identify, among others, two different theoretical approaches in the research literature. In the propositional approach, word meanings are represented as propositions, about the core meaning. But in schema theory, what gets represented is knowledge associated with the things to which the words refer. As a result, propositional models appear to be forced to specify special processes for the comprehension of metaphor, whereas schema-based models perhaps need not do so (Ortony et al, 1978, p.936).

Different theoretical notions about language comprehension are likely to lead to different predictions about the comprehension of metaphor. It is important to say how much the metaphor is related with language and in particular, if it is just a linguistic phenomenon or if it depends on extra-linguistic factors also. There are two directions for those who believe the latter. An extreme position comes from D. Gentner (1977) whose results weaken the position that young children lack metaphorical ability and are compatible with the hypothesis that such ability is present at the outset of language. And a more modest position which uses the pragmatics point of view (as described by J. Searle in section 2.3.2) tends to see non-simple nominative metaphors as context dependent. Gildea and Glucksbert (1983) argue that when the relationship between the two subjects of the metaphor is ambiguous or vague, as when either several alternative relationships or none at all come to mind, then a context that provides information about the relationship can facilitate metaphor comprehension by suggesting the ground of metaphor (Gildea et al, 1983, p.587).

On the other hand, research which investigates metaphor from the semantics point of view shows it as a context independent phenomenon. These studies use to relate metaphoric understanding with cognitive stages. Pollio and Pollio (1974) suggest that children who are in the stage of concrete operations are able to use frozen and novel figurative language within a specific context but may be unable to explicate the use of such language in completely abstract terms until they move from the stage of concrete operations to the stage of formal operations. Other investigations (Billow 1975, Winner et al, 1976) suggested three steps preceding the attainment of mature metaphoric understanding.

In the first step (or stage) a magical world would be invented in which X can be Y. For example, the child could take the statement "The prison guard was a hard rock" as the transfiguration of person into stone. Such kind of interpretation is called magical. During the second stage, older children juxtapose in some respect the two terms of metaphor in such a way that the link between them is transformed from one based on identity to one based on contiguity. Such shift in the meaning is called metonymy. In the example which is given above, the metaphor could come to mean that the guard worked in a rock prison. The last step is the primitive metaphoric stage. Children might find it easier to draw a similarity between two terms belonging in the same realm.

Winner (1976) also shows the paradox that although the capacity to understand metaphoric figures of speech develops only during late childhood and early adolescence, studies focusing on the child's ability to produce figurative language have repeatedly documented the spontaneous use of metaphors, similes, and other figures of speech by preschool-age children (Winner, 1976, p.289). Taken together with results of prior research on metaphor, these findings suggest that spontaneous production occurs first, followed by comprehension and then by the ability to explain the rationale of a metaphor. The spontaneous metaphors produced by young children are most often visual comparison prompted by stimuli in the environment. But the fact that a child cannot report how he or she understood something does not in itself justify the conclusion that it was not understood. On the other hand, in looking at the spontaneous production of metaphor in early stages of language acquisition, care has to be taken in judging what is and what is not true metaphor. Children at this age learning to recognise and correct perceptual, cognitive and conceptual error so they produce categorical errors and mistakes that can be taken as metaphorical expressions but are not (Matter & Davis, 1975).

2.6 Summary and Conclusions

In general, two perspectives can be identified in the intention of the present chapter to illustrate various accounts of metaphors. The first derives from a branch of disciplines which includes studies of the philosophy of language, linguistics and cognitive psychology. Here, the discussion carries the burden of my argument for a variety of reasons. The major reason is the fact that the study of metaphor has been predominantly undertaken by scholars in the area of philosophy and literature. On this level, the shift from the point of view which assumed metaphors to be a mere embellishment in the domain of emotions to the view which is dominant until today and has broken down the cognitive/emotive dichotomy by recognising serious cognitive accounts on metaphor, is represented. Arguments of the latter have been divided into two pathways. The first shows metaphor basically as a comparison between two objects or ideas (comparison theory) and the second as an interaction between two systems of associated ideas (interaction theory). Recent studies have been influenced to a large extent either by the comparison or the interaction theory. The need to put together studies of the philosophy of language with studies in linguistics and cognitive psychology in one branch, derives from the fact that many of the theories concerned with the cognitive accounts of metaphor refer to the theories of language which are usually influenced by the variety of theories related to the philosophy and philosophy of language.

The second perspective is the epistemological point of view. Metaphor here was rejected as a mere embellishment by empiricism and, until recently, logical positivism. For these two epistemological approaches metaphor has no place in the scientific explanation where language must be precise and deduced to empirical statements. On the other hand in Kuhn's theory of scientific revolutions, metaphor plays a crucial role in the shift of meaning between different paradigms. Furthermore, metaphor has found its place in science and in particular in what is considered as scientific explanation by two epistemological views 'referential' and 'mild' realism, presented in section 2.4. Despite their differences, what they share is the basic idea that metaphors are inherent in the scientific explanation whenever there is the need to suggest new terminology about concepts and their relationships which are concerned with unobservable but real entities and their relationships.

Finally, the difficulties in the research on metaphor from the point of view of the cognitive psychology seem to be inherent in the nature of this field (the study of metaphor). In addition, this research tradition is incomplete in respect to whether older children's comprehension of abstract scientific concepts is based, through metaphorical extensions, on concrete concepts related with their everyday physical experience. But one should bear in mind that any serious accounts to answer the problems and complications raised by the studies and further research questions, demand research work which will consider the arguments from various perspectives about the nature of metaphor. The fact that so far most of the attempts to study metaphor are anecdotal accounts does not mean that one cannot investigate aspects of the problem.

The present study stands on the side of those theoretical and empirical accounts which believe that metaphors are not found exclusively at the linguistic surface but are widespread both in the scientific and commonsense discourse without any simple correlation between surface linguistic cues and either their presence or type. Thus the position which is taken is that metaphors are primarily about things and events, not primarily about words and sentences. It is also believed that metaphors have an explanatory power both in commonsense and scientific reasoning to provide the means to step from the known properties and processes of things and events to those which are unknown.

APPENDIX 3

NOTATION OF REPRESENTING IMAGE SCHEMATA AND AN EXAMPLE OF ANALYSING A LESSON USING IMAGE SCHEMATA

3.1.1 Representing image schemata

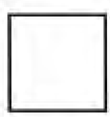
In order to represent metaphorical constructions made by Image schemata in data analysis a sort of notation is needed as a way of representing their variety. Therefore representations are employed as aids in the description of particular image schemata. Such representations are particularly useful for two reasons:

- they identify the key structural features of the schemata and illustrate their internal relationships
- they are heuristic tools for qualitative data analysis, giving a partial representation (and no more) as required for the local interpretation of discourse fragments.

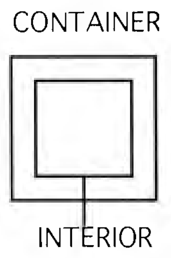
We also need to clarify that the representations of image schemata are only representations and are not the schemata themselves. The fact that the image schema is neither a set of propositional statements nor a concrete image, prevents us from describing it either as a mere theoretical construction or as a mere representation.

3.1.2 Notation

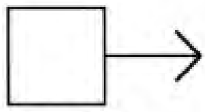
To begin with we will start with the representation of participants in image schemata. Any participant: Agent, Patient, Container, Interior, Part, Whole is represented as a square :



In the schematic notation of the Containment schema we should be able to recognise and name at least two participants: Container and Interior, and their in-out orientation:

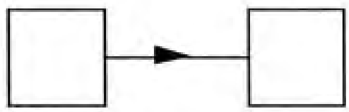


In order to avoid confusion with the categories of the linguistic analysis, instead of using the linguistic terms Actor and Goal the terms Agent and Patient will be preferred instead for representing Agent structures. Agents are represented as:

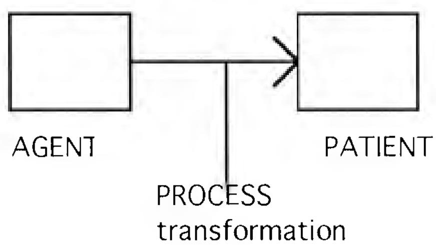


The Agent is the participant from which the vector emanates - the participant which 'does':

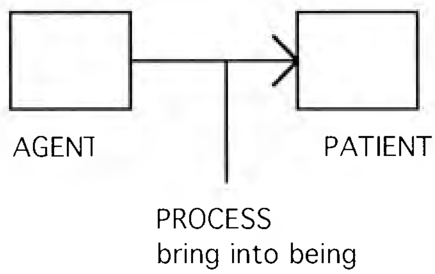
The agent's action can bring a change at the state of the Patient either by transferring (movement) it , e.g. :



or transforming it, that means the Agent brings some change (transforms) to what the Patient is, e.g. :



or it is the main cause of bringing a new entity into being without always stating explicitly whether the new entity is a transformed one or the outcome of the interaction of entities:



3.2 Analysis of a lesson

This is an example of analysing a lesson in terms of the image schema approach. The analysis shows how the notation of image schemata is used in order to represent them.

School :	A
Date :	25.11.94
Class :	YR 8
Teacher:	Jane
Topic:	Acid Rain and Carbon Cycle (double lesson)

This double lesson is divided into two parts. The first half is about the phenomenon of weathering and how students can plan their experiments in order to study weathering. The second part is about the Carbon Cycle. Aspects of the Carbon Cycle were discussed in previous lessons in the classroom by making reference to textbook materials. In this lesson the Carbon Cycle is constructed as a whole.

First Part: Acid Rain

By reading the working sheet, the teacher starts the lesson with a definition of *weathering* [page287, line1-6]:

When there's material like brick and stone exposed to the effect of wind, rain and frost their surfaces can be damaged and loosened. Scientists call this "weathering", they think that pollutants, like the acid in rain can speed up weathering.

The definition of weathering is represented as an Agent structure: materials like *brick* and *stone* are exposed to the effect of *wind*, *rain* and *frost*. The Agent(s) in this case are: *rain*, *wind*, and *frost* and the Patient(s) are materials like *brick*, and *stone*. The action of the Agent brings about observable changes to the Patient:

...their surfaces can be damaged and loosened

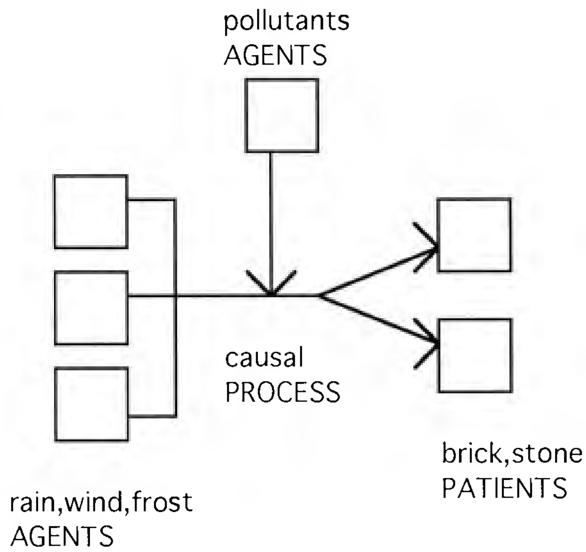
The scientific term which is used to describe this process is a nominalization:

weathering [p287, L4]

The speed of the Agent's action is increased by entities which are pollutants such as *acid rain*. So the process of weathering consists of three parts:

AGENT: *rain, wind, frost*
ACTION: *pollutant speeds up the action*
PATIENT: brick, stone

and can be represented schematically with an image schema of an Agent structure:



By making a meta-textual statement the teacher leaves out some other related processes also referred to by their scientific terms:

erosion and things like that [p287, L8]

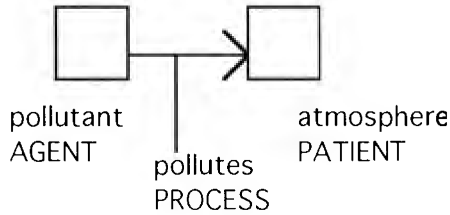
Going back to line 5 we could say that there is also an implicit definition about acid rain, because the answer to the question what is acid rain, will be: something that can speed up weathering. The teacher is going back to weathering [p287, L1-5] by making a resumptive conjunction and recalling its definition [p287, L10]. The entity *pollutant* so far is seen as part (not necessary) of the definition of the entity *weathering* [p287, L17-18]. Then the teacher is focusing on the entity *pollutant*, asking for its definition [p287, L19]. The students' answer makes an interesting shift from the noun *pollutant* (introduced so far as a condition which increases action and its effect on the Patient) to the verb *pollutes* (process):

something that pollutes the atmosphere [p287, L20-22].

The teacher's reply to this answer focuses on the meaning of the process *pollutes.*

What do we mean by pollutes the atmosphere? [p287, L22].

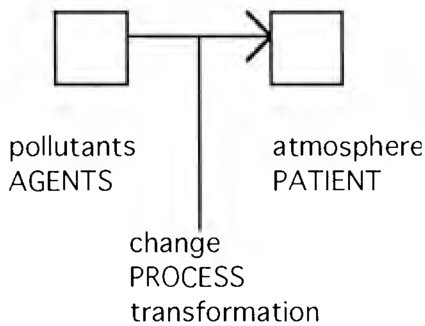
The question can be represented schematically as an Agent structure:



The answer which follows the teacher's question:

Changes that makes it bad... [p287, L22-23],

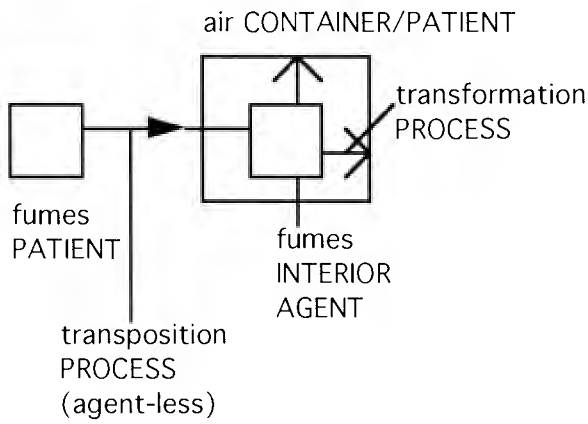
replaces the verb *pollutes* by the verb (with the broader commonsense meaning) *changes* giving at the same time a property to that in order to characterise the kind of *change*. The property *bad* is being given to the *atmosphere* because of the action of the Agent. This process which is represented schematically below:



is elaborated by an example which is an explicit analogy :

like put bad fumes into the air or something [p287, L24]

in a way that causes some kind of problem or damage [p287, L25]. The elaborated process can be analysed as a combination of a Containment and an Agent structure represented below:



So far the Agent-structure of weathering has been elaborated in two ways, the scientific and the commonsense one which are represented with the schemata above. The commonsense one highlights the transformational type of process which takes place in this Agent-structure. Notice also that the analogy elaborates the Agent-structure with one more schema the Containment schema. What is left out (look at the schema above) is that we do not know :

I) where *fumes* come from

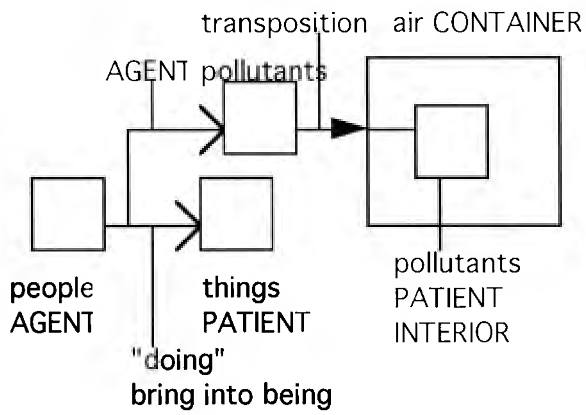
II) how *fumes* get into the atmosphere (by transposing themselves, so they are Agents in respect to their transposition and at the same time Patients in respect to their creation or there was another Agent to put them into the air)

III) what *fumes* are made of

The teacher's question below elaborates the first of the questions above by shifting back to the level of the target domain of the analogy:

And how does that pollution get there? [p287, L26]

The answer is also a partial answer to the question how pollutants are produced. It is interesting to notice that as the schematic representation shows in this case the process of making things is the Agent which does two things at the same time: producing pollutants and sending them into the air [p287,L27-29]:



The answer also is elaborated by some examples:

Factories and cars, in other words, things that we do isn't it? Not necessarily natural things, mainly things that people do , like driving their cars...

The teacher's elaboration to the students' answer is at a more general level:

so pollutants are things in the air,... [p287, L32-33] replaced immediately (corrective clarification) :

... substances in the air [] which ... life style . [p287, L32-36].

As the definitions of the entities and their processes have been constructed the teacher asks students to name some different building materials that can be used in their already planned experiments [p288, L1-5]. The purpose of the latter is to investigate how the weathering of different building materials is affected by acid rain. For such an experiment, a sample of different building materials is needed [p288, L6-23], as well as some diluted acid [p289, L2-3]. *Bricks*, *marble*, *limestone*, *sandstone blocks*, and *cement* are used as instances of building materials. *Dilute acid* is also used as an instance of the Agent *pollutant*. References to thing-like entities here are at two levels: the commonsense level of our everyday experience with thing-like entities such as different kind of building materials and the level of scientific knowledge which refers to classes of things. The teacher uses instances of the commonsense level to make reference to the scientific level which is more abstract and in some cases presupposes some kind of generalisation (as it happens with the classes of things). Reference to the scientific level is made by giving labels to entities from their scientific usage such as *weathering*, *pollutant*, *building materials*, *acid rain*.

An interesting question raises the issue of how an entity is identified, in this case *dilute acid*:

How are we going to know if something is acid? [p288, L23].

The teacher's question invites students to recall some information from their memory about the differences in the colour of the PH indicator paper. The definition of what *indicator paper* means rests on the meaning of the term: "indicator", so in some sense it is a tautological definition:

indicate means to show something [p289, L6]

or at least a replacement of the scientific term *indicator* by the everyday term *shows*. Indicator also in this case is identified by its action: what does it do? Changes its colour [p289, L3].

Then by reading the work-sheet an elaboration of the property of the natural weathering is given by the teacher in terms of a *lengthy process* using an analogy between 'real time' (how long it takes for a natural process to be accomplished) and the concept of time as it is used in everyday life (e.g. duration of a lesson) [p289, L17-22]. By comparing the two different kinds of timing (natural process versus lesson's time) teacher and students come out with the result that in the laboratory, in contrast with real life, they need to speed up the effect of the phenomenon of weathering in order to have an answer as soon as possible [p289, L22]. In this case there is a shift from the concept of 'natural time' (which takes more than a 'lesson's time') to the concept of 'lab's time'.

Among the different ways to speed up the effect of the process of weathering (such as increasing the amount of water used in the process, concentrate the water flow at a specific place on the surface of the affected entity, using dilute acid instead of acid rain itself e.t.c.) [p289, L26-34] the meaning of the concept *dilute acid* needs to be elaborated. Thus a definition:

Watered down, that's right, added water ... [p290, L1]

in terms of everyday concepts is accompanied by an example (exemplifying the definition):

... like you dilute your orange squash before you drink it. [p290, L1-2].

Then the main question of the experiment:

... how much the acid has affected the weathering of one sample...[p290, L3-4]

is elaborated with the idea of the comparison between samples, which also rests upon the idea of the control sample [p290, L5-7]. The comparison between the control variable sample and the other samples demands some measurements. And measurements cannot be carried out without observations [p290, L29-32]. Observations are given in terms of colour and texture of materials. The latter (texture) are observable mainly by touching: *rough, smooth, pitted, bits flaking off* [p291, L9-18].

This part of the lesson ends with the teacher's suggestions to students about how they would better plan their experiments.

Second Part: Carbon Cycle

The next topic is initiated by a meta-textual statement by the teacher:

what I quickly wanted to go over was the carbon cycle. [p293, L32-33]

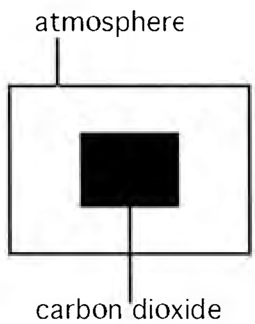
The grammatical past tense reflects the fact that the next topic is continued from the last lesson. So the teacher in order to remind students what the last lesson was about, makes references to specific pages of the textbook used (Oxford Science Programme) [p294, L13-18]. At this stage of the lesson the teaching is full of meta-role statements from the teacher who asks for student's attention to various things, such as what she is going to write on the board:

I am going to write carbon dioxide gas in the atmosphere. [p294, L21]

The lesson begins with questions about the location of atmosphere and Carbon dioxide in nature (at the same time as she locates them on the board):

Where's the atmosphere?
All around us. [p294, L22-23].

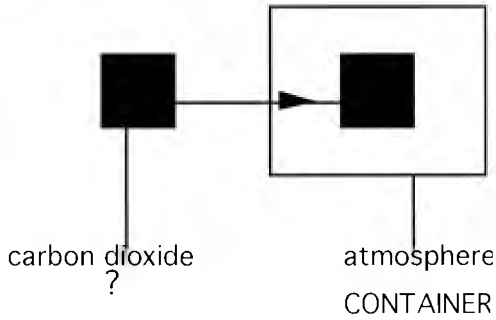
The location of the Carbon dioxide gas (in the atmosphere) and the location of its 'container' (the atmosphere) can be represented by the following containment schema:



which reflects a prior initial question:

How does carbon dioxide get into the atmosphere? [p1294, L24-25]

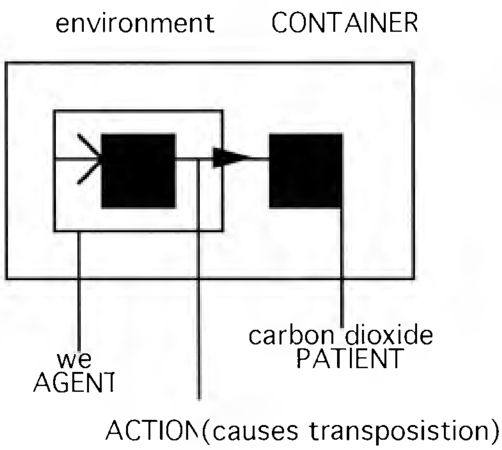
What the question is looking for is the type of the Agent-structure. The answer will show if the Agent-structure has an Agent which puts CO_2 into the atmosphere (even if the Agent is the CO_2 by itself) or if the process is Agent-less:



The answer given by students:

We breathe it out [p294, L26]

can be also represented schematically as a combination of a Containment and an Agent Structure. The container acts on its interior by transposing its location (in-out orientation)



The answer is followed by an analogy:

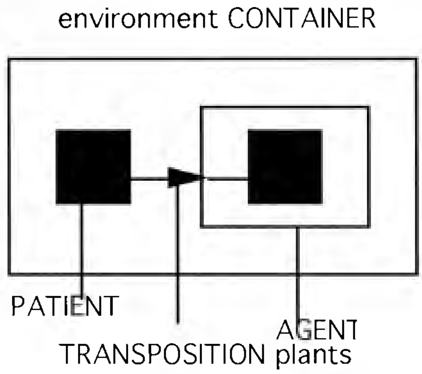
T: *We breathe it out. Just us?*
S: *Animals* [p294, L27-28]

which shifts the discussion to a more general level of categories of living things and not of specific instances of categories. So from entities *we* and processes with which students have immediate experience such as *human breathe* there is a shift to entities and processes with which we share the same nature such as *animals breathe.* Trees in contrast with animals take carbon dioxide in:

trees take it in and plants [p294, L30] the "and" here works as a corrective conjunction at the clause level so the clause:

trees and plants take it in :

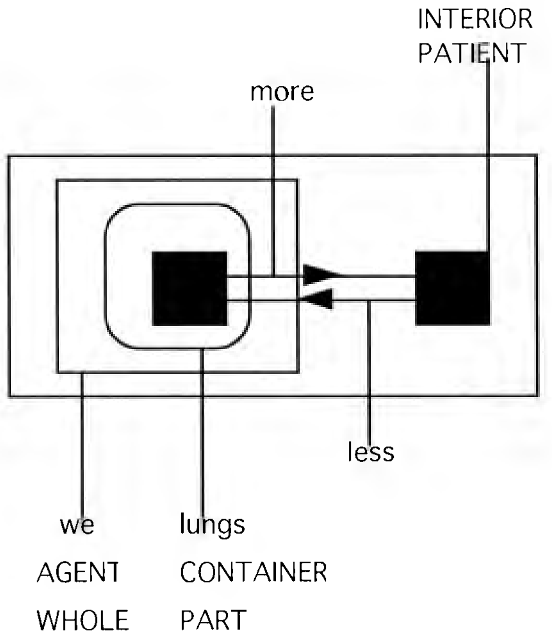
is represented by a schema which is the same as the one above, only its in/out-orientation is different:



The teacher in her effort to avoid misunderstanding is trying to make clear the difference between the two categories: plants and animals, by going back to her initial, starting point: how animals breathe out Carbon dioxide. Then the resumptive movement is followed by some kind of particularisation [p295, L14-21]:

T:	*Where does the carbon dioxide come from?*
S:	*air ... lungs .... /*
T:	*From our lungs OK What's it doing in our lungs?*
S:	*Nothing...what we breathe... /*
T:	*We breathe out more than we breathe in. We're adding to the carbon dioxide in the air every time we breathe out. Something's going on in our bodies that's making carbon dioxide ..*

The passage above can be represented schematically by a combination of a Containment, Agent structure and Whole-Part schema:



With this last schematic combination the connection between the top and the central part of the Carbon cycle as it is represented by teacher's drawing on classroom's board has been build up (see figure 1, page 285).

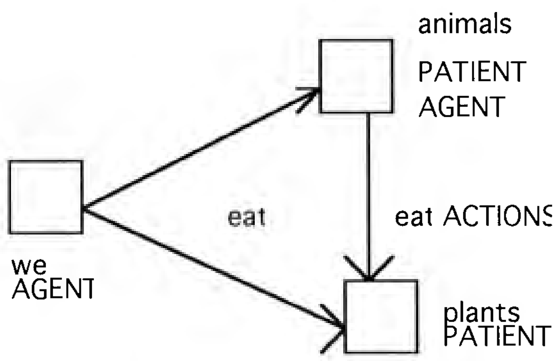
The insistence on distinguishing animal and plant processes continues by the teacher insisting in the use of proper terminology. The 'right terms' are recalled by the teacher in order to remind students of processes and to help them to fit these processes properly into what has been constructed so far (represented schematically above). So *photosynthesis* is concerned with plants and *respiration* is concerned with animals. Because both concepts above need to be fitted into the cycle, a question of clarifying their connection follows:

> *What's the connection between respiration and photosynthesis?*
> *What's the relationship between them?* [p295, L25-29]

followed by an answer:

Animals eat the plants and we eat animals or we eat the plants [p295,L30-31]

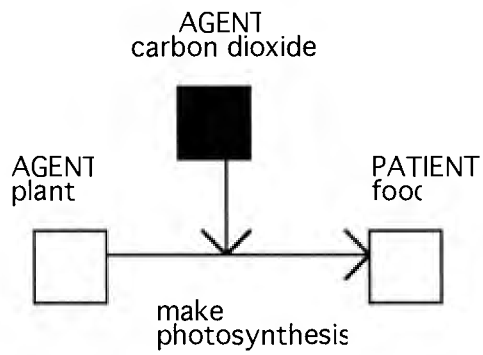
schematically represented as an Agent-Patient structure:



elaborated by particularising it [p296, L2-4] :

> *Well done, in a process called photosynthesis which they use carbon dioxide from the air to make that food.*

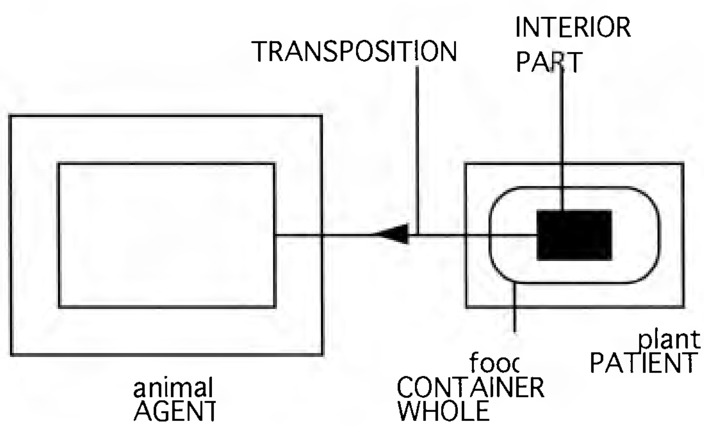
in terms of an Agent structure:



The *food* is connected to animals by going back to respiration [p296, L5-7] :

> *Animals eat the plants so now the carbon dioxide that was used to make the food has been incorporated into that food.*

The whole process is represented as a combination of an Agent structure, Containment and Part-Whole schema:



The process is exemplified at the same time, by the teacher who is using an example familiar to students:

Why do we need food? [p296, L8]

The question above shifts the discussion from the animal's level to the human level. The teacher answers the question by particularising student's response:

to live...

using the appropriate terminology:

...energy. [p296, L8-9]

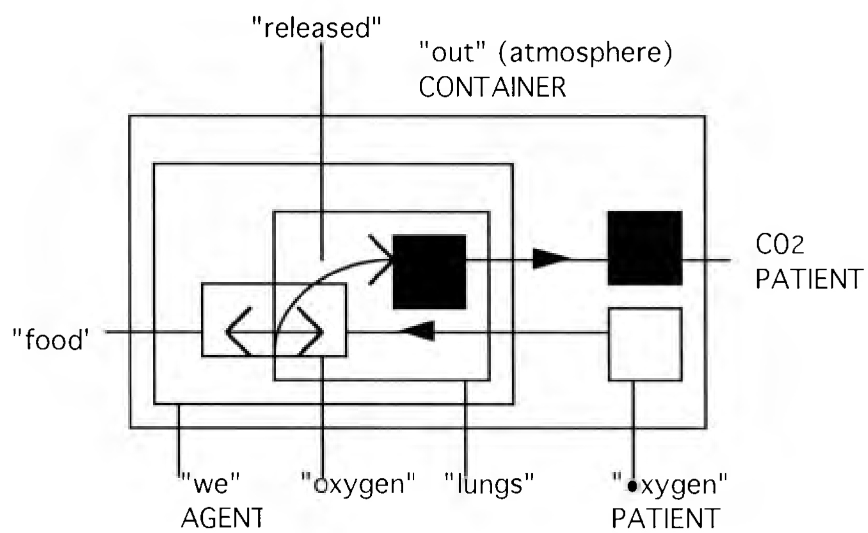
and by making reference to properties which are carried on by energy [p296, L10-16]:

T: *How do we release that energy?*

T: *For energy is one reason we need food. How do we release that energy? / S: ....by breathing in / T: By breathing in which gas / S carbon....ox.. /*

T: *Oxygen. Right, we breathe in oxygen. The oxygen and the food react together and change, releasing energy and also releasing the / S: carbon / T: Carbon dioxide and we breathe it / S: Out /*

Teacher's elaboration above can be represented schematically as a combination of a Containment, Agent structure and Part-Whole schema:



Later, the teacher goes back to the concept of respiration, which is now elaborated in more detail [p296, L23-24 & p297, L1-7]. As the definition of respiration is built up the entity Carbon dioxide is elaborated with the property: *waste product.* [p297,L2-7].

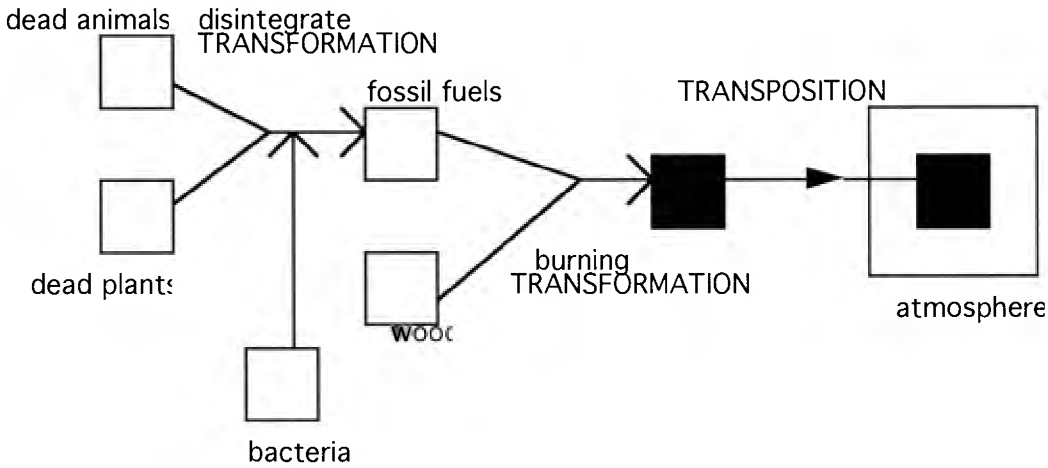
The process of how CO_2 gets into the atmosphere is seen also in another way [p297, L8-13]:

> *T:* *Is that the only way that carbon dioxide gets into the air these days?*
> *What other ways?*
> *Where else?*
> *Burning things , in particular which things?*
> *What are the fossil fuels?*

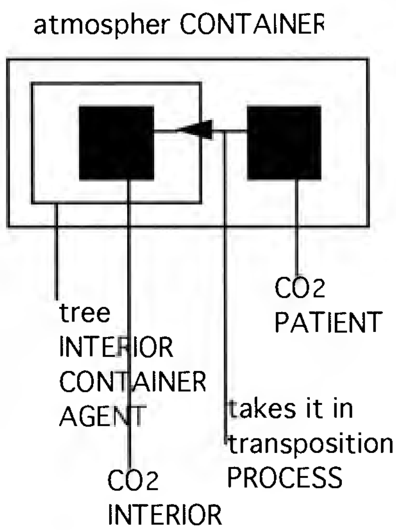
The teacher exemplifies the process of *burning* by providing instances which are closer to students' everyday understanding [p297, L20-34 & p298, L1-3]:

> *T:* *What do they use in what we call the developing countries a lot for fuel? What do you use if you go camping sometimes?*
>
> *S:* *.... / T: No, what do you use if you go camping sometimes / S: Wood / T: Wood / S: .... / T: I'm sorry, I didn't hear it / S: .... / T: OK burning fossil fuels and wood puts carbon dioxide into the atmosphere / S: Can we.... / T: In a minute. How do how are fossil fuels actually produced / S: Over millions of years / T: Over millions and millions of years from what / S: ... dead animals... / T: Right, dead animals and plants, what happens to them / S: they rot / T: They rot, where, they disintegrate, they rot / S: ...ground /*
>
> *T:* *Under the ground OK, which sort of bacteria are we talking about probably? / S: Oxygen ... nitrogen.. / T: Oxygen hating bacteria OK. So, the animals, when they die over millions of years, turn into / S: Fossils / T: Fossil fuels [ ] and then when we burn them, we release energy and we release the carbon dioxide.*

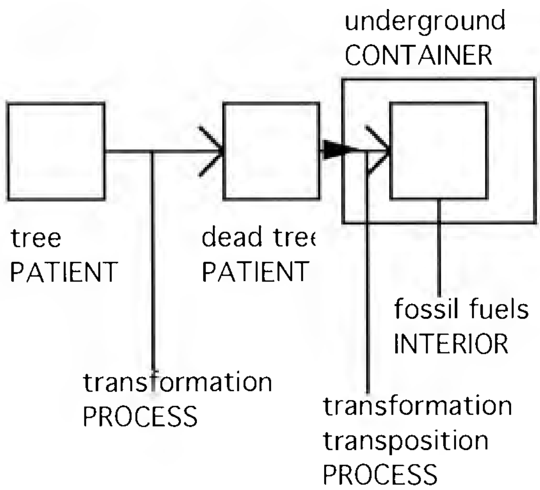
The various processes and entities in the extract above are represented by a combination of a Containment and Agents structures schemata of various types (transformations and transpositions):



With this schema above the connection between the bottom, left and top part of the drawing of the Carbon cycle on the board is made (see figure:1, page 285). By using a resumptive procedure, the teacher goes back to the schema above in order to particularise on the process of how Carbon dioxide is absorbed by plants [p298, L5-8]. A process which is represented schematically as a combination of an Agent-structure and a Containment schema:



Finally, the teacher elaborates the right part of the carbon cycle [p299, L14-22] in respect to the bottom part of figure 1 (page 285):



The analysis of this lesson illustrates that teachers' and students' construction of entities can be represented in a convenient way by image schemata. The underlying meaning of entities is constructed at the level of image schemata. The teacher often refers to entities in terms of their scientific names without violating the basic, image schematic relations in which these entities are realised. This is also evident by the fact that she often exemplifies scientifically named either process-like or thing-like entities using examples familiar to students. Commonsense representations of meaning are also realised by the same image schemata used for scientific representations. So image schemata are applied both to commonsense and scientific entities and in many cases entities from both realms are related within the same image schema.

At the level of image schemata, teacher's and students' contribution to the construction of entities is at different scales: either at the scale of a specific part of a schema, or at the scale of an entire schema and less often for students at the scale of a combination of image schemata. Finally the analysis in terms of image schemata can be a useful tool to show the effect various representations of entities might have on their meaning (see chapter 7).

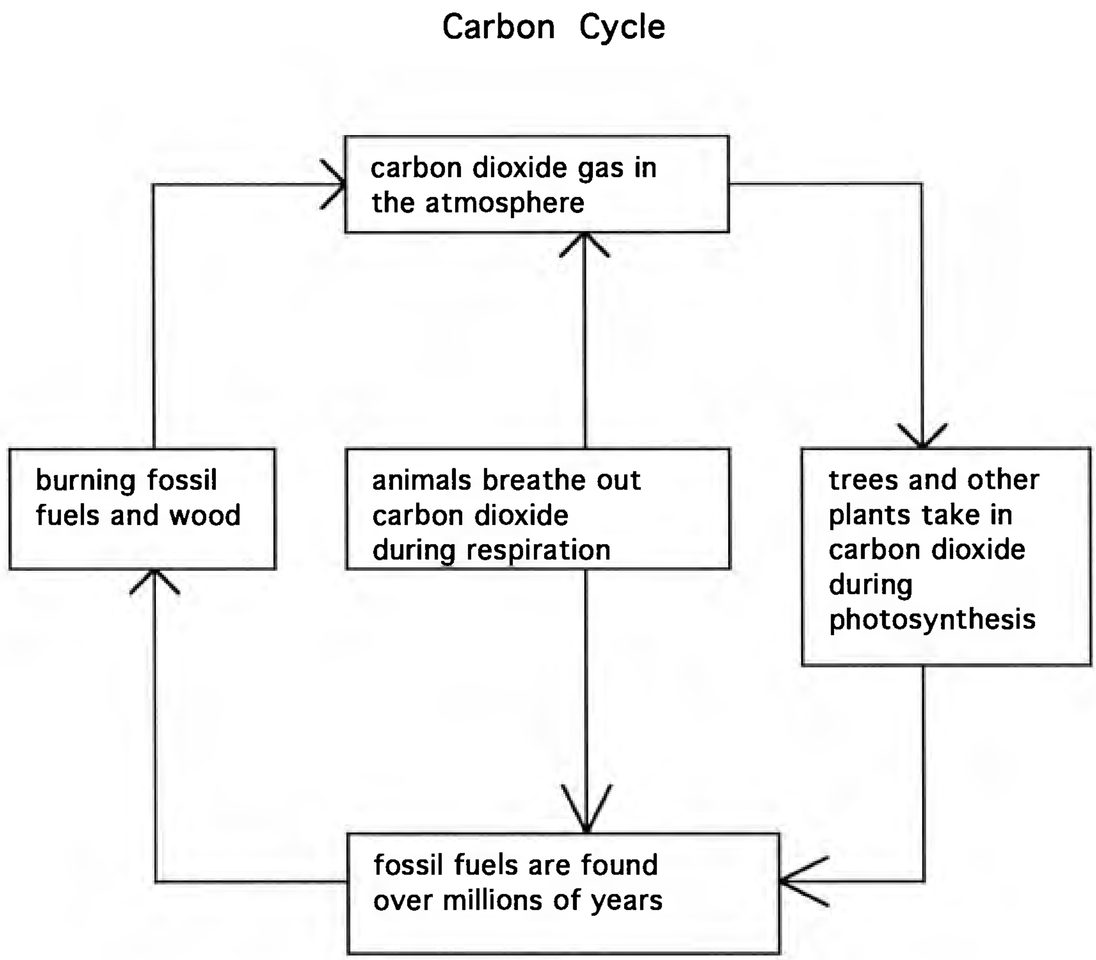

Carbon Cycle
carbon dioxide gas in the atmosphere
burning fossil fuels and wood
animals breathe out carbon dioxide during respiration
trees and other plants take in carbon dioxide during photosynthesis
fossil fuels are found over millions of years

Figure: 1

3.3 Transcribed Lesson

School: A
Date: 25.11.94
Class: YR 8
Teacher: Jane
Topic: Acid Rain & Carbon Cycle

T Just because [ ] listen and I'll explain what's happening. Right, you're not going to be on television (*Sounds of disappointment*), and we're not going to be famous (*Sounds of disappointment*) [ ] What's happening is that some of the students at the University in London are doing a little bit of research and they just want to record some lessons, I'm talking, they just want to record some lessons and to take them back to the University and look at them in their own good time and find out answers to their questions. Right? So all we need to do is for everyone to just behave as you normally would - perfectly - you know, like you normally do! / S:.... / T: No, perfectly / S:...I've left my homework at home...(*laughter*) / T: You've left it at home / S:...and I think I left it there, can I.... / T: Yes, go quickly /

S: (*general chatter*)

T: Right, let's get the register done please, Jessica, Angie, Deepah, Beverley, Mitch, Kelly - Kelly Smith, Fiona, Natasha, Kelly - Kelly Stevens, Charlie, Natura, Kelly, Natalie, Venetia, Kieren, Jodi, Helen, Tracy, Odine and Chatna (*sounds of answers as each name was called*). Thank you. Right, let's have a look at the homework first can we please? / S....[ ] / T Has anybody got a copy of the sheet I could just borrow please [ ] Thank you. Right, can everyone else see a copy of the sheets / S: No ... Yes... / T: Who said No / S: ... / T Have you got one of your own? / S: .... / T: Right thank you very much, if you can share then Mitch can borrow this one. / S: Thank you Miss / T: Anyone else that can't see a copy of the sheet [ ] Right. When there's materials like brick and stone exposed to the effect of wind, rain and frost their surfaces can be damaged and loosened. Scientists call this "weathering", they think that pollutants, like the acid in rain, can speed up weathering. [ ] / S: ..... / T: We will put it in the glossary when we come to Module F because Module F goes into more detail about weathering and erosion and things like that.

T So, what is weathering, what do we mean by weathering? Natalie / S:...effect of the wind and rain... / T: Right, not, not necessarily wear it away but / S: .... / T: damage it and loosen it so that perhaps the surface looks crumbly. Right, so that's damage, [ ] to the surface of rocks or buildings, stone brought about by things like wind and rain and frost, the different weather conditions, which is why it's called weathering. Pollutants. Scientists think that pollutants might speed up this change, might make it go faster. What do we mean by a pollutant?

S ... / T: Yes? / S: ... something in the atmosphere .. / T: Something that pollutes the atmosphere. What do we mean by pollutes the atmosphere? / S:....Changes. that makes it bad like put bad fumes into the air or something / T: Something that / S: .... / T: Changes the air in a way that causes some kind of problem or damage and how does that pollution get there?

T: Yes? / S: Factories and / T: Factories / S: Cars / T: Cars, in other words, things that we do isn't it? Not necessarily natural things, mainly things that people do, like driving their cars / S: .... / T: Sorry / S: Why is... / T: This is a tape recorder. OK? Right, so pollutants are things in the air, substances in the air [ ] which cause some kind of problem or damage [ ] and generally put there as a result of our activities, particularly our modern life style. You have to design and carry out an experiment to find out how the weathering of different building materials is affected by acid rain. Now what you can get is some different building materials, can you think of some different building materials? Bev?

S: Brick /

T: Brick /

S: Limestone /

T: Limestone /

S: ..Marble.. /

T: Marble, concrete /

S: .... /

T: Charlie? /

S: Sandstone /

T: Sandstone blocks, cement /

S: natural stone /

T: natural stone, Yes /

S: .... /

T: Ordinary stones like they use in the Cotswolds /

S: What's that black stuff called that they put on the roads

(several voices) Tar /

T: Tarmac, bitumen /

S: ... /

T: Yes asphalt, OK, so we can get samples of different building materials and then we want some dilute acid. How are we going to know if something's acid, acidic / S:.... / T: or not? Put your hand up, hand up, Mitch / S: that red and green kind of.... tells us where acid.... / T:

Right, that that paper, that red and green and / S:....*(babble of voices)* / T: what do you call red and green and blue that changes colour with acid paper / S: .... / T: what / S: .... / T: Good, well remembered p h paper indicator paper - what does indicate mean? / S: To show something / T: To show something that shows us ... The opposite of acid is alkaline, and what's in the middle? / S: Green... / T: The green colour / S: Neutral /

T: Neutral - good well remembered from last lesson. You can have some water, maybe access to a freezer, and perhaps some running water from a tube attached to the tap. Some information to help you. Natural weathering is a lengthy process - what does that mean Tracy? natural weathering is a lengthy process, [ ] can you explain that in your own words. What do you think they mean by a lengthy process? [ ] Is it something we're going to be able to do in a lesson, if it's a lengthy process? / S: ...experiment...

T [ ] An experiment but would we be able to get it finished in one lesson if it's a lengthy process? / S: No / T: No, so what's a lengthy process mean? / S: ...long time /

T: Takes a long time, that's right. In order to speed up the effect in a laboratory, you might like to try soaking samples in water for several hours and then placing them in a freezer over night. You could also try the effects of using a fine, high-speed jet of water from a hose or a tap. So whereas natural stone would be exposed to pitter patter drops of rain over a long, long time, we can speed up the effect of those by having.... a jet of water, a fine jet and concentrating it just in one place on the stone to see if that has any effect. Instead of acid rain, you could use dilute acid. In the labs we have bottles of dilute acids and dilute alkalis. What's dilute mean? Dilute / S: ... water.. /

T: Watered down, that's right, added water. like you dilute your orange squash before you drink it. You won't know how much the acid has affected the weathering of one sample, unless you have a similar sample which hasn't been treated with acid for comparison. So we need what we call a control, something that hasn't gone through the same process. So that we can compare it at the end. How many people actually managed to plan an experiment? Even if you didn't get right the way through it, how many people did have some ideas? [ ] OK, Helen, did you have any ideas? /

S: .No I have but I didn't... /

T: You got them from the sheets, well that's fine, that sheet was there to give you information. Right Helen, can you start us off then?

S ..... /

T: What did you think we might do? / S:.... / T: OK, so collect some samples / S: .... / T: What sort of things did you think you might use? / S: ...natural stone....... / T: There might be some / S: .... / T: So you're going to have a look round and see if you can find some places where obviously weathering has had an effect. Right, and then what are you going to do?

S ..samples that have been..... /

T: Right, so you're going to get some samples which have been exposed and some other samples where it's been sheltered. / S: .... / T and describe them, measure them or what? / S: Yeah.. /

T: Both those things, describe and measure them. What sort of measurements would you take or what sort of observations would you make, what would you be looking for? [ ] What evidence is there that something might have been weathered? / S: ..moss.. / T: moss growing on them, yes, plants growing on the surface can have an effect because their roots can get into any little cracks and then as the plant grows, their roots can force those cracks wider apart. That can be a cause of weathering, yes.

T: Charlie?

S: .... stones come loose ... / T: Yes, when something's been weathered, bits come loose don't they and crumble away / S: I was going to say that as well... / T: .You were going to say that as well. So what would the surface look like? / S: ... rough.. / T: Might look rough / S: .... / T: ah ah / S: ....cover it and see if.... / T: Right, see if bits break away, Mitch? / S: On my Mum's wall, right she's got ... it's bright orange and all the rest of that's dark. / T: So a different colour perhaps, there might be a colour change. So we're going to make some observations [ ] and there might be things like colour changes or the texture of the surface, whether it's rough or smooth or pitted or bits flaking off. That would tell us, might give us some clues as to which sorts of stones weather easily and which don't but how could we actually find out what caused that? [ ] If we look at something that's already been weathered, does that help us to find out what really caused it or do we need to do something else, Jessica?

S: You can get a sample of the like material that isn't like weathered and then you can like ....you leave it somewhere where it's windy and rainy and .... / T: Ah ah / S: ... and there's a lot of frost and then after about a week, come back and see if it's changed

T: Do you think a week is long enough if we're just going to leave it to the wind and the rain and the frost, remember what they said, weathering is a / S: Long *(several voices)* / T: Lengthy process so how could we speed that up?

S: A jet of water /

T: A jet of water, or /

S: ...smaller stones lots of bits.... /

T: a smaller stone you think will change quicker than a .... small pieces /

S: .... / T: OK, might help, what else? / S: ... in the rain ....same process....weathering and then you could add the acid and.... /

T: Right, so we could use acid in the laboratory instead of acid rain and see if that has any effect on the stone. So what would you do, just leave it soaking in the acid or pour acid over it or what? / S: .... some amount.. / T: OK and then just brush some acid onto it, yes that's a possibility. How many pieces of the brick will you use? /

S: two /

T: Two, alright /

S: ..because one that has the acid on ... no, you need more than two. /

T: Tell me why you said two in the first place /

S: because you have one to go in the acid and all that lot and then one with.... /

T; Right and why do you need one we haven't put in the acid. Yes?

S: Just to compare / T: To compare them at the end and see what the change has been / S:....more than two / T: Right, why do we need more than two? / S: ...because one in the freezer...and one in acid and see which one... / T: Right so that we can have one that we leave untreated, one that we put in acid, one that we soak in water and put in the freezer and what was the other one? / S: ...just put one in the freezer... /

T: And one in the freezer without soaking it in water. OK There's various different combinations but you leave one untreated so that you have a comparison and then at the end of your experiment, you can look for things like colour changes, changes in texture, bits flaking off. Do you think the material will be as strong when it's been weathered as before hand so you could maybe do some sort of test to find the strength of it whether it's easier to break now than it was before, things like that. So those of you who didn't get very far with your homework, do you think you'd be able to get a bit further if I ask you to have another go tonight? And those who did make a start, do you think you can go into real detail now with drawing apparatus and a table maybe for your results and things like that? OK, let's leave that for the moment then, so can you put that away, now whose did I borrow / S: .... / T: The one at the end here / S: .... / T: We will do yes, oh you're going to do it are you? / S: ... / T: Well, try it and see / S: .... / T: Yes / S: ..that was on the floor.. / T: Thank you / S: .Can you do timetables... / T: What for the parents' evening? / S: ....

T: Can you come to Room 20 because I've actually got it in my register. If you come at registration sometime .... /

S: ..what day... /

T: Any registration time because I'm keeping it in my register / S: Miss..... / T: I don't know...Alright, let me just get these books out for everyone else. Mitch, can you give some books out for me please? 2, 4, 6, 8, 9, 10, 11, 12.....17 altogether, alright? / S.... / T: So some people will have to share. Something else I quickly wanted to go over was the carbon cycle. Remember you, I think you've all got to the point now where you've drawn pictures of the carbon cycle. You remember, with the chicken, the dead chicken / S.... / T And the lightning cloud / S.... / T: Can you find that in your books please, find it in your books / S: .... / T: Which one / S.... / T Well go and swap it over then please Kelly / S: .... / T: Yes, can I borrow your / S: .... / T: It's that one / S: which one?... / T: Kelly, no need / S: .... / T: This one / S: ....

T No that's the nitrogen cycle, sorry, you're right, you're right, sorry / S: .... /

T: Well then can you look at someone else's book, look over someone's shoulder sorry, it wasn't the one with the dead chicken, that was the nitrogen cycle - I got confused. It's the one with the factories and the man eating the chicken and the chicken eating the corn / S: (laughter and coughing)... / T: If you haven't got it with you, just look over someone else's book please / S: ...... / T: [ ] You'll also find it in your text book, it's in your text book that's where you copied it from on page 109.

S: ..... [ ] / T: Fine [ ] / S:.... /

T: Let's start, you don't have to copy this down yet 'cos it's in visible writing anyway [ ] I'm going to write carbon dioxide gas in the atmosphere. Where's the atmosphere?

S All around us /

T: All around us, OK [ ] How does carbon dioxide get into the atmosphere?

S We breathe it out /

T: We breathe it out. Just us? /

S: Animals /

T: OK animals /

S. and trees take it in and plants... /

T: Alright, let's just do one thing at a time Mitch, animals breathe out carbon dioxide? / S.... / T ..Mitch, that's enough....[ ] Why do they breathe out carbon dioxide, where does the carbon dioxide come from?

S .... /

T: No, no the trees are going to do something else in a minute, we'll look at that. Where does this carbon dioxide coming from that we are breathing out?

S: the greenhouse effect... / T: We've got little green houses inside us? / S: (laughter).... /

T: Carbon dioxide is one of the gasses that causes the greenhouse effect we think. But you just said we breathe out carbon dioxide. Animals breathe out carbon dioxide. Where's this carbon dioxide coming from?

S: air ... lungs .... /

T: From our lungs OK What's it doing in our lungs? /

S: Nothing. .what we breathe... /

T: We breathe out more than we breathe in. We're adding to the carbon dioxide in the air every time we breathe out. Something's going on in our bodies that's making carbon dioxide ... Odine?.. / S: .food... / T: It's something to do with food / S: .... / T: Good. / S: Photosynthesis / T: That's what the plants do / S: (laughter) / T: Now, it's not funny that / S: respiration / T: Hey, good, it's not as funny as you think. What's the connection between respiration and photosynthesis?

S: They go together /

T: How do they go together? What's the relationship between them / S: ...animals... / T: Animals and plants right / S: animals eat the plants and we eat animals or we eat the plants / T: Right / S:.... / T: Listen listen then, listen / S: .... / T: The plants make food in a process called photosynthesis / S: .... / T: Say it / S: .... / T: say it / S: .... / T: Well done, in a process called photosynthesis which they use carbon dioxide from the air to make that food.

T Animals eat the plants so now the carbon dioxide that was used to make the food has been incorporated into that food. Now the carbon's got into us / S: .... / T: Just a minute, why do we need food? / S: .to live... / T: Well be a bit more specific / S: energy /

T: For energy is one reason we need food. How do we release that energy? / S: ....by breathing in / T: By breathing in which gas / S carbon....ox.. /

T: Oxygen. Right, we breathe in oxygen. The oxygen and the food react together and change, releasing energy and also releasing the / S: carbon / T: Carbon dioxide and we breathe it / S: Out /

T: Out. That's the atmosphere and what happens then / S It goes round / T: It goes round again that's why it's called the carbon cycle.

S: .... / T Just a minute Mitch 'cos Charlie had her hand up as well / S: . ..breathe it in as well.... / T: Sorry / S: .... is all that happening.... /

T: : No, the oxygen I just breathed in is probably still going round in my blood stream and the carbon dioxide I'm breathing out is from some oxygen I breathed in a little while ago. Right, OK, so the animals breathe out carbon dioxide during the process that we call res / S: res... / T: Respiration [ ] good and that's the process where we release energy from the food that we've eaten by breathing in the oxygen, the oxygen goes all round our bodies in the blood stream.

T Get's to every little part of us every cell, every brain cell, every cell in my big toe down to my finger tips, round to my back, up to my shoulders. The oxygen goes all round to every cell and reacts with the food that I've digested to release energy. And one of the waste products of that Kelly / S:.... / T: One of the waste products of that is / S: .... / T: What I breathe out, no / S: ... / T: Carbon dioxide, right. That is a waste product but from something else OK So animals breathe out carbon dioxide.

T: Is that the only way that carbon dioxide gets into the air these days? / S: ..No.. / T What other ways / S: From factories / T: From factories / S: ... / T: Where else / S: Cars / T: Cars / S: .... / T: Sorry / S: Houses / T: From houses / S: Burning things / T: Burning things, in particular which things? / S: Fossil fuels /

T: Fossil fuels. Right. What are the fossil fuels /

S: *(babble of answers)*

T: Wow /

S: (another babble) / T: Is it just fossil fuels, what's the other big fuel that's used a lot. Not necessarily in this country / S: *(babble)* / T: Methane - well that's part of natural gas isn't it / S *(babble)* / T: What do they use in what we call the developing countries a lot for fuel?

S: .... / T: No, what do you use if you go camping sometimes / S: Wood / T: Wood / S: .... / T: I'm sorry, I didn't hear it / S: .... / T: OK burning fossil fuels and wood puts carbon dioxide into the atmosphere / S: Can we.... / T: In a minute. How do how are fossil fuels actually produced / S: Over millions of years / T: Over millions and millions of years from what / S: ... dead animals... / T: Right, dead animals and plants, what happens to them / S: they rot / T: They rot, where, they disintegrate, they rot / S: ...ground /

T: Under the ground OK, which sort of bacteria are we talking about probably? / S: Oxygen ... nitrogen.. / T: Oxygen hating bacteria OK. So, the animals, when they die over millions of years, turn into / S: Fossils / T: Fossil fuels [ ] and then when we burn them, we release energy and we release the carbon dioxide. Now, how does carbon dioxide get used up from the atmosphere?

S: The trees breathe it in / T: The trees, not breathe it in but the trees / S: Take it in / T: Take it in OK during the process of / S: ... / T: OK Trees and other plants / S:...Miss, oxygen.... / T: [ ] take in carbon dioxide / S:... / T: During / S: a process called photosynthesis.... /

T: Photosynthesis OK Why is it called Photo? Is it something to do with cameras? / S: No /

T: What's it to do with then? /

S: .Photos... / T Yes / S.... / T Well it is plants that are doing this but why do we call it <u>photo</u>synthesis / S.... /

T: Chatna, no Chatna? What do you need to take a photograph apart from a camera? /

S: Film /

T: A film and? /

S: ..oxygen....light /

T: Light, OK Yes it's a process of making food and it gives out oxygen, but what it needs, as well as the carbon dioxide and as well as water, it needs / S light / T Light.

S Chlorophyll, what's chlorophyll? /

T: Chlorophyll is the green substance in plants that traps the sun's energy so that the plants can put all these things together and make food / S:.... / T: Natalie / S: how does.. / T: OK What does / S: ... oxygen.. / T: Sh listen, what does synthetic mean / S ....

T: We talk about synthetic materials, synthetic fibres, what does that tell you? / S: They're made from... / T: They're made from / S: Natural things / T: No, it's the opposite of natural things / S: *(babble)* /

T: Woah, if you're all just going to shout out, people are going to get confused [ ] Think about the question, don't just shout out all the words that you remember we've used in the past few weeks in any order / S..../ T: Synthetic substances are substances that have been put together, not natural substances, right, so photosynthesis is talking about putting together carbon dioxide and water in the presence of light, using light energy from the sun / S:.... / T : Well light is a form of energy / S: .... make glucose / T: To make glucose / S: .... / T: That's the food / S: .... /

T: and releasing oxygen that's right and then the trees can die and the other plants can die and be turned into fossil fuels as well, can't they? It's not just dead animals, it's dead plants as well and actually we should have put plants in here because plants do breathe, well, they do respire and give out some carbon dioxide and they take in a lot more carbon dioxide during the day time, at night time they don't take in carbon dioxide because there's no? / S: .... /

T: No light so no photosynthesis going on that's right. Can you please copy that down. I suggest that the back of your / S: .... / T: Oh good, I suggest that the back of your books where you've got your glossary - you've got the glossary at the back? / : S Yes / T: OK [ ] /

S: where do we copy...at the back? /

T: Yes if you copy this down at the back if you haven't already done it.

T: Copy this down at the back. This is the carbon cycle / S: .... / T: If you've done it in the front, don't worry [ ] too late to worry now .. but I didn't actually ask you to write it down as I was talking [] alright [ ] if you don't understand it, then just ask.

S: I don't understand .... / T: You don't understand it Kelly - you alright / S: Yes.... / T: That's the one from - I'll come to you in a minute Kelly, right just....there / S: ... / T: .... /

S: .Miss have you got my book?... /

T. ...Yes...have I got your book...not that I'm aware of I don't think. Didn't I give them back last lesson /

S: ...I wasn't here....[ ].... /

T: I could have taken it over to the office and left it there so can you do it on paper for now....yes....[ ] .... / S.....

T: Oh, this is in levels... / S: Here's our one.. /

T: Good aren't they. Do you actually use them / S: .... / T: And do you have to get them from this address or are they on sale in the shops / S: .... / T: Can you ask him / S: Yes / T and if it's from here perhaps you could write that down for me [ ] Very good / S: here there at stage three...that one. three to six, ... three to seven...

T How do you find the language in here? / S: .... / T: Can you understand the way it's written or do you find it's a bit complicated / S: I'm having... / T: Have a read of that sometime and let me know what you think about the way it's written and the language / S: .you know about the open night... / T: Can you come to my tutor room, Room 20, sometime because I've got my sheet of appointments there because I've got a Year 8 tutor group and I've left it in my tutor room / S: .....

T Well, any registration time, lunch time or Monday morning any registration time /

S: In my experiment I'm using stones and marble and brick ....see what one dissolves and what one doesn't dissolve / T Uh uh / S I can't get the marble from anywhere and .... /

T: Well we've got some marble chips, little bits of marble, would that do / S Yes / T Haven't got a big slab of marble, but some little chips

S ....little bit /

T: Yes, I've got some little bits. How are you going to make your tests fair /

S: If you measure the amount of acid.... / T Right / S: in the marble and the stone.... /

T: Right [ ] what else would you have to do to make it fair [ ] measure the amount of acid / S: measure the / T: measure the amount of stone / S: Weigh the amount of stone / T: That's how you'd measure it presumably / S: .... / T: OK [ ] /

S: ...I don't know....

T How long are you going to leave it? / S: I'm going to leave it for a [ ] I'm going to have to ....Wednesday until Friday.... /

T: OK and you're going to leave it all for exactly the same length of time. Is that a way of making it fair? /

S: Yes /

T: Right. Anything else you need to do to make it a fair test? Supposing Kelly bets you £10 what the answer is going to be. How are you going to make sure she doesn't cheat. / S: ....her not be there when I do it / T: (laugh) No, apart from that, can't exclude her from lessons [ ] how are you going to make sure that it's all fair and you've got an equal chance of winning? Well, think about measuring the acid and measuring the stone by weighing it [ ] leaving it for the same length of time, is there any other way that she could possibly cheat? / S: ... look at it (laughter) / T: No I don't think that / S: .... watch her do it

T: Well for instance, if you did your experiment with.. erm.. a small amount of acid and added lots of water to it and you did your experiment just with the acid and not watered down at all, would that be fair?

S: No, it's got to be the same /

T: So the concentration has got to be the same [ ] OK / S: three drops of water and three drops of.. /

T: Whatever- Right, so the concentration and the amount and the amount of stone and the length of time you leave it.

T: Supposing Kelly had hers over by a radiator where it's nice and warm and you leave yours by an open window where it's cold. Is that fair? / S: No / T: So what will you do? / S: .... / T: So that what's the same then what are you talking about / S: so that they're both cold..... / T: How do we measure hot and cold what piece of apparatus do we use

S ... thermometer /

T: A thermometer and what does a thermometer measure? /

S: Temperature /

T: That's right, so we need to put them at the same temperature to make it fair don't we? [ ] so that's at least 5 things you've told me

S .... / T: Right, well done / S: .... / T: OK do you think everybody would? / S: ... / T: It just strikes me that some of the words are a bit complicated / S: ....some of them are... / S: ...you know the open evening...can I come to you.... I've worked it out with Miss S...but I have to book it for...

T Can I just point out to everybody please that if you want to make an appointment for open evening, can you come to Room 20 some time which is my tutor room because I've got my list in there because I'm a Year 8 tutor. Could you come to room 20 please, otherwise you'll have to wait until Friday's lesson.

S ....I don't know what that means / T: Yes today's Friday isn't it? Sorry, Wednesday [ ] / S: .... / T: Yes.... You can cope with that, can't you? / S: .... I have.... /

T: Now you've written everything down one after the other right, now is that how I've written it on the board? Is that how I've written it on the board? /

S: No /

T: No, so let's start again over there and let's do it bit by bit / S:.... / T: You can go into the margin, yes / S: ..... do I have to write.... / T: What.... / S: ... I can just copy ..just do the arrows.... / T: But the arrows will all cross over one another and it won't give you some information as clearly / S: but I don't want to do it all again...

T: But if you don't do it all again, I don't think you'll understand it properly and if you don't understand it, then you're not going to be able to answer the questions in the test for one thing are you?

S: What test? /

T: The test we're going to have very soon when we get to the end of this topic. / S: .... /

T: Ah, so let's do it again over here. Right, when you've finished that, will you please turn to which ever page you're on in the text book and you've got just over 20 minutes of the lesson left so you just carry on from wherever you are in the text book. If you need any help, I'll try and come round to you, I'm just helping Kelly at the moment / S: .... /

T: Yes that's OK [ ] right Kelly, look, I started in the middle, no sorry, I started at the top - carbon dioxide gas in the atmosphere. Draw a box - it might be better to do the writing first and draw a box around it. Kelly do the writing, then draw the box around it then you'll know how big a box you'll need. Right, carbon dioxide gas in the atmosphere and that stays, more or less the same amount all the time because some things put carbon dioxide into the air and other things take carbon dioxide out of the air / S: ...trees cut down ..and if they're not cut down... / T: That's right, two reasons for not burning down the rain forest isn't it?

S ....over here.... go to the library and look up the carbon cycle in the next lesson / T: Do you want to go to the library now? / S: .... / T: Will you write a note and I will sign it / S: Miss can we go to the 6th form library? /

T: No. /

S: Why? / T put a box down there. Because it's for the 6th Form and the type of books they've got in there probably wouldn't help you anyway because they tend to be A Level books or more advanced books / S..... / T: I use the 6th form library yes, / S....

T Just draw a box down there please / S: ... I'm moving... /

T: Right, now how does the carbon dioxide get into the air? /

S: We breathe it out /

T: OK, so that's that box that says animals breathe out carbon dioxide during respiration. Respiration is, again, I would write it first if you know how big a box but remember that you've got to get a box over here and a box over here and a box in the middle so keep it within those sort of limits / S: ..... / T: Animals breathe / S: .... done it wrong again then / T: ....out on the next line / S:

.... / T: Carbon dioxide on the next line [ ] Right, during / S: .... / T : On the next line, sorry / S: My Mum went ... last night.. / T: Did she? that was very brave [ ] / S: ....[ ] / T: ....Can we talk about this later and get on with what we're supposed to be doing now please.....turn to whichever page you're on in this book....tell us / S: ....[ ] / T: That's the sort of thing that's best done as homework really, isn't it yes, so do that at home, just turn over to there / S: have you got... / T: You'll have to come to room 20 and find out 'cos my list is there / S: .... / T: Put that into a box, come on.. (end of recording)

APPENDIX 4

TEXTS AND IMAGES FROM TEXTBOOKS

List of textbook material

4.1: *Caring for the soil* (Pollock, S. (1991). *World in Danger: Earth*, Belith Press, Unlimited)
4.2: *Soil cycles* (Pollock, S. (1991). *World in Danger: Earth*, Belith Press, Unlimited)
4.3: *What happens to carbon during decomposition* (Nuffield Co-ordinated Science, Biology)
4.4: *The Carbon Cycle* (Johnson, M. & Morrell P. (1982). *Environmental Science*, Blackie and Son Limited)
4.5: *A cycle of gases* (Cochrane, J. (1987). *Air Ecology*. Wayland Publishers Ltd)
4.6: *The flow of energy in living systems* (Johnson, M. & Morrell P. (1982). *Environmental Science*, Blackie and Son Limited)

4.7: *Living organisms* (Active Science 2, Key Stage 3)
4.8: *Living cells* (Active Science 2, Key Stage 3)
4.9: *Cells and more cells* (Active Science 2, Key Stage 3)
4.10: *Living things* (Nuffield Science, Key Stage 3, Year 9)
4.11: *All together, now!* (Nuffield Science, Key Stage 3, Year 9)
4.12: *Organisms in patches* (Nuffield Co-ordinated Science, Biology)
4.13: *The farming cycle* (Nuffield Science, Key Stage 3, Year 9)
4.14: *Looking for patterns in life cycles* (Nuffield Science 13 to 16, Study Guide 1)
4.15: *The nitrogen cycle* (Active Science 3, Key Stage 3)
4.16: *The carbon cycle* (Nuffield Science, Key Stage 3, Year 9)
4.17: *The nitrogen cycle* (Nuffield Science, Key Stage 3, Year 9)
4.18: *The carbon cycle* (Oxford Science, Programme)
4.19: *Carbon cycle in a terrestrial ecosystem* (Ecology Unit 9, Cambridge University press, 1985)
4.20: *The Nitrogen Cycle* (School B, Norman, Year 10)
4.21: *The Carbon Cycle* (Active Science 4, Key Stage 4)
4.22: *The Nitrogen Cycle* (Ecology Unit 9, Cambridge University Press, 1985)
4.23: *The Carbon Cycle* (School A, Jane, Year 8)

Appendix 4.1

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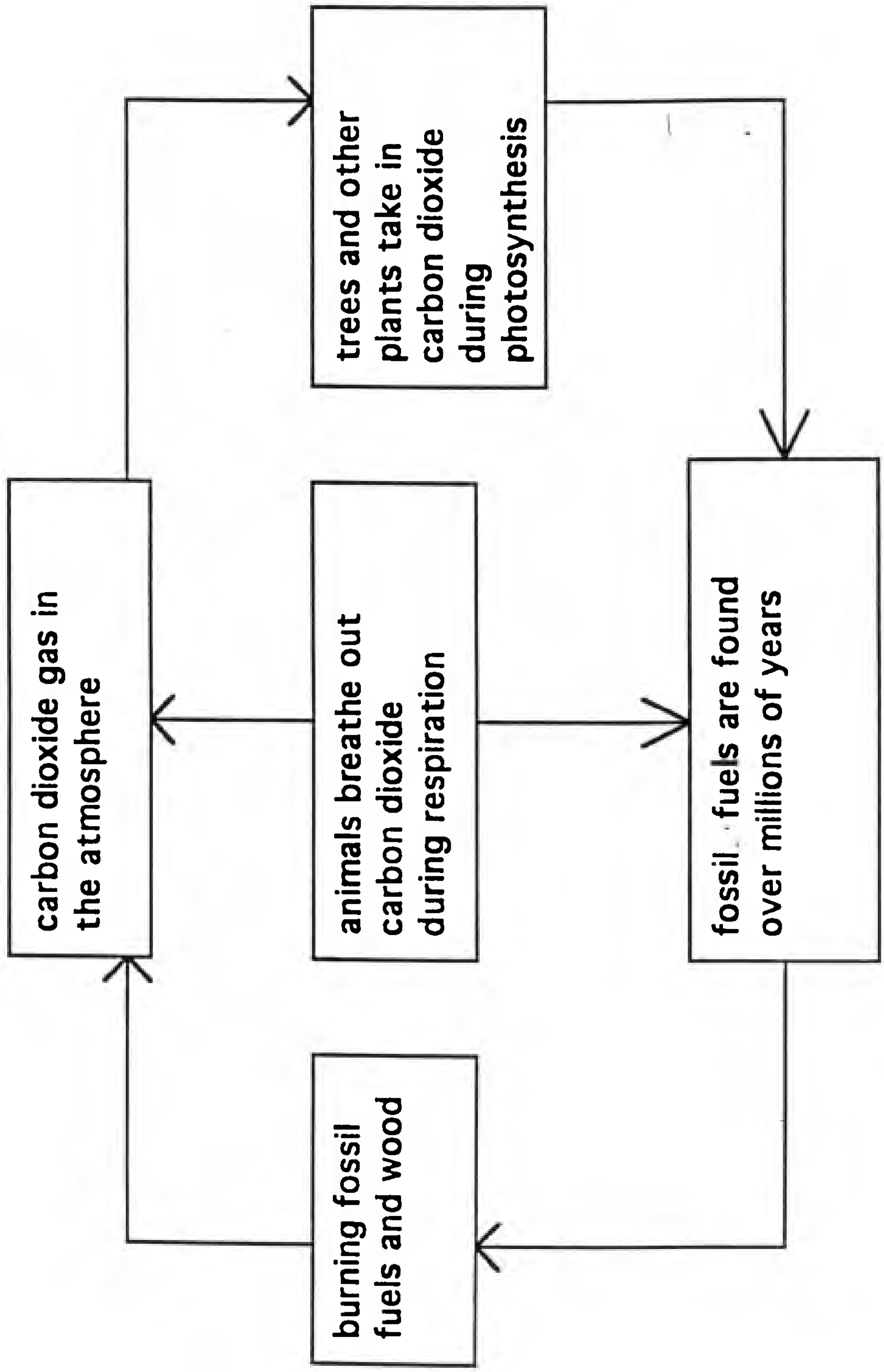
Appendix 4.23

Carbon Cycle



APPENDIX 5

INTERPERSONAL ASPECTS OF IDEATIONAL PROCESSES AND IMAGE SCHEMATA

5.1.1 Readers treated as interactive participants

Textbooks vary regarding how they are addressed to the reader. This depends on the whole structure of the textbook and its purpose for which it is written. In some textbooks the text is organised in a structure which is the same for each theme or topic. This is the case with the Active Science series in which there are certain locations for the contents to be placed. Each new topic begins with the relevant information placed on the top of the page and followed by images, such as pictures, drawings and graphs. Various sorts of tasks are indicated by a label, like observing, planning, investigating and the steps or stages that the task contains are usually framed. Questions that seek information or call on students to reflect on the knowledge which is available in each topic are usually mixed (conflated) with the given information or they are numbered on one side of the page next to the text that the questions are about. At the end of each topic some extra work, quite often in terms of practical activities, is placed at the bottom of the page (see Appendix 4.15 for example). So for a student who is familiar with the Active Science textbook, either the physical appearance of some elements on the page or where is he/she reading on the page indicates to him/her what sort of relation with the text is involved.

The Nuffield Science series of textbooks have a different structure. Here it is the kind of textual information in each topic which determines how the contents should be arranged on each page. Depending on what the text is talking about, certain kinds of activities, tasks and questions appear at various places on the page, marked and coloured differently in relation to the rest of the text (see Appendix 4.12 for example). But we should notice here that neither the number of what the text asks the reader to do nor the content of these demands are as massive as they are in the Active Science textbooks. Comparing both kinds of textbooks, the impression the Nuffield Science textbook gives to the reader is that he/she has got a lot of things to read and less things to do. This is also made clear by the overall structure of the textbook which gives priority to the text. The latter appears in one column either on the left or on the right side of the page depending on where the images are placed. This column of text spreads from the top to the bottom of the page giving the impression that what is written is like a coherent story rather than pieces of information which are found loosely connected or even isolated all over the page - as it happens with the Active Science. In that way textual cohesion appears as an important issue in Nuffield Science textbooks since this is what holds each page together as a whole.

The whole structure of the textbook is consistent with its purpose. The Active Science textbook is written in a way that it can be used both as a reference book and workbook in the everyday activities of the science classroom. It is also accompanied by other sorts of materials like worksheets. The entire timetable of a science lesson can be based on the very tightly planned structure of the textbook. For that purpose the latter is addressed both to the individual student and to groups of students. The structure of the text is the same with little or no change in books addressed to students in successive years.

Nuffield Science textbooks look more like a reference book, almost always addressed to the individual student in the second person rather than to a group of students working together. In the same way as Active Science, its series of textbooks are addressed to a whole range of ages. With the exception of the primary school resources, the structure of the textbook is the same regardless of the age range of students to whom it is addressed.

Looking at how the reader (in our case the student) can be possible engaged with the text we notice that in Active Science textbooks there are mainly two ways in which the reader is addressed. The reader is either addressed in the second person in the part of the text which provides the relevant information for the topic or he/she is asked to be involved (either in groups or as an individual) in various activities (answering questions, investigating, observing, planning, e.t.a.). The former is found more frequently in texts written for younger rather than older students. The latter probably because it depends on the structure of the text, does not vary in relation to the age range. The differences between the two ways in which the reader is addressed have as a consequence a different kind of engagement with the text.

To begin with let us take an example of a text which is addressed to the reader as an individual in the second person. The passage below is an extract from the information given on the top of the unit under the title *New cells from old* :

(1) Your cells are dying all the time. Every day about 200 thousand million of your red blood cells die. If you did not make new ones, you would have none at all after six weeks..

(2) Your skin cells also die. You have about seven layers of skin cells which wear away. If new skin cells did not grow, your skin would very quickly disappear.

In this little extract we notice that the reader is realised linguistically as one of the participants which is involved in various material processes. In the beginning the reader appears as the classifier in nominal groups which tell us what sort of cells the text is talking about. It is not clear whether agency is involved in the first two clauses in which the nominal groups *Your cells* and *your blood cells* are the MEDIUM(S) through which the material processes are realised. But in the next two clauses the reader addressed as *you* is the ACTOR which makes new cells - so in respect to ACTORS's action *cells* are the GOALs which are brought into being - and the ATTRIBUTER in relation to it *cells* are the participants which are either possessed or not. The next paragraph of the extract continues in the same way; nominal groups define the identities of the participants which are either the agents or the affected or the one that are possessed by other participants.

What this analysis shows is that due to textual choices the reader is treated linguistically in the same way as the participants that are supposed to be the object of students' study. The reader becomes an interactive participant in the text involved in all sort of processes in which any participant in the text can be involved. This has the effect that the reader now is seen as an entity which is built up by other entities, acts on entities and is affected by other entities' actions, a property discussed in the next section (5.2) as the objectification of the self. The persistent use of the second person in nominal groups which define categories of entities makes clear textual choices which are in contrast with those addressed to older students. In the latter very rarely and in most of the cases marginally only is the reader engaged in the text:

(3) All animals and plants are made up of tiny living units called cells

and later in the same textbook we read:

(4)Advanced organisms (like you and me) are built up from many millions of cells.

In these examples above we notice the differences between the nominal groups, like *All animals and plants* and *Advanced organisms* and those which are chosen in the extracts discussed earlier.

Looking at the places in the text in which readers' participation in tasks like observing, planning and investigating is demanded, we notice that the reader is engaged in a different way with the text. He/she is not now a part of the cast of the participants which are involved in the story the text is providing. Either addressed in the second person as an individual or as a group of students who are working on the same thing, he/she is involved in processes which create a distance between him/her and the entities that are supposed to be studied. If we look at the material processes in which the reader is involved at these parts of the text, we notice that in most of the cases he/she does not interact directly with the entities which have to be studied but through other sort of entities and process-like entities. These are diagrams, drawings, written lists of entities, or carefully planned experiments in which still various devices intervene between reader's actions and the physical world, like precise measurements of entities, procedures which define which entities would interact and under what conditions, even the knowledge about something either obtained as information or gained through the same procedure (experiment) (see for example *How fast does yeast reproduce?* and *What does yeast need to reproduce?* , Active Science 1, Key stage 1, page:100).

All these entities above create also a physical distance in the text between the reader as an interactive participant and the physical world. His/her distance with the latter is realised linguistically in two ways:

a) through a clause complex in which human's agency gets through several steps of processing before it reaches the entities that should be studied and

b) instrumentally in that the reader interacts with entities through processes and participants which become the instruments that carry ACTOR's agency.

If we look at the Active Science textbooks as a whole we notice that reader's interaction with the text as it is described above is the dominant one which surpasses the sort of engagement in which the reader is part of the cast of the participants that make the 'story' the text is saying. So if we consider the overall effect of the relation between the reader and the entities that are supposed to be studied by him/her, we notice that at the end this relation is objectified. 'Humans' are involved through certain process-like and thing-like entities with the physical world. These entities draw a line between the student and its object of study, even if the boundaries of this line are not always very clear. But what is clear is that the relation between the two is not blurred as in the cases in which the reader is addressed as a part of the physical world, an insider rather than an outsider, who is engaged within the natural world and not from a distance. At the end what choices about the text do is to invite the reader to create a text: 'a story about what the world is and how it behaves' by engaging him/her in an 'instrumental' world of entities that keeps him/her in a distance and outside of the physical world.

The case is opposite with the Nuffield Science textbooks. In the extensive accounts of their textual information - compared with the Active Science - the reader is quite often addressed as an individual in the second person. But less often are readers addressed in the inclusive first person (plural). In both these ways, the reader is engaged as the Agent or the Affected in relation to the cast of the participants which are in the story that the text is offering. This relation is realised linguistically in the same way as in Active Science in terms of material processes in which the reader is either the ACTOR or the GOAL and in terms of identifying or attributive relational processes. We also notice that this sort of engagement with what is for the reader the object of his/her study appears in various topics regardless of the age range the text is addressed to.

Looking for example in the Environmental Science section which deals with the concept of habitat from the Co-Ordinated Science, Biology addressed to those students who are at the stage of preparing themselves for the GCSE examinations; we notice that the reader is either identified in relation to the participants that are found in the text:

(5) Perhaps the reason we like warm, dry conditions is that we are still in some ways tropical animals

or he/she is actively engaged with them, by doing things on them or affected by them:

(6) Have you ever weeded a garden? It can be a tedious job but if it is neglected, then the garden plants will not grow so well.

In the Science Year 9 textbook looking at the topic of respiration in living organisms we notice that the reader is again actively engaged in a whole range of processes. This is not only reflected in the text:

(7) How fresh is the air you breath?
The porous membranes lining you lungs are easily clogged up by dust and other particles in the air....

but in images as well. An image which represents all parts of the lungs of humans is labelled as *The structure of your lungs. (Which one is whole?).*

Another way in which the reader is involved in the text as one of the members of the cast of the participants which has a role to play in relation to other entities is by being an entity which is made of other entities and having a size. In respect to the former, part-whole relations are identified with the reader being either a place in which other entities are located or an entity which is located in other place-like entities. When size relations are identified then there is a chance for the reader to become the measure which provides accounts of the size of other entities. Therefore, similarities and differences between him/herself and other entities are now legitimate. In that way the text invites the reader to become an instrument by him/herself which gives him/her an access to the physical world. In Active Science we will probably never see the reader becoming an instrument through which relations are identified. What is the case there as we have seen earlier is that certain processes and measurements which are at a distance from the reader are the instruments which engage him/her with the physical world. Part-whole relations and size measurements are often come together in Nuffield Science making the effect described above more dramatic:

(8) Your body is made up of millions of tiny packages which are only a fraction of a millimetre across

(9) You were once a cell, a tenth of a millimetre across. This tiny cell divided into two and each part divided into two again, and so on, until you were made up of millions of cells. A lot of this happened in the nine months before you were born. (Key stage 3, Year 9)

Notice in the second extract above the effect produced by the use of the past tense concerning the reader (*You were once*). It is not only that the reader becomes an active participant by being identified as an organism made of cells and being involved in various processes; it is also the fact that all these processes are located in a real time sequence, in contrast with the timeless verb structures of the first extract.

For topics in which it is hard to see how the reader can be involved as an active participant it is analogies and metaphors which do most of the job of bringing him/her in the text. An analogy which shows how water passes through the cell membrane of a plant makes use of the reader and his/her first hand experience with the everyday commonsense world:

(10) Here is the theory: imagine that the cell membrane is not a waterproof skin but well aware that a thin jersey is not very waterproof - it easily lets the rain through. But if you go out in a snowstorm, you can keep quite dry. The snowflakes are too big to get through the holes in the jersey.

The analogy is a very accessible tool for the reader which makes him/her think about something that cannot be engaged directly with. This is another sort of useful instrumental relation between the reader and the physical world which is found quite often in Nuffield Science textbooks but very rarely in Active Science. At the end what the analogy does is that it creates a parallel story which has the same script (pattern of relations between the participants) with the story which is the object of students' study. This parallel story gives the chance to the reader to take part as a participant, otherwise he/she could not be involved in any other way.

Finally, we should not let it pass unnoticed that when the reader is engaged in tasks and questions he/she is addressed again in the second person in processes that are realised linguistically in terms of mental processes of seeing and thinking. The reader is engaged with the entities as the SENSER and the entities are engaged with him/her as the PHENOMENON. But the questions and the tasks in which the reader is invited to participate are not so extensive (either in number or in length) as in Active Science, so as a result SENSER and PHENOMENON are in most of the cases in direct contact.

It is not the intention of this section to say which one of the two series of textbooks is better or more appropriate for learning and teaching. Interpersonal aspects in respect to how the reader is engaged in the text are discussed by taking into account the overall structure of texts and specific semantic functions which are used consistently in them. In doing so, the interest of this section lies in the ways in which one textbook is more effective than the other in respect to specific linguistic choices.

The way the Nuffield Science textbooks are written has the opposite effect from the way the Active Science textbooks are written. The Nuffield Science text invites the reader quite persistently to get involved as an entity among other entities. As a result the reader who follows what the 'story' of the text is talking about finds him/herself as a participant of that story, an insider rather than an outsider who is engaged only in an instrumental way with the participants of the story. By being inside the story the reader sometimes becomes him/herself the instrument through which the physical world is approached. In all these ways the text is open to the reader in a different way; instead of inviting him/her to create a text by being involved in a considerable number of activities as the Active Science does, it opens the possibilities to the reader to create knowledge about the physical world from his/her direct relationship with it.

5.1.2 Summary and Conclusion

The interpersonal aspects of transitivity patterns in two series of textbooks (Active Science and Nuffield Science) were the focus of the present section. The role the reader is brought into play is studied in relation to the whole structure of the textbook and the way the reader is addressed within that structure. We can point here at various aspects of the interpersonal metafunction within the framework described above. Texts vary to the degree the reader is addressed as one of the participants among other participants in the text. This raises the question of whether the reader is treated as an interactive participant with the entities represented in texts. Material processes realise interaction between entities and the reader; the latter acts directly on other entities or he/she is acted upon by them.

On the opposite end, the individual can be addressed as being involved in processes which create a distance between him/her and the entities that are supposed to be the object of his/her study. This distance is realised more often by clause complexes of mainly material processes in a way that the reader does not find him/herself in direct contact with entities but always through others. The latter which can be material entities such as scientific instruments or conceptual entities such as theoretical entities or methodological processes eventually carry reader's actions to entities. This relationship between reader and physical world can be described as an instrumental relationship. In rare cases the reader is represented as becoming the instrument by him/herself. This is a step towards further objectification of the 'self', since now the reader is not only found in direct contact with material entities but he/she is represented as being one of them that is a material entity him/herself.

Finally, explicit accounts of metaphors and analogies put the reader in a situation where he/she can be involved directly in the physical world elaborating otherwise inaccessible situations (such as unobservable entities). In particular, analogies become the 'instrument' in the reader's mind which permits him/her to have access to the physical world.

In each of the cases above interpersonal aspects of the relation between textbook and reader have epistemological and learning implications. Knowledge of environmental science is either seen as objectified and impersonal, therefore, learning should be carried on by a number of processes which realise this instrumental relation between the learner and his/her object of study. It is an inevitable consequence that in this case what counts as more important is the application of the 'instrumental relationship' as correctly as possible. That is also why texts which promote this interpersonal dimension insist in the repetition and correct application of methodological entities and the use of instruments. On the contrary where the reader is treated as an 'interactive participant' emphasis is put on how he/she makes sense of the world by realising him/herself as part of it. Action is seen as a valuable learning tool here in realising relations between entities.

5.2 Objectification of the self and personification

5.2.1 Introduction

This section is about the interplay of objectification and personification. These processes are first discussed separately, and it is then shown how in fact they work together, being two related aspects of how teachers can attempt to relate commonsense and scientific thinking.

5.2.2 Objectification

Teachers' references to students as physical entities involved in what is taught about has a double effect. The self is objectified in a way that talks of students themselves as objects, and so suggests that they should think in this way. At the same time familiarity is built up with other entities in relation to which the 'self' is physically involved. Objectification is mainly realised in two ways; textbooks and teachers make direct reference to students in the second person or in the first person plural, and by engaging the 'self' as an entity in processes in the same way as other material and non material entities are. For example in the chapter *Depending on fuels* from the textbook Oxford Science I, processes like eating and respiration involved in the Carbon cycle are represented in relation to human beings addressed as 'we':

Plants take in carbon dioxide gas from the air. They use the Sun's energy to combine this with water and minerals to make new plant material. This process is called **photosynthesis** . We eat plants as food, so our bodies have carbon in them. We get energy by 'burning up' our food, but without any flames! This is called **respiration**. When we respire, we make carbon dioxide gas which we breathe into the atmosphere.
(Oxford Science I, p.108)

In this extract above the human body is objectified to the extent that it is not represented in the same way that we use to know and experience it in everyday life. Eating plants is not just food which satisfies our hunger, but it is also the process in which carbon is transferred from plants to human bodies. Food also is not just stored in our bodies but is burnt up similar to fuel being burnt in machines to make them work. The analogy between the human body and machines even if it is implied rather than explicitly addressed since no mention of machines is made it is explored whether it works or not. The food might be burnt like fuel in order to get the same thing machines get ; energy, but the process of burning fuel is not exactly the same as the process of burning food. This is represented by putting the process in inverted commas and the clarification being accompanied by an exclamation mark, that there are no flames as the result of burning. Then this specific sort of burning which is not the same as what we usually know as burning is given a name *respiration.* Finally even if the process of burning now has a name so other thing-like and process-like entities related with respiration can be discussed by making reference to it, for example by saying that...*during respiration carbon dioxide is made which is released back into the atmosphere* ...this is not an option which has been chosen for the specific textbook. Again respiration is seen from the point of view of the objectified self which is involved in the process of making and as the maker of the carbon dioxide: ... *when we respire we make* CO_2 *gas.* Notice here the difference between the process of making and the process of releasing; in the specific extract carbon dioxide is not represented as a waste product of human body, but as the entity which is made - the action of making directly refer to us as 'we' - and will be used later by plants.

In sum, the objectification of the human body in this little extract above is the result of sustaining its reference to it as *we* in various sorts of relations with thing-like, e.g. *plants, food, carbon , carbon dioxide gas* and process-like, e.g. *eating, burning, respiring, making, breathing* entities. It is not just 'we' who are objectified but a couple of thing-like and process-like entities with which we are related on everyday basis. So *eating* is transformed into a process of getting carbon in the body, *food* turns to be the carrier of carbon, *burning* is transformed into respiration and *breathing* turns to be as taken carbon dioxide gas out of our body into the atmosphere. At the same time familiarity is achieved with scientific entities like carbon and respiration, by engaging them with everyday objects and processes. Plants are made by carbon so eating plants means taking carbon into our bodies. Respiration is not represented as an agentless process remote (which is kept apart) from what we are used to think of as acting. It is 'we' who respire acting directly on an unobservable entity by making it and removing it out of our bodies.

The chapter *Depending on fuels* (Appendix 4.18) was the main source of information for the teaching of Carbon cycles in one of the lessons of the Year 8 classrooms which was video-recorded. The teacher asks the students to reflect on the diagram of the carbon cycle from this chapter which was used in earlier lessons by the students in order to draw pictures of the carbon cycle. Before we see how the diagram is elaborated in the classroom we should notice that one of the main figures at the centre of the diagram is a man connected with arrows with a chicken eating corn on the ground and a label up on the sky which says *carbon dioxide in air.* Both diagram and text impose references to humans in relation with the entities involved in the carbon cycle. In the same way as we saw in the analysis of the text extract above, the discussion between students and teacher addresses human involvement in the first person (either in plural or singular) and the self is represented as objectified after being involved in a series of natural processes directly related with physical entities:

T: *Where's the atmosphere?*
S: *All around us...*
T: *How does carbon dioxide get into the atmosphere?*
S: *We breathe it out/*
T: *We breathe it out. Just us?*
S: *Animals...*
T: *...What's it[carbon dioxide] doing in our lungs?*
...We breathe out more than we breathe in. We're adding to the carbon dioxide in the air every time we breathe out. Something's going on in out bodies that's making carbon dioxide...

(Lesson: Carbon cycle p.9,10)

In this extract above the location of the atmosphere is given in relation to human presence. The latter is represented as an entity which is part of the natural world and interacts with other entities. Schematic structures like containment relationships and agent structures are the realisations of the objectification of the 'self'. Human beings are represented as contained within the atmosphere. At the same time they are represented as the makers of carbon dioxide, which is brought into being in their bodies. They also see themselves as the agents which transfer carbon dioxide from one container to another; breathing into the atmosphere more carbon dioxide than they breathe in their lungs. All this sequence of agent structures which addresses an unbroken continuity between the self and thing-like or/and process-like entities is taken as unproblematic. The process of objectification is also represented by the fact that both humans and animals are considered in the same way as instances of the category of living organisms which release carbon dioxide into the atmosphere. At the same time and in the same way as we saw above with the piece of textbook, familiarity with entities which belong in the realm of scientific knowledge is gradually established:

T: *Animals eat the plants so now the carbon dioxide that was used to make the food has been incorporated into that food. Now the carbon's got into us /*
S: *.... /*
T: *Just a minute, why do we need food? /*
S: *to live... /*
T: *Well be a bit more specific /*
S: *energy /*
T: *For energy is one reason we need food. How do we release that energy? /*
S: *....by breathing in /*
T: *By breathing in which gas /*
S: *carbon....ox.. /*
T: *Oxygen. Right, we breathe in oxygen. The oxygen and the food react together and change, releasing energy and also releasing the /*

S: *carbon /*
T: *Carbon dioxide and we breathe it /*
S: *Out /*
T: *No, the oxygen I just breathed in is probably still going round in my blood stream and the carbon dioxide I'm breathing out is from some oxygen I breathed in a little while ago. Right, OK, so the animals breathe out carbon dioxide during the process that we call res /*
S: *res... /*
T: *Respiration [ ] good and that's the process where we release energy from the food that we've eaten by breathing in the oxygen, the oxygen goes all round our bodies in the blood stream.*
T *Get's to every little part of us every cell, every brain cell, every cell in my big toe down to my finger tips, round to my back, up to my shoulders. The oxygen goes all round to every cell and reacts with the food that I've digested to release energy.*

(Lesson: Carbon cycle, p.11,12)

The human body is not only taken to be the place within which unobservable entities interact with each other and chemical processes take place, but it is also the Agent which acts directly on unobservable entities like carbon dioxide and controls processes like digesting food and releasing energy. It is interesting to notice that in this extract human agency is stressed to such an extent that the reality of unobservable thing-like and process-like entities is shifted onto the level of the reality of everyday entities, like food and therefore becomes unasked and obvious.

5.2.3 Narratives afford personification

Personification stands on the opposite side of objectification. It is now the natural entities which are represented as closer to 'us'. In that way personification affords relationships between entities which cannot occur otherwise, such as attributing living properties of intentionality to them and engage them in developmental (evolutionary) processes.

Let us take for example an extract from a lesson, illustrated before ((12) in section 7.3.5) as an example of a passive blockage where two sequences of agent structures meet each other in an opposite direction, during which the teacher represents a specific sort of pollution; the devastating effect the excessive amounts of fertilisers have on the environment when they are washed into ponds:

T: *The leaves fall off the leaf yeah. The leaves fall off the tree ..... the leaves will fall off the tree, what happens they get broken down, the nutrients will go into the soil next season all that nutrient will make the tree grow again, all the weeds that will die the nutrients will go into the soil so you get that cycle of nutrients going round all the time. Here, exactly the same thing happening* *and everybody lives happy ever after, the sun is shining. What effect has that got? Er sorry....*

S: *.... the plants ..*

S2: *Photosynthesis*

T: *Photosynthesis. Right, so the plants now can make food. They can take in nutrients, they can grow. What else do they do?*

S: *..... air*

S2: *.....*

T: *They release oxygen into the water. What else will they do?*

Ss: *Take in the carbon dioxide*

T: *Take in the carbon dioxide because its ... will be releasing carbon dioxide into the water. Plants will be releasing oxygen into the water. ...... he needs the oxygen the plant needs the carbon dioxide so as soon as the carbon dioxide level begins to rise ... the plants will take it up. As the oxygen level begins to rise the animals in the lake, animals in there will take it up. So there's balance all the way through and everybody lives happily ever after, until one day*

S: *Farmer Bloggs*

S2: *and his cattle*

T: *Farmer Bloggs comes along*

S: *...*

S2: *yesterday....*

Ss: *....*

T: *He comes along because he decides it's about time he scattered some fertiliser on his patch on the side of the river. The sun disappears from the riverbank and we've now got a nasty cloud has to climb over the top here the water vapour condenses down it comes as rain and that obviously dissolves the fertiliser. The fertiliser gets*

S: *Leached*

T: *Leached from the soil. Some of it will run off etc ...that* to go into the pond so *now we have an increase of nitrates, phosphates*

S: *....*

T: *and potassium in the water. The plants themselves think that this is great, because there's nothing better than plenty of food. They've got the best conditions they've got plenty of food and they're going to lap it all up. And they are going to grow like mad. However, as we mentioned earlier, they are these little small green little things that were floating on the surface called*

Ss: *Algae*

(Lesson: Nitrogen Cycle, p.2)

In this extract we notice that the teacher represents what happens around the pond in the context of a story. As it has been discussed in section 7.3.2, stories such as the one above have a plot and thing-like entities are the active participants which share certain roles in this plot. Each participant is not independent in the specific story but its action depends on or brings about other participants' actions. In that way agency is stressed because each agent's action seems inevitable and there is no place for accidental actions. Even an event which might pass unnoticed in the context of teaching science *the sun is shining*, here has a specific effect: plants can make food due to photosynthesis. A *nasty cloud* which can be thought of as an entity which should have no place in scientific talk, in the plot of this story is represented as an active participant which climbs over the top of the pond and triggers a process -

represented as scientific this time *the water vapour condenses down it comes as rain...* So in this story the students are confronted with some thing-like and process-like entities that might not be expected in a 'scientific story', but are being put in the context of talking science. Properties and behaviours of living organisms, like human beings and animals, are attached to plants representing them more alive than we thought they were. These are intentions:

T: *Take in the carbon dioxide because its ... will be releasing carbon dioxide into the water. Plants will be releasing oxygen into the water. ...... he needs the oxygen the plant needs the carbon dioxide so as soon as the carbon dioxide level begins to rise ... the plants will take it up.*
(Lesson: Nitrogen Cycle, p.2)

and desires:

T: *and potassium in the water. The plants themselves think that this is great, because there's nothing better than plenty of food. They've got the best conditions they've got plenty of food and they're going to lap it all up.*
(Lesson: Nitrogen Cycle, p.2)

Plants also seem to be as active as animals and humans due to the intensive use of agent structures in which they are involved as Agents. These agent structures are of those kinds that animals and humans are involved too, like making *...so the plants now can make food* and transferring entities from one place to another *They can take in nutrients...They release oxygen into the water... Take in the carbon dioxide* . The cyclic, repetitive character of these actions leaves no doubt how important is all this repertoire of roles which the plants have for the story's plot. Plants and animals are seen as the agents which keep in balance everything that happens in the pond. Nevertheless, the story has prepared the ground in what can be seen as an unexpected overturn. The participants are represented as powerful enough so that even a little cause which upsets all this well orchestrated balance of actions can have an enormous effect. The fertiliser dissolved by rain is washed into the pond and causes plants like algae to grow very quickly on the surface of the pond:

T: *So, in no time at all these plants are all flourishing very well but in not time at all so do the algae. And they're growing like mad on the surface of the water, and in no time at all they form a blanket over*
S: *over the land*
T: *the whole pond. And immediately that cuts out the sunlight. No sun?*
S: *No photosynthesis*
T: *No photosynthesis. The plants down here cannot make food.*
S: *They don't .... oxygen*
T: *They die, because they've died they don't?*
S: *Make oxygen*
T: *make oxygen to put back into the water.*
S1: *....*

S: *....chain reaction*
T: *No oxygen being put into the water means the fish*
S: *die*
T *would die. Also added to this, because the amount of dead stuff at the bottom will now increase very quickly, so will?*
S: *Nitrates*
S2: *Nitrates*
T: *The bacteria*
S: *.... nitrate ...?*
T: *Because now there's a lot of food for the bacteria. The bacteria are living things so what will the bacteria*
S: *....*
T: *use up?*
S: *... erm*
S: *Oxygen*
T: *They will use up the oxygen. They will produce?*
Ss: *Carbon dioxide*
T: *Carbon dioxide and before you know it, you've come across puddles ponds etc where you get the weeds across the surface right they can still flourish because they've got sunlight on the surface. But you move that and you can smell the stench coming up from there. That now is totally dead.*
(Lesson: Nitrogen Cycle, p.4)

The initial cause leaves no alternative effects. The relationships between Agents and the processes that they cause, have been linked so tightly that now if any process is disturbed, that disturbance has a definite effect back on other agent or affected entities:

-if the sunlight is cut photosynthesis does not take place
-therefore plants cannot make food
-without making food plants die
-dead plants do not make any oxygen
-without oxygen being put into water fish die
-dead stuff at the bottom of the pond means that nitrates are increased
-more nitrates cause more bacteria to develop
-more bacteria take in more oxygen and produce more carbon dioxide
-with most of the oxygen used up without being put back into the pond the latter dies

At the end we notice that the entire pond is represented as a living entity by attaching to it a vital property that only living organisms have: it dies. The personification here implies that the pond is a living system because it sustains a number of processes which are kept in balance. These processes support various forms of life and without them these forms of life will cease to exist. So the pond is the superordinate entity and the Whole, and its Parts, the subordinated entities, which are nested within it are processes of life. The Whole obtains living properties because its Parts are living. It is very important that the amounts of some entities in the pond are kept at a certain level, otherwise the balance is upset and processes cannot be sustained any more. So in the same way that an organism dies if it is starving from oxygen, the pond dies as well, since it cannot support any life process.

Pond here is realised as a living entity (a living system), rather than a simple container. Personification works out the ontology of entity like image schemata. As it has been discussed in section 7.4.2.2, containment relations are primarily thought of as working out the nature of entities due to their property to impose boundaries and represent them as discrete from others. The difference between the pond represented as a container and its representation here is that personification transforms the entity into a system of relations which sustain it as one whole 'thing'. Like the metaphorical extension of containment relations it is because of co-ordinated agent structures that the parts are bound together into one whole entity so as the latter can be now considered as a living entity separated from others.

5.2.4 Analogies afford personification

Personification can be addressed through explicit analogies as well. The teacher who introduces new terms to students for living organisms which are seen in a different way, as parts of the food chain is assisted with analogies from the realm of labour relations in our everyday life:

T: *So green plants then make the food. If somebody makes something what word would we*
S: *Creating*
S2: *Produce*
T: *Produces. So here we have what is actually called within the food chain the producers. Right. They produce the food. They make the food it's like factories, factories make things so we say factories produce right. Here green plants make food using energy from the sun so we've call them producers. When something that's been made by a factory they've produced it they will take it along and somebody would sell it. You may come along you will buy it you are a?*
S: *Consumer*
S2: *Buyer*
T: *A consumer*
S: *Consumer ..*

(Lesson: Food chain, p.10)

Producers thus plants are seen as factories which make things by using raw materials. In the same way factories' products are addressed to consumers, other living organisms get what the plants made by eating them. The role of plants as producers and their contribution to us as consumers is overemphasised to the extent that the former are seen as necessary for the survival of the latter, in a way that plants are labourers who 'work' for the benefit of humans:

T: *The excess oxygen is released back into the atmosphere, the extra oxygen is released, the oxygen that's not required is released back into the atmosphere. So now you we start looking at green plants in a different light. They provide us with food, it doesn't matter what we eat the energy that's in that food will have eventually been trapped by green plants, so they provide us with energy they also clean up the atmosphere for us they take the carbon dioxide the stuff that we produce that we don't want slightly poisonous for us so we get rid of it they take it out of the atmosphere so they clean up the atmosphere for us. Also, they put oxygen back into the atmosphere oxygen which we cannot live without, so not only do they provide us with a means of trapping energy from the sun so that we can we use it, they also recycle the gases so we can get rid of the carbon dioxide taking oxygen.*

(Lesson: Food chain, p.10,11)

Agent structures which are usually used to represent activities of people, like *they provide us with food, they clean up the atmosphere, they recycle gases* are now used to represent plants' actions. As a result the personification of plants brings them to a position equally important to ours. Power relations between plants and humans work in both ways, from humans to plants and from plants to humans. We have the power of using plants' labour for our survival - even if this is represented here without cost from the part of the consumer - but on the other hand if plants stop working then we cannot do what they do by replacing them so our survival is seriously threatened. At some points this relation is seen as a relation of mutual interdependence and solidarity; plants need us in the same way as we need them *they also recycle the gases so we can rid of the carbon dioxide taking oxygen.* Plants' role in the overall food chain is overemphasised and their contribution to it is seen as cruelly neglected from a human's point of view:

T: *We do it even ... right you .... plant ... a potato and you pull it up by its roots and you nick its food supply, it has worked all the way through the summer to store its preserve of food down in the potato underground so that when conditions get bad in the winter and it dies it's now got energy stored underground so when conditions get favourable next year it can grow again. Oh no, we come along and nick the whole lot and we use that as our energy supply.*

(Lesson: Food chain, p.11)

Finally, the whole argument is used back again by the teacher to make an ethical point; thinking how cruel is to kill and eat animals does not mean that it is less cruel to use plants as our food supplies.

In section 6.3.2.1 we have seen how material processes of doing and making represent and realise plants in the same way animals are realised. In the example above it is noticed that personification moves one step further in plants realisation as animate entities. It is not now just the sharing of the same grammatical and schematic structures which brings plants and animals, humans nearer to each other, but the fact that the two realms of entities exchange goods between them. The latter relation draws from the world of everyday exchanges between people, and as a result brings with it further implications about how the relation between human beings and plants can now be realised. These implications turn to be ideological implications such as fair trade, underpaid labour e.t.c. which can raise ethical questions. But it should not be underestimated the fact that the personification is able because it is grounded in common patterns of agency that both plants and humans share.

5.2.5 Discussion

So far mainly three aspects of the exchange of meanings between student and teacher, textbook have been discussed. These are:

a) the process which can be from less to more direct in which the reader/hearer addressed as 'you/we' can be seen as part of the same grammatical structures which represent scientific knowledge (Appendix 5.1),

b) the reader/hearer seen as being part of image schemata such as agent structures and containment relations and finally

c) the student being part of a story or/and in a position of saying stories (narrator).

The emphasis in the present section is on the implications the decrease or increase of the distance between the 'knower' and entities from the world have on the representations of both.

In this part of the thesis, it is underlined that it is not just the 'self' as a single entity which is either objectified or personifies other entities, but a whole range of thing-like and process-like entities which are part of the self or surrounds it. So at the end it is not single entities but a whole range of relations which are objectified or personified. This is realised by the same image schemata and grammatical structures which are shared by two entities belonging into different realms of experience. It is important to notice here that in this process of 'sharing', the ontology of each entity (that is its nature) is worked out in a rather silent way. It is also this aspect of 'sharing' which brings not one entity against another with a purpose to compare them and see how far they are similar or different, but their relation is realised as one of continuity. According to the latter, what counts is (due to the extent that the two entities share the same schematic and grammatical structures) how far one, starting from one entity, can go in order to reach the other entity. That is why the relation between the two is represented here as one of a distance between them. See it in that way personification and objectification turn to be two opposite ends of the same process. Both result to the reduction of the distance between the self and other entities. So at the end it is a matter of point of view really whether a relation will be looked from the point of view of the self which is objectified or from the point of view of the entities which are personified. This also means that irrespectively from which point of view the relation is looked at it is an interaction between the two realms of entities and implications occur to how we realise both of them. Again here interaction reminds us of Black's view about metaphor who insisted that in metaphor one subject brings a change to another without the metaphor being a one way relation between them. Notice that by the term 'subjects' (primary and secondary) Black (1962) means 'systems of relationships' and not just single thing-like entities, as it has also been pointed emphatically in the beginning of this paragraph.

5.2.6 Summary

Objectification and personification as they have been discussed above work in opposite ways but they are heading at the same direction. While the latter brings scientific entities closer to the subjective 'self' the former brings the subjective 'self' nearer to scientific entities. But in both cases the result is the same; the distance between the 'self' and the object of the inquiry is reduced. As a result, the scientific world of entities is represented as more accessible and familiar than it might be thought at the first place. Unobservable entities seem more real and less problematic for the commonsense thinking. On the other hand some very different aspects of the objects of the commonsense knowledge are highlighted when they are looked in a different way through the prism of the scientific thinking.

Thing-like and process-like entities which belong in the realm of scientific knowledge can be seen in terms of entities which belong in the world of commonsense knowledge, and the other way round; the commonsense can be seen in terms of the scientific. This two way process is realised mainly by the fact that both commonsense and scientific entities share the same kind of schematic realisations: containment relationships and either stressed or suppressed agent structures of bringing something into being (making), transforming and transferring. The result of this sharing is that both kind of entities are found in continuity where one acts on another or is affected by the other or being part of the other. This continuity among entities entails relationships between them which could not been permitted otherwise (by holding the two realms apart). Personification and objectification form a safe way to create an interplay between science and commonsense understanding, which can both help students to understand, and can keep or arouse their interest.