THE ROLE OF EXISTING KNOWLEDGE IN READING COMPREHENSION AND CONCEPTUAL CHANGE IN SCIENCE EDUCATION

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ABSTRACT

Recent research in science education has illustrated that students, prior to formal science teaching, have constructed for themselves interpretations of and explanations for many natural phenomena, and that these beliefs may persist despite up to five years of science tuition. The research has also demonstrated that these beliefs, which are part of a student's existing knowledge, are an important factor in determining what learning, if any, will occur. This has led to the development of a view of learning in science as conceptual change, rather than concept acquisition, and as an active, constructive process rather than a passive, absorptive one. This view (and in particular the generative learning model) has been adopted in this study.

A parallel development in reading research has also emphasised the role of existing knowledge in reading comprehension and a view of reading comprehension as the active construction of meaning.

The current research spanned both these two related fields of reading comprehension and conceptual change in science education and focused on the role of existing knowledge in both processes. In particular, it investigated the role of existing knowledge (for example, the everyday meaning of 'animal') of some 13-year-old students in comprehending a text about the scientific concept of <u>animal</u>, and in what ways this influenced conceptual change.

Three different methodologies were used - one in each of the three phases of the research programme. These were the qualitative interview techniques (the 'spot-the-mistake' and 'reading-to-learn' interviews) and quantitative survey measures.

The findings gave further support to a constructivist view of reading comprehension and conceptual change, and a strong interactionist view of reading comprehension was suggested, as existing knowledge not only contributed to the constructed meanings, but influenced what constructions were made.

The main finding was that existing knowledge was used not only to construct a meaning but to evaluate it in terms of whether to accept or reject the construction. Learning in science, therefore, involves not only the construction of the intended meaning, but accepting it as well. Learning difficulties may occur at either the construction or acceptance stage. The results suggested that in science education, students' difficulties in accepting a scientific construction may be as great as, if not greater than, those in constructing the scientific conception itself.

The implications of the findings for teaching and learning, the curriculum, reading in science classrooms and textbook authors are discussed in the final chapter.

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CHAPTER 1 : AN OVERVIEW

1.1 INTRODUCTION

Before they start their schooling in a formal way, children have constructed for themselves intuitive interpretations of and explanations for many natural phemonema. Recent research in science education has documented the nature of some of these beliefs (Archenhold et al, 1980; Gilbert, Osborne and Fensham, 1982; Driver and Erickson, 1983; Osborne, Bell, and Gilbert, 1983). For example, many students have an everyday concept of animal, in which only the large, four-legged, furry, terrestrial creatures such as a cow, dog, and lion, are considered to be animals (Bell, 1981a).

These beliefs appear to persist despite formal science teaching (Bell, 1981a), and would appear to be an important factor in determining what learning, if any, will occur. In recent years, the view of science learning as requiring conceptual change, rather than concept acquisition, has been receiving increasing attention (Posner, Strike, Hewson and Gertzog, 1982; Hewson, 1981a, 1982; Cosgrove and Osborne, 1985).

Research into reading comprehension has also emphasised the role of existing (or prior) knowledge. What a reader already knows appears to influence what specific meaning she or he will construct from a text (see chapter 2.3).

This present investigation spanned both these two related fields of reading comprehension and conceptual change in science education, and focused on the role of existing knowledge in both processes. In particular, it investigated the role of the existing knowledge (e.g. the everyday meaning of 'animal') of some 13-year-old students in comprehending a text about the scientific concept of animal and in what way this influenced conceptual change.

1.2 THE NEW ZEALAND SCIENCE SYLLABUS AND THE CONCEPT OF ANIMAL

The concepts of living things, animal, and plant are basic to a study of biology from both a structure and function, and an ecological perspective. The New Zealand Primary-to-Standard Four Science Syllabus and Guide (1979) lists these three concepts as worthy of attention for children of 5-11 years. However, the specific ideas listed include only:

'Living things can be either plant or animal' (Level 1, 5-7 years)
'Green plants make their own food' (Level 2, 6-9 years)
'Green plants convert light energy to chemical energy' (Level 3, 8-11 years)
'All animals are dependent on green plants for food' (Level 2)
'Some animals are dependent on other animals for food' (Level 2)
[p.60, 61]

The distinction between plants and animals on the basis of their mode of nutrition is not emphasised, and hence the scientific meanings of the words 'plant' and 'animal' are not given. In the lists of associated skills are:

'Classify living things according to one attribute' (Level 1)
'Classify living things according to two attributes' (Level 2)
'Classify living things according to three attributes' (Level 3)
[p.60]

No mention is made of what these attributes might be, although the scientific distinguishing characteristics of growth, nutrition, reproduction, movement and sensitivity are embedded in the lists of ideas. Interestingly, a Level 2 skill listed is:

'classify animals according to habitat, body covering, food, life cycle, locomotion'. [p.63]

Whilst these activities may help pupils to develop skills of categorisation, they may equally well help to reinforce the intuitive or everyday concept held by many children (Bell, 1981a). In addition, no explicit mention is made that the named groups of humans, mammals, fish, birds, insects and frogs are also animals, and that grasses are plants. Therefore, whilst acknowledging the educational importance of the concepts of living, animal, and plant, this syllabus does not directly promote the teaching of the scientific meanings of these three words.

The biology in the Forms 1-4 (ages 11-14) Draft Science Syllabus (1978) is very much orientated to ecological studies and does not differ significantly from the official version (1967, 68). The ideas included are groupings of living things, producers, food chains, adaptive features, interdependence (Level 4, age 11-12); and biological classification, distribution, trophic groupings, food chains and webs, energy flow in the living world, adaptive features, and animal, plant and decomposer nutrition in terms of photosynthesis and digestion (Level 5, age 13-14).

This 1978 Draft Syllabus and Guide does not explicitly suggest the teaching and learning of the concepts of living, animal or plant, nor their revision, although the ideas of producer and consumer are mentioned, as is that of the classification of living things. However, as these three concepts are explicitly mentioned (although ineffectively) in the primary science syllabus, and as 11-14-year-old students do know of these concepts (although not in the intended way), there is little to encourage an intermediate or secondary science teacher to include a teaching unit on these three concepts.

Dissatisfaction with the emphasis on the ecological concepts in the Forms 1-4 syllabus (1967, 1968, 1978) had been voiced by many in science education and researched in the exploratory phase of the Learning in Science Project (Freyberg et al, 1982). Concern was expressed that the ecological concepts were too abstract for the students, and that students often lacked the prerequisite knowledge of different kinds of animals and plants to cope with the abstract and superordinate concepts of ecology, for example, energy relationships. The biological aspects of the indepth phase of the Project (see Stead, 1980) highlighted that many intermediate, secondary and tertiary students do not have or tend not to use, the biological concepts of living, animal and plant in a scientific context, arguing the need for their specific inclusion in the curriculum. Teaching and learning activities were developed and evaluated in the action-research phase of the project (Boe, Cox, and Bell, 1981). While the findings and publications of the project are increasingly being used by science teachers in New Zealand, the official syllabus has yet to incorporate them. Hence, it is probable that many 13-year-old students in New Zealand, although they have met and used the word 'animal' in science lessons, may not have had specific teaching on the concept. They tend to have and use an everyday meaning of the word and not the scientific one (the distinction between the two meanings is described in detail in Section 2.4.2). Moreover, teachers' use of the Learning in Science Project materials in other countries, tends to suggest that the problem is certainly not unique to New Zealand.

A FRAMEWORK FOR THIS STUDY

As mentioned, this investigation spanned both the two related fields of reading comprehension and conceptual change in science education, and focused on the role of existing knowledge in both processes. Throughout the investigation, comprehension and conceptual change were viewed as constructive processes in which a person actively generates links between the text stimuli and her or his existing knowledge, to construct a meaning, as suggested in the generative learning model (Wittrock, 1974; Osborne and Wittrock, 1983). The generative learning model also suggests another role of existing knowledge - that of the evaluation of the constructed meaning. The use of existing knowledge in both the construction and the evaluation of a meaning for the text was of central concern to this investigation.

Possible ways to promote generative comprehension and conceptual change, as suggested in the literature, were taken into account in the texts used in the research, and their effectiveness was evaluated.

Relevant research on reading comprehension, and on learning in science education is reviewed in Chapter 2.

The research design is outlined in Chapter 3, describing both the qualitative and quantitative methodologies used.

In Chapters 4, 5 and 6, the results are documented and discussed.

Lastly, the overall conclusions and implications are discussed in the final chapter.

CHAPTER 2 : A BACKGROUND TO THE STUDY AND A REVIEW OF THE LITERATURE

2.1 READING IN SCIENCE EDUCATION

Students are required to understand written information in most science lessons. They may be asked to read:

experimental instructions, procedures, results;
extra factual information to that given orally in class;
revision information, e.g. summaries, outlines;
written exercises, e.g. worksheets, crosswords;
copied notes;
exam and test questions;
homework instructions;
diagrams; or
labels and instructions on equipment.

The written material may be presented on:

the blackboard;
the overhead projector;
a wall chart;
teacher written cyclostyled sheets, or in
published books or textbooks.

It is common at the secondary and tertiary levels for students to be required to learn through reading a science text. However, students may have difficulty reading science texts. Two sources of information as to the nature of these difficulties are the comments of people involved directly in science education, and the findings of previous research. Each of these sources will be explored in turn.

2.1.1 Some teachers' and authors' views on reading difficulties in science

Sixteen science teachers, five reading teachers, and seven authors were asked what they saw as the relevant issues in reading in science. A full account of the interviews and correspondence is given in Bell (1981b). A summary of the main issues raised is given here, with a few representative quotations to illustrate each of the key issues.

First, many acknowledged the use of reading to learn in science. The purpose of an extended reading to learn task may be to provide background information on a topic; additional or extension information; practice or reinforcement work; or summaries and reviews. Many teachers expressed a wish for reading material that students can read without assistance, since students may be required to read science material when the teacher is absent from the classroom because of illness or in-service training, for example; for homework; and to supplement the teacher's classroom input. However, many science teachers felt students are unable to be independent readers as they have difficulty in comprehending the available reading material. Many of the suggested reasons for this were text-based, such as:

The words used by the author

The scientific terms

'The (they students) don't know what "stalactites" mean or... "geometrical" or..."crystal lattice".'

[Science Teacher]

Scientific words with dual meanings

'The actual vocabulary itself...it's just not the technical vocabulary, it's a specialised, scientific vocabulary. The words have meanings in general use as opposed to scientific use.'

[Reading Teacher]

Non-technical words

'...third formers have difficulty with a word such as "hazard". They wouldn't know what "hazard" meant. "Exterminate"...'

[Science Teacher]

The style of writing was another factor. Science texts may be difficult to comprehend because they are typically:

Expository

'On the whole, they [science texts] have to be expository, because it's the nature of the subject. They [the students] find it dry and because it's not narrative, they tend to say that it's boring...it doesn't relate personally to them.'

[Reading Teacher]

Impersonal

'I would like to write a text in the first person...unfortunately I have been unable to convince publishers.'

[Author]

Concise

'...the dilemma of concise and fully expanded writing. Two choices one has is to keep the total amount of printed material to a minimum by writing economically - and running the risk of student's not being able to understand the text because too much background knowledge is taken for granted, or too many ideas are linked together in one sentence.'

[Author]

Have complex sentence constructions

'...kids do not like passive structures. So any sentence which is an inverted sentence, which is so sophisticated, is difficult for average to lower readers.'

[Reading Teacher]

And are conceptually dense

'And I said to them, "What do you like about this book?" and they could tell me specifically that it didn't rush on to new things all the time...that you kept getting the same information being presented in different ways...'

[Reading Teacher]

However, the text is only one factor that contributes towards students' difficulties in comprehending science texts. The reader's cognitive processes are also important in reading comprehension and learning. Examples of these were mentioned by teachers:

The students' understanding of the concepts mentioned in the text

'I mean, people have tried to simplify it as much as possible... but you can't make the concepts easier.' [Reading Teacher]

The existing knowledge of the readers

'But I think that's one of the big problems - that science texts, even very simple looking science texts, presume this tremendous background...'

[Reading Teacher]

Constructing a meaning of the text

'Often they can read the words but it's putting it together so it means something to them. They read the words like it's deciphering the code and the sentence doesn't hang together.'

[Science Teacher]

Reading strategies and skills

i) Rate of reading

'We try to make the point that in science, as in anything else, you vary what you read - the way in which you read - what purposes at the moment, for instance, I'll be doing skim reading, reading quickly with science classes but making the point that it's for specific things - it's not something you do all the time.'

[Reading Teacher]

ii) Word skills

'...take the word "hydrolysis", we discussed the word "hydrolysis" in the fifth form this morning. "Hydro" means water and "lysis" means sort of to break up. They got that, it was no longer a strange word.'

[Science Teacher]

In summary, some science teachers and authors commented that:

1. secondary and tertiary students may be asked to learn by reading in science education, often independently of the teacher;
2. many students have difficulty comprehending science material; and
3. possible reasons for these difficulties may be text or reader based, although most comments related to textual problems.

2.1.2 Reading difficulties in science from the research perspective

The above summary is mirrored in a review of research in reading in science education. Gould (1977) found that pupils were often expected to use the text as a source of information, in 42 percent of the observed biology lessons with teaching support, and in 12 percent without teaching support. Mann (1981) found that the main use of textbooks was when the teacher was absent or for homework. Davies, Greene and Lunzer (1980) reported that approximately 10 percent of the learning modes of 14-year-old British students and 9 percent for 11-year-old students, was reading. As Witte and Otto (1981) commented, much of the research on reading in science has been concerned about investigating student reading difficulties in terms of text analysis. Such studies include those on the style of scientific writing - Smith (1972), Rosenblum and Markovits (1976), Eisenberg (1977), Knutton (1983) - and those on the readability of science materials and suggestions for rewriting them to improve readability and comprehension - Mallison (1972), Gould (1977), Dilena (1978), Ricker (1978), Thomas (1978) Greene and Szabo (1979), Holliday and Braun (1979), Howe and Early (1979), MacDonald (1980), Reid and Miller (1980), Davies, Greene and Lunzer (1980) Walker (1980), Wright (1982), Bell and McGrath (1983).

Suggested solutions to reading problems in science often centre on the teacher activity of integrating developmental reading instruction in science classes. That is, students are helped to develop more effective reading and study skills. Examples of such research are Mallison (1967), Shepherd (1969), Smith (1970, 1972), Thelen (1976, 1979), Davis (1977), Cohen and Poppino (1978), Ekwall and Milson (1980), and Davies, Greene and Lunzer (1980). However, Greene and Szabo (1979), Thelen (1979) and Wright (1982) noted, that reduced readability of texts and increased use of study skills may not automatically result in increased learning from the text.

Recent research in reading comprehension and in learning in science science education (reviewed in Sections 2.3 and 2.4) suggests that an important factor in reading comprehension and learning is the existing knowledge of the reader/learner. There are, however, few studies in the literature which specifically consider the role of existing knowledge in reading in science education. One example is the study by Adejumo and Echindero (1980) which investigated the use of advance organisers to enhance learning from texts. This study promoted the idea that appropriate knowledge added to the students' existing knowledge, would increase learning by reading. While many of the studies investigating the role of existing knowledge in conceptual change in science education are applicable to the written as well as the spoken word, often only the influence of the spoken word has been investigated.

2.1.3 Summary

Both practitioners and researchers have expressed concern about the difficulties students have in reading to learn in science education. While both text and reader-based factors are felt to contribute to the difficulties, only the text-based factors have been described to any extent in the literature on reading in science education. Reader/learner based factors, particularly the role of existing knowledge, have, however, been more fully researched in the general area of reading comprehension, but not specifically in science, and in learning in science but not related specifically to reading. Relevant studies in these areas will be reviewed, following a section on definition of terms.

DEFINITIONS OF TERMS

In this section definitions or meanings for key terms used throughout the study will be given and elaborated on.

2.2.1 Text

The word 'text' is used to refer to any written or printed communication. In educational settings, it may be teacher- or pupil-written words or published textbooks. As Spiro (1980a, p.250) points out, expository texts are used to contribute to the growth of the reader's existing knowledge of the text's topic, and not merely for communication.

2.2.2 Existing knowledge (also called prior knowledge)

This term refers to the knowledge constructed and stored by a person in her or his working and long term memory, at the time of comprehension or learning. The adjective 'existing' is used, rather than 'prior', to indicate that this knowledge is theoretically available to a person for use at the time of comprehension and learning. It also conveys the idea that the knowledge is continuous in time and not discontinuous as the term 'prior' suggests. The adjective 'prior' begs the question 'knowledge prior to what?'.

There have been many descriptions of what this knowledge is. For example, Gagné and White (1978) distinguish between networks of propositions, intellectual skills, images and episodes. Trabasso (1980), in a discussion of the knowledge required by a reader to make inferences during reading, lists conceptual knowledge, knowledge of text structure, knowledge of social interaction and human intentionality, and knowledge of causal relations between events. There is also knowledge of language and its use, for example, syntactic, lexical aspects of language as well as pragmatic areas such as the distinction between given and new information (Clark and Clark, 1977) and cooperating principles (Grice,1975). Hence, existing knowledge refers to conceptual knowledge, procedural knowledge (rules for action), world knowledge, linguistic knowledge, social knowledge and memories of specific events and experiences. Associated with all of these different kinds of knowledge are the connotative and affective aspects, that is, the associations and feelings experienced and connected with an aspect of knowledge. In this investigation the conceptual knowledge of the learner is given central focus. But it is acknowledged that it cannot be isolated and disassociated from other aspects of the learner's total knowledge.

The view of the nature of knowledge adopted in the present investigation is in keeping with that advocated by Kelly (1955) and Pope and Gilbert (1983). Knowledge is not seen as 'absolute truth' that can be directly transferred or transmitted by the teacher to be passively absorbed by the student. Rather, knowledge is seen as 'personal' and 'private', and is constructed by each student for herself or himself. Knowledge, as it must be constructed by each person, exists only in the minds of people. Language, either written or oral, is a way of negotiating and sharing personal meanings. The print on a page guides and leads to the construction of meaning.

2.2.3 Concepts

Gilbert and Watts (1983) have analysed the ideas on concepts underpinning recent studies in science education. These are:

1. The classical view of a concept in which all instances of a concept share common properties and which are necessary and sufficient to define the concept. This view is discussed by Stead (1980, pp 9-17). It implies that when a student does not use the scientific concept, say of animal, the student's existing knowledge is flawed, lacking, or contains an error of misconception.
2. The actional view of a concept in which concepts are seen as active, constructive and intentional ways of organising experiences. Research in science education based on this view of a concept seeks to elicit a student's personal knowledge as distinct from public knowledge, for example, a consensus scientific view. In agreement with the views of Kelly (1955), people are seen to generate their own individual conceptions for phenomena. Where the personal meaning of a student is different from the consensus and public meaning of the scientific community, the difference is not viewed as a lack or deficiency but as the result of a commonly occuring natural developmental process.

These personal meanings have been termed 'alternative frameworks' and 'alternative conceptions' (Driver and Easley, 1978), 'gut science' and 'lay science' (Claxton, 1984) and 'children's science' (Gilbert, Osborne and Fensham, 1982).

3. The relational view of a concept which is seen as intermediary between the classical and actional view. In here is placed the work on family resemblance, natural categories, and prototypicality (Rosch, 1973; Smith, Shoben and Rips, 1974). Although the ideas of examplars and distinguishing characteristics are used, the notion of 'fuzzy' concepts and individual meanings is also involved. Also tentatively placed in this category is the notion of preconceptions (Novak, 1977). By comparison, in this view the learner is implied as being less active than in the actional views, but more so than in the classical view. For example, Shoben (1980) gives support to the activity of comparison in the computational model of sentence comprehension.

The actional view of a concept is adopted in the present study, as it is congruent with a view of the learner as being active and constructive, and of the constructed meaning as being personal, not absolute.

2.2.4 Conceptual change

Adopting an actional view of a concept implies a related view of conceptual change, which is here taken to mean a change in a person's conceptual knowledge. If one accepts that students, when they start their formal science education, have their own personal meanings for words e.g. the word 'animal', then it is not a case of their learning the scientific concept as if to fill a blank space, but of modifying and changing their existing knowledge in some way, for example, to expand its applicability and detail, to modify it towards the accepted scientific meaning, or to add and relate the accepted scientific meaning to the personal meaning. Hence, Gilbert and Watts (1983) argue that the term 'concept development' is a term more consistent with the actional and constructivist view of a concept than the term 'concept learning'.

Conceptual change has also been likened by West (1982) to the evolutionary and revolutionary paradigm changes in the history of science (Kuhn, 1970). Evolutionary changes are seen as small, on-going changes in a person's existing knowledge. The alternative terms 'cognitive capture' (Hewson, 1982) and 'assimilation' (Strike and Posner, 1982; Posner, Strike, Hewson and Gertzog, 1982) relate to the same notion. Revolutionary changes involve radical, re-structuring of relevant aspects of person's existing knowledge, and have been alternatively labelled 'cognitive exchange' (Hewson, 1982) and 'accommodation' (Strike and Posner, 1982; Posner, Strike, Hewson and Gertzog, 1982). West (1982) makes the distinction that in evolutionary change the existing knowledge of the learner may be a 'building block' for the learner to reshape, but that in revolutionary change the existing knowledge of the learner may be a 'stumbling block' as an adherence to this existing knowledge may inhibit the restructuring and transformation to a new view.

In the present study, the word 'conceptual change' will be used to denote a change in a person's conceptual knowledge (with related changes on other aspects of existing knowledge) towards accepted scientific meanings and encompasses both changes of an evolutionary and revolutionary nature.

2.2.5 Learning

Learning is viewed here as involving both comprehension and conceptual change. Comprehension and conceptual change are two aspects of essentially the same process - the cognitive process of a person making sense of her or his world. This process may be viewed as an active, constructive one carried out by the learner through generating links between the incoming stimuli (oral or visual) and the person's existing knowledge (Osborne and Wittrock, 1983). Comprehension occurs when a person is able to generate these links. If no links are generated, no meaning or understanding is constructed. The product of comprehension (the constructed meaning) contains elements of the stimuli and the existing knowledge involved in the generation of the link. Freyberg and Osborne (1981) suggest that the use of existing knowledge in the process of comprehension tends not to leave it intact or unaltered. To varying degrees, a person's existing knowledge will be modified during her or his continuing attempts to make sense of the world. At times, a person may be able to generate links and construct a meaning without significant changes to her or his existing knowledge. We say the person has comprehended the situation. That is not to say the person has constructed the meaning as intended by the author, but that she or he has constructed a meaning that makes sense to her or him. At other times, in the construction of a meaning a person may significantly change her or his existing knowledge. The new construction may be added to existing knowledge or existing knowledge may be restructured so as to integrate the new constructions. Comprehension (that is, making sense of the world by the generation of links between incoming stimuli and a person's knowledge) is achieved by or results in altering the existing knowledge, at least minimally. If that change is relatively permanent, we say that learning has occurred. Learning involves both comprehension and conceptual change. Comprehension may not always involve conceptual change.

The area of learning is a vast field to research. The present investigation concentrated on investigating a narrow segment, namely, reading comprehension (i.e. comprehension of text) and its influence on on conceptual change of one biological concept of animal. The concept of animal was chosen because of the researcher's previous research (Stead, 1980) into students' understanding of this concept.

The literature reviewed in the remainder of this chapter is arbitrarily divided into two main sections: research in reading comprehension and research in learning in science. This does not reflect a wish by the researcher to distinguish between reading comprehension and learning but to provide a framework for integrating the work of two groups of researchers - those investigating primarily the comprehension of the written word, and those investigating primarily learning in science. Both groups are studying essentially the same phenomena but in different contexts.

2.3 READING COMPREHENSION

The view of reading comprehension adopted in this investigation is a constructive and interactionist one, in which the reader/learner's existing knowledge plays a dominant role. While much of the research relates to comprehension in general, it will be discussed in terms of reading comprehension only.

To give a historical perspective to the study, some earlier and differing views of reading comprehension will be described, followed by the research findings on which the adopted view of reading comprehension is based. Finally, current constructivist models of reading comprehension will be described and critiqued.

2.3.1 An earlier view of reading comprehension

The importance of both a reader's existing knowledge and text factors in reading comprehension, is widely accepted. However, the relative importance attributed to either varies among researchers. Some focus primarily on a 'text-based' approach to comprehension (Frederiksen, 1977) and investigate the effect of such factors as text cohesion on comprehension (linguistic devices, such as pronouns, that link sentences). Others attend primarily to the role of existing knowledge in comprehension (for example, story grammars). The research reviewed below is relevant to an understanding of the development of the work of the latter group.

In the mid-sixties the most well-developed approach to comprehension stemmed from theories based on the transformational linguistics of Chomsky (1957, 1968). Sentences were said to have both superficial (surface) and underlying (deep) structures. The surface structure refers to the words and sentences themselves, and the deep structure to the meaning embodied in the words and sentences. Comprehension is said to be a matter of recovering or accessing the deep structure (or meaning) by processing (or transforming) the surface or syntactic structure of the text. A full analysis of meaning is therefore obtained by interpreting the deep structure from the surface structure. All that is needed for the complete semantic description of a sentence is contained in that sentence. Meaning is conceived to be 'in' the language and to have a status independent from the writer or reader (Spiro, 1980a). Knowledge is viewed as expressible in and embodied in language and a skilled reader can decode the language into knowledge. In this view, difficulties in comprehension are said to be traceable to failures of skills, for example, some words are not in the reader's vocabulary, a rule of grammar was misapplied, or an anaphoric reference may have been improperly co-ordinated.

Recent writings also reflect a view that meaning is conceived as being 'in' the words and needs only to be 'extracted'.

'...meaning is extracted from a surface representation'.
(Shoben, 1980, p.309)

'...extraction of information from its visual form'.
(Gough, 1983, p.209)

Several early models of the reading process, for example that proposed by Gough (1972) [and elaborated in Gough and Cosky (1977), Gough and Hillenger (1979)] were more concerned with the decoding process, than that of comprehension. Gough's early model was commonly called a 'bottom up' or 'outside-in' model. The reader is said to derive meaning from the text by by first decoding or deciphering the print, to map the written form of a word (the graphome) on to the spoken form (the phoneme). The phonological form is then used to locate the meaning of the word in the mental lexicon. The meaning of this and each subsequent word is deposited in the primary memory where a person applies her or his knowledge of syntax and semantics to discover the relations between words and place them in an abstract structure. The model is a linear one, in which print is processed in a hierarchical way through various knowledge levels, with the semantic knowledge of the reader being utilised towards the end of the process to derive a meaning. Gough does not ignore comprehension, but argues that, after decoding has taken place, the comprehension process is no different to that which occurs in speech comprehension.

The automaticity model of LaBerge and Samuels (1974) is similar in its treatment of meaning, and to a minor extent attempts to incorporate the reader's use of existing knowledge at different levels in the reading process. Both models were criticised by Smith (1979) and Samuels and Eisenberg (1981) in that they failed to account for comprehension of the higher level processes, such as inferring. In fact, Gough (1972) characterised the end point of his 'outside-in' theory of reading as 'the place where sentences go when they are understood', reached by a procedure that he left to a wizard in the head named Merlin. This was meant to reflect the complexity of the process and our lack of understanding of it. LaBerge and Samuels (1974) stated explicitly that in its then simple form, their model dealt only with word meanings and not comprehension of extended discourse.

In summary, these early outside-in-models are characterised by limited accounts of the role of the reader's phonological, lexical, syntactic and semantic knowledge, and only scant accounts of comprehension.

The lack of emphasis on the role of a reader's existing knowledge is evident in the studies conducted between 1970 and 1975 on learning from the text as reviewed by McConkie (1977). The first half of the review is allocated to studies on text factors, such as structure, cohesion, content and serial position, and to studies on assessment of what is learnt and retained during reading. Existing knowledge is considered here in the context of the cognitive representation of what is retained after reading a text. This is not unexpected as initial research on existing knowledge is able to be categorised into two lines (Thorndyke and Hayes-Roth, 1979). One, conducted in the domain of artificial intelligence, has sought to define new data structures for encoding complex descriptions of the world, and the second has been concerned with memory for connected discourse. The second half of the review is allocated to studies concerned with the influence of readers' behaviours in tasks required of them, for example, expectations about evaluation, rate of reading, and use of imagery. McConkie (1977) summarises that these studies reveal that the reader is 'an active processor of information rather than simply a receiver and storer of a copy of the stimulus'. The influence of the information processing model of cognition is evident. The control of the reader in the reading and learning process is being promoted but only in terms of selective attention, and rate of reading, for example. McConkie asserts that research into the psychological processes of reading and learning will aid in identifying the combination of variables that maximises learning for educational purposes. Hence, he goes on to review the research investigating, what he terms, extratextual information, for example, the reader's prior (sic) knowledge, ability to transfer learning, retrieval processes such as free recall, and individual differences, such as verbal abilities. Acknowledging that these studies are a beginning only, McConkie concludes that future fruitful research would be on the 'mental activities' involved in comprehension and learning.

There was, however, a growing body of research and theoretical literature advocating and describing the role of a reader's existing knowledge in the comprehension of extended discourse in particular. Acceptance of a major influence of a reader's existing knowledge went hand-in-hand with a constructivist and interactionist view of comprehension. (The terms 'constructivist' and 'interactionist' are differentiated in Section 2.3.3 and 2.3.4 respectively.) While the literature on the use of existing knowledge and the constructivist and interactionist views is inextricably woven together, they will be treated separately in this review in an attempt to highlight key developments and ideas.

2.3.2 The use of existing knowledge in reading comprehension

Research in the early seventies began to indicate that performance in comprehension and memory tasks has a broader base than simply the semantically-interpreted deep structural relations underlying linguistic inputs, and added to our understanding of the use of existing knowledge in comprehension. Kintsch (1972), Bransford, Barclay and Franks (1972) and Anderson and Ortony (1975) suggest that readers often know more and recall more than a sentence specifies directly. The different aspects of the role of existing knowledge have been investigated and described. Bransford and Johnson (1972) and Dooling and Lachman (1971), suggest that certain knowledge may be necessary for meaningful processing of the text in the first place by helping readers to create a context. The context provided by the existing knowledge acts as a framework to intepret the text (Anderson, Spiro and Anderson, 1978). Knowledge of a topic may not be sufficient for optimal comprehension unless it is used in the construction of a meaning (Bransford and Johnson, 1972). Increased existing knowledge of a topic, results in increased comprehension of a text (Pearson, Hansen and Gordon, 1979).

Individual prior experiences of the reader influence what existing knowledge will be activated when a meaning is being constructed from a text which is vague or ambiguous (Anderson, Reynolds, Schallert and Goetz, 1977). Moreover, the differing existing knowledge of different readers may result in different meanings being constructed from a relatively unambiguous text, and in different parts of a text being considered more important, and therefore better remembered and re-called (Pichert and Anderson, 1977; Anderson, Reynolds, Schallert and Goetz, 1977; Anderson, Pichert and Shirey, 1983; Goetz, 1979).

Reader's existing knowledge was also used to explain the findings of the research on text analysis and its relation to comprehension and recall. Meyer and others, for example, Meyer and McConkie (1973), Clements (1976), Marshall and Glock (1978-79), Mandler and Johnson (1977), Kintsch (1976), developed systems for representing the propositional structure of text and related this structure to memory and recall after reading or listening to a passage. Meyer based her prose analysis technique on the case grammar of Fillmore (1968) and the semantic grammar of propositions of Grimes (1975). This procedure for prose analysis yields a hierarchically arranged display of the content of the passage and is termed the content structure since it shows the structure or organisation of the content in the passage. The content structure of a passage is said to show how some ideas in the passage are subordinate to other ideas (Meyer, 1975, 1977 and Clements, 1976). The main finding was that the height (placement) of the information in the hierarchical content structure influences its recall. Ideas located high in the structure are better remembered after reading or listening to a passage than ideas low in the structure.

Explanations for the effect of text structure on comprehension and recall, centre on the match between the reader's existing knowledge and the organisation provided by the author. For example, the research of

Bailey (n.d.) was based on the hypothesis that recall (and learning) would be improved if there was a greater match between the reader's expectations of the organisation of the text and the organisation provided by the writer. Clements (1976) explained his results by stating that the information staged high in a text is better recalled as it is more likely to be connected to relevant parts of already existing memory structures. Other studies (e.g. Myers and Paris, 1978; and Elliot, 1980) investigated readers' awareness of the organisational features of prose and its reported aid in memory and recall.

Other researchers, for example, Rumelhart (1975), Kintsch (1977), Mandler and Johnson (1977), Stein and Glenn (1978), investigated the effect on recall of a passage of the reader's existing knowledge of prototypical text structures, such as story grammars or story schemas. These were conceived as idealised internal representations of the parts of a typical story and the relationships among these parts. Anderson et al (1983) described a reader's knowledge of the conventional characteristics of distinct text types (e.g. a tale, a personal letter, a newspaper article) as textual schemata.

However, several important issues arise from the discourse analysis work. Firstly, one strong assumption made by many discourse analysis researchers is that the structure - the content structure of a particular text, or the characteristic organisation of a distinct text type - corresponds to some extent to the way people comprehend and store information during comprehension. This seems congruent with a view of comprehension as a matter of recovering the deep structure and meaning of a text by processing the surface or syntactic structure of the text.

Another common feature of the discourse analysis is that the text structure is treated as though it were an inherent, unchanging attribute of the text, interpreted in the same manner by all readers (Goetz and Armbruster, 1980). Thus, the importance of an element of text is determined by the position of that element in the structure of the text. Such a view presupposes that the meaning of the text is in fact invariant across readers and across contents. Mosenthal and Tierney (1984) caution against studies in which linguistic analyses of text (e.g. text cohesion) are used to explain readers' imposed structure on the text (e.g. text coherence). This is an important point as it is allied to the distinction that meaning does not reside inherently in words, sentences, or print, but that meaning is something that is constructed by the reader, and therefore, exists only in the mind of the reader (Spiro, 1980a, p.245).

The importance of a reader's existing knowledge was also given high prominence by the 'inside-out' models of reading (Smith, 1978, Goodman and Goodman, 1977). A reader's strategies for constructing a meaning of the text are said to be controlled by the reader's own existing knowledge. The reading comprehension process is said to begin with intention - the intention of constructing a meaning of the text - and this is very much a part of the reader's existing knowledge and under her or his control. Through strategies of predicting, sampling, and confirming, readers can construct a meaning of the text. The reader then controls attention and selectivity, and the prediction, hypothesising and monitoring of possible meanings of the text. Reading is said to begin, proceed, and end in meaning, and the source of meaningfulness must be the existing knowledge in the reader's head. Nothing is said to be comprehended if it does not reflect or elaborate on what the reader already knows. Difficulties in reading comprehension are viewed as dependent on the nature and use of the reader's existing knowledge.

The extent of the influence of existing knowledge is suggested in two main summaries of the above findings. Firstly, that the existing knowledge a person has, is a principal determiner of what will be learnt and remembered from a text (Anderson, 1977; Anderson, Spiro and Anderson, 1978; Lipson, 1982). This is in keeping with the work of Bartlett (1932), Piaget (1947) and Ausubel (1968).

Secondly, while the hierarchical structure of textual units is important, it is not an invariant property of the text as it can be altered by the readers' perspectives, based on their existing knowledge (Spiro, 1977; Pichert and Anderson, 1977; Anderson, Spiro and Montague, 1977; Marshall and Glock 1978-79).

2.3.3 An interactionist view of reading comprehension

With the increasing awareness of and evidence for the use of existing knowledge in reading comprehension, many researchers now take an interactionist view of reading. That is, both the roles of the text and the reader's existing knowledge are acknowledged. Comprehension is conceived as an interactive process involving the text stimuli and the reader's existing knowledge (Royer and Cunningham, 1981; Wittrock, 1981a). However, equal importance may not be placed on each factor. The term 'interactionist' not only implies an interaction between text stimuli and existing knowledge, but also an interaction between all component factors and processes involved in reading comprehension. For example, Spiro (1980a) describes an interactive model of the reading process as one in which the different kinds of existing knowledge from orthographic to schematic knowledge, interact in a heterarchical, not hierarchical fashion, that is, communication between the levels of knowledge is not limited to adjacent members of the hierarchy. Each knowledge source can contribute input at various points in the complex process of comprehending text.

An interactive model can also be one that describes the reading process as one in which different processes interact, e.g. automatic processes and those requiring attention (LaBerge and Samuels, 1974; Spiro, 1980a), or interaction between the processes for comprehending sentences and those for comprehending extended discourse e.g. Van Dijk (1977), Kintsch and van Dijk (1978), Calfee and Spector (1981), Samuels and Eisenberg (1981).

The term 'interactive' is also used to imply that the reading process is not unidirectional in terms of the influence of the various component processes. Comprehension can be viewed as proceeding from the 'top down' as well as from the 'bottom up'. That is, it can be directed by existing knowledge (conceptually driven) or by text stimuli (text driven) (Bobrow and Norman, 1975; Rumelhart and Ortony,1977; Rumelhart, 1977). The different meanings of the word 'interactionist' can be in part attributable to the complex nature of comprehension. Acknowledgement of this complexity entails, to some degree, adopting an interactionist position so that the many factors are acknowledged.

The adoption of an interactionist position is evident, for example, in the work of Bransford, Barclay and Franks (1972); Bransford and Johnson (1972); Anderson and Ortony (1975); Kintsch (1977); Anderson et al (1978); Frederickson (1977); Goodman and Goodman (1977); Tierney, Bridge and Cera (1978-79); Goetz and Armbruster (1980); Juel (1980); Spiro (1980 a, b); Walker and Meyer (1980); Baumann (1981); Goetz et al (1981); Samuels and Eisenberg (1981); Royer and Cunningham (1981); Johnston and Pearson (1982); Peeck, van den Bosch, and Kreupeling (1982), and Townsend (1982).

Gough (1983) acknowledges the interactive nature of reading comprehension, in the light of the research on the influence of context:

> 'The obvious significance of context effects on word recognition is that they refute a strictly 'bottom-up' model of reading like that I offered a decade ago.'

He adopts the view that both context (involving existing knowledge) and form (text stimuli) are two potential data sources for the reader. He proposes that interaction between the two, may be weak or strong. A weak position is one in which context and form provide separate and independent sources of information, which are then simply combined.
A strong interactionist position is seen as one, in which the two sources are not independent, that context not only provides information for the construction of meaning, but also influences what meaning will be constructed.
Gough et al (1981) take the weak interactionist position, and add that:

> 'context influences a separate, (and presumably later) stage than that in which form is processed.'

As stated previously, the term 'interactionist' will be used in the present study in the sense of the interaction between existing knowledge of the reader and the text stimuli, and between conceptually and text driven processing. Even within this meaning of 'interactive', varying importance can be given to either the existing knowledge or the text. Research based on an interactive position, can be classified into those that consider primarily the role of the reader's existing knowledge, and those that consider primarily the text variables. This investigation may be placed in the former group, taking, what Gough (1983) would term as a strong interactionist position. Primarily focussing on one set of factors, reflects not only the complex nature of reading comprehension and researching into it, but also the researcher's theoretical view of reading comprehension. Collectively, but not individually, the many studies go some way towards constituting a comprehensive model of the reading process.

2.3.4 A constructivist view of reading comprehension

With the growing experimental evidence to support the theoretical views on the role of existing knowledge in reading comprehension, there was a developing school of thought that meaning was not embodied 'in' language, but that it was created or constructed by the reader. This view is called the constructivist or constructive view. That the meaning of a word was not embodied in language, and that a word can therefore have flexible meanings, has been emphasised in linguistics by Wittgenstein (1963) and Labov (1973). They suggested that the meaning of a word depended on context and its function.

The constructivist view was also advocated as an alternative to the interpretive view of semantics, by Barlett (1932) and Bransford, Barclay and Franks (1972), for example. The interpretive approach is closely allied with a 'meaning-in-the-language' approach, in that the deep structure of a sentence needs only to be interpreted from the surface structure for a full analysis of the meaning to be available. A constructivist approach, on the other hand, considers sentences as data, which readers can use to construct semantic descriptions of situations, along with their own existing knowledge (Anderson, 1977; Rumelhart and Ortony, 1977; Wittrock, 1981a). In other words, readers' comprehended meanings contain more information than is directly represented in the linguistic input.

The constructive view of comprehension is also one, in which the reader is seen as an active participant. And more so than in earlier models. The reader is not perceived to be a passive processor of information, e.g. recovering the deep structure; encoding and retrieving information from memory. Rather, the reader is accorded control of the construction of a meaning, using both text stimuli and existing knowledge.

Research evidence supporting a constructivist rather than interpretive approach,is exemplified in Kintsch (1972), Anderson and Ortony (1975), Spiro (1977).

The constructivist view of meaning has been greatly elaborated on and extended by the research in artificial intelligence and cognitive psychology, through investigations into the organisation of readers' existing knowledge and the process of comprehension. There appear to be, however, varying degrees of commitment to the approach, allied with the historical development of the approach. Some researchers (for example, Kintsch, 1977) used such terms as 'construct' and 'generate' but it is doubtful if they attached to these words the same meaning as late constructivist researchers. However, it can be argued that Kintsch did not work within the framework of the strict 'meaning-in-the-language' approach. In many of these earlier studies, the construction of meaning approach is a way of explaining an interactionist position. The constructive process is not the focus of research. Such research is exemplified by the work of LaBerge and Samuel (1974); Winograd (1977); Blachowiz (1978-79); Tierney, Bridge, Cera (1978-79); Goodman and Goodman (1977); Smith (1978); Goetz and Armbruster (1980); and Royer and Cunningham (1981).

Other research has explicitly investigated and discussed the process of constructing a meaning to comprehend a text, and these studies will now be reviewed in detail.

A strong constructivist approach is taken by Collins, Brown and Larkin (1980) who propose a model-based view of comprehension. Such a view argues that a central purpose of inference is not simply to fill in the missing connection between surface structure fragments of the text using context and world knowledge, but that the central purpose of inference is to make an underlying model which 'organises and augments the surface structure fragments in the text'.

In supporting this model-based view, Collins, Brown and Larkin (1980) distinguish the comprehended meaning from the text stimuli and from the reader's existing knowledge. Whilst acknowledging the input of both into the construction of meaning, they may be seen as suggesting that the constructed meaning is not equivalent to the text stimuli nor to the reader's existing knowledge. It is something additional to the text and to the reader's existing knowledge. While this distinction is somewhat academic as the constructed meaning is inextricably linked and becoming part of the reader's existing knowledge, it is a useful distinction in terms of a way to view the process and product of comprehension so as to increase our understanding of it.

Collins, Brown and Larkin (1980) continue to describe the construction of the model, by referring to a 'target structure', which specifies the constraints on the kind of model to be synthesised. In this way, the target structure acts as an organisational principle for guiding a set of inference procedures. That is to say that the target structure guides the process and product of comprehension. In elaborating on this term 'target structure' they distinguish between two ways of viewing the term. Firstly, it may be viewed as a <u>non-generative structure</u>. That is, the target structure permits only a limited number of models to be constructed from it. The purpose of inference is to select and fill out the template or target structure. In this category they place the work relating to frames (Minsky, 1975; Wingograd, 1975), scripts (Schank and Abelson, 1977) and schemas (Anderson, 1977; Rumelhart and Ortony, 1977; 1977; Spiro, 1980b). The target structure, if viewed in this manner, is part of the reader's existing knowledge, and this existing knowledge controls and, to a large part, determines the processes and products of comprehension.

Secondly, the target structure may be viewed as a <u>generative</u> structure, in which case it can give rise to an infinite number of possible models. Collins, Brown and Larkin suggest that the control exercised by the target structure is more subtle and requires the growth of the target structure hand-in-hand with the feeding in of the variables of the model. Viewed in this way, the target structure is also part of the reader's existing knowledge and this part of the reader's existing knowledge is modified and reorganised while it is being used to construct a meaning of the text. This distinction between a non-generative and a generative base to the comprehension process, provides a useful framework with which to review constructivist (and also interactionist) views of comprehension, including reading comprehension. The work of the schema theorists will be reviewed first, then the progressive-refinement theory of Collins, Brown and Larkin and then the work on the generative model of reading comprehension as exemplified by the work of Wittrock and his colleagues.

2.3.5 Schema theory

Schema theory was developed in the field of cognitive psychology and artificial intelligence to account for the comprehension of and memory for extended discourse, both oral and written, and attempts to explain the evidence for the central role of the existing knowledge a reader brings to the reading task. It is, therefore, both a constructivist and interactionist theory (Spiro, 1980a; Anderson, 1977). However, schema theory not only outlines how existing knowledge exerts an influence on the comprehension process but it also suggests how that existing knowledge is represented, organised and stored in memory. Schemata, according to schema theory, are the fundamental elements on which all information processing depends. Accordingly, schemata are involved in the process of interpreting sensory data, in encoding and retrieving information from memory, in organising actions (both mental and physical), and generally guiding the flow of information processing (Rumelhart, 1980). More specifically schemata (i.e. existing knowledge) are said to:

a) provide a framework with which readers construct a meaning of the text,

b) guide inferencing and elaboration of the textual data, and

c) guide the specific interpretation given to a text by providing a mental set or perspective (Royer and Cunningham, 1981; Townsend, 1982; Anderson et al, 1977).

The role of existing knowledge 'structures' has been mainly discussed in terms of schemata, but initially it was also discussed in terms of frames (Minsky, 1975) and scripts and plans (Schank and Abelson, 1977). Whilst these terms are not synonymous, the various concepts are closely enough related to be treated together and under the one term of schemata (Rumelhart 1980). The work on schema theory has been documented by -

> Minsky (1975), Winograd (1975), Anderson (1977), Rumelhart (1975, 1977), Rumelhart and Ortony (1977), Schank and Abelson (1977), Spiro (1977), Anderson, Spiro, Anderson (1978), Rumelhart (1980), Spiro (1980a), Spiro (1980b), Spiro et al (1980), Abelson (1981), Johnston and Pearson (1982), Pearson and Spiro (1982), Anderson and Pearson (1984).

These writings are now collectively reviewed here.

What is a schema?

Rumelhart (1980) defines a schema as a 'data structure for representing the generic concepts stored in memory' (p.36) and Pearson and Spiro (n.d.) as a 'hypothetical knowledge structure, an abstract entity to which human information processors bind their experiences with real world phenomenon'. A person may have a schema for an object (chair, bird), an abstract idea or feeling (love, hate), an action (dancing, swimming) or an event (concert, exam) (Pearson and Spiro, 1982). A schema is broader than a concept in that it embodies relationships between concepts (world knowledge) as well as definitional knowledge. For example, most people's schema of 'animal' has variables such as habitat, number of legs, type of body covering, as well as personal experiences with animals. A scientific definition of 'animal' relates mainly to its consumer mode of feeding. Furthermore, a schema also embodies a prototype of meaning, that is, meanings are encoded in terms of the typical or normal situations or events that exemplify that concept. For example, most people's schema of 'animal' encompasses a prototypical concept of an animal based on family resemblances (Rosch and Mervis, 1975) rather than on the scientific concept. The prototype is a result of categorisation based on characteristic (e.g. legs, fur) not defining features (e.g. consumer feeding) (Smith, Shoben, and Rips, 1974). The characteristic features are those common to a category of objects but which do not define membership in a criterial sense.

A schema also includes behavioural sequences, and the term 'script' is often used to refer to one kind of schema about events and sequences of events. For example, a script for 'seeing a film' includes not only the name of the film, and the theatre, but also about what to wear, how to buy a ticket, and how to behave inside the auditorium.

Schemata are said to embody the appropriate knowledge framework. Only the specifics or variables need to be filled in or instantiated. This is often referred to as the 'slot-filling' activity. Rumelhart (1977) illustrated this with the schema for the concept buy, which has the variables of PURCHASER, MONEY, SELLER, MERCHANDISE, BARGAINING. What is required is that these variables be exemplified or instantiated. For example, the PURCHASER may be a child, adult; woman or man. The MERCHANDISE may be food, clothing, etc. As a schema involves a prototype of meaning, the range of values of the variables is restricted usually to the typical or normal values, unless otherwise specified by written or oral communication. The knowledge of typical or likely values is called variable constraints. In the above example one would not expect the variable of PURCHASER or SELLER to be instantiated by inanimate objects such as a car or a rock. Therefore, we do not have a schema for every single situation, but for each kind. Schemata are not just templates to be matched - one for every situation - but frameworks which require the variables to be instantiated. Schemata may also be viewed as hierarchical, and seen as a network of subschemata. For example, the schema for face consists of subschemata of mouth, nose, eye and ear.

How do schemata work?

The comprehension process may be viewed as one of selecting and instantiating schemata. The product is therefore the instantiated schema. Instantiating a schema, that is, assigning values to the variables may be done in two ways. Sensory data may be used to assign a value. For example a text may provide the data as in the sentence 'A herbivore is an animal, such as a cow, that eats plants'. The word 'animal' is exemplified by the text (or author). If we cannot assign values to variables using sensory data, then variable constraints can help in providing default values for the unspecified variables. Default values are initial guesses for variables whose values have not yet been or cannot be sensed. In the above example, default values for the variable of plant may be grass, hay, corn or swede. Plants that may be excluded are seaweeds, pinetrees or water lilies, as these are not usually considered to be normal plant food for cows. In this way, schema can help to make inferences about unobserved or unsensed aspects of the situation being comprehended. It is in this way that schema theory provides an explanation of the way existing knowledge (schema) helps a reader to make inferences and elaborations on text data.

It also follows that if people, because of their prior experiences, have different variable restraints embodied in a schema, then their possible default values and inferences may differ. Hence, inferencing is very much related to the use of schemata, in that inferences are made by the reader in selecting and instantiating a schema. To instantiate a schema, a reader may make a 'text-connecting inference' in terms of recognising the relationship between elements in two different text segments and acting accordingly in filling slots. Or the reader may make inferences in the assignment of default values to variable slots in the absence of any value data in the text. It is generally expected by writers and readers that not all data for comprehension are given (Grice, 1975). It is also assumed that the information to be inferred by the reader will be similar to that of the writer.

Using a schema is not a matter of selecting one template for each situation, but of using it to construct a model of the situation (Rumelhart, 1980). This construction involves existing knowledge (the schema) and text data (in the case of reading comprehension) to instantiate the schema. The process is both constructive and interactive. Schemata are flexible in terms of the range of the possible variables, although not infinitely flexible.

In this sense, schemata are said to be like theories in the way they function in the construction of an interpretation of an object, event or situation. Using schemata, we construct our own model of reality. Schemata are informal, private and unarticulated theories about the nature of objects, events and situations. The total set of schemata we have available for interpreting and comprehending the world,constitutes our private theory of reality. The total set of instantiated schemata in a particular situation, is our internal model of the situation at that moment. Forming our model of the situation involves selecting and instantiating an appropriate schema. Readers are said to have understood a text when they are able to form an instantiated schema that offers a coherent account of the text. To the degree to which a reader fails to form such an instantiated schema, the text will appear disjointed or incomprehensible. Also the degree to which the readers instantiated schema matches the author's, determines the degree to which the reader has constructed the author's intended meaning.

If schemata are viewed as theories, then we can apportion to them predictive qualities. Schemata allow our interpretations to far outstrip our sensory observations. For example, if we read the sentence 'Jane went to a film', we can predict or assume that a ticket was purchased and that she sat on a seat to view the film. Hence, in making predictions or inferences we have assigned default values in an appropriate schema, based on our own past experiences of going to see a film. When we have constructed a meaning of the text, we may not be able to distinguish between our beliefs (the default values and existing knowledge) and the observed values of the variables (Spiro, 1977). In reading to up-date our existing knowledge (as opposed to reading for recall experiments and school tests) the contribution of the text and existing knowledge to the instantiated schema may be blurred.

A schema may also be viewed as a procedure whose function is to determine whether and to what degree, the schema itself accounts for the sensory data. A primary activity of schema is said to be the evaluation of its 'goodness of fit' for the making sense of the situation. This procedure has been likened to the process of hypothesis testing (Rumelhart 1980). This role of existing knowledge in reading comprehension has been similarly discussed by Smith (1975, 1978). If a promising schema fails to account for some aspect of the situation, the comprehender has the option of accepting the schema as adequate in spite of the inconsistencies, or of rejecting the schema as inappropriate and looking for another possibility. Therefore, the fundamental processes of comprehension are likened to hypothesis testing, evaluation of goodness of fit and parameter estimation (Rumelhart, 1980). Hence, comprehension is not only an active process in terms of constructing a meaning but in terms of evaluating that model as the most plausible one. In other words, a reader's existing knowledge is used not only to construct a meaning of a text but to evaluate it as well.

How a promising schema is activated is of interest here also. Two basic ways have been suggested (Rumelhart, 1980; Pearson and Spiro, 1982). Firstly, a schema can activate a subschema. For example, a schema of animal may activate a schema of bird. This has been called conceptually-driven activation as existing knowledge has guided the comprehension process. It is in a sense expectation-driven processing in that another aspect of existing knowledge is being used to account for the sensory input. A second mechanism for schema activation is bottom-up or data driven activiation, when a sub-schema has activated a schema. For example, a tree schema may activate the plant schema to better explain the senory input. Bobrow and Norman(1975) used similar terms - conceptually-driven and data-driven - to describe the comprehension process itself. The two uses of the terms are very similar. Pearson and Spiro (n.d.) discuss the control of comprehension by combining the two uses of the terms. In summarising they distinguish between bottom-up processing and top-down processing. In bottom-up processing, the comprehension process is largely controlled by the data at hand (e.g. the print on a page) and the reader assumes a more passive receptive role, waiting for data to suggest the selection of a schema. In top-down processing, the reader assumes a more active role, using her or his store of schemata to generate hypotheses about the probable nature of the text. The schemata and hypotheses guide the reading comprehension process. Pearson and Spiro (n.d.) thus propose an interactive model of reading based on schema theory. They view the reader as shifting between one mode of processing and the other, depending upon her or his familiarity with the data and style of writing of the text and the purpose for reading. Hence, in terms of schema theory, comprehension involves selecting a schema through data- or conceptually driven processing, instantiation of the schema (using sensory data or default values), activation of related schemata, and evaluation of 'goodness of fit'. Reading comprehension to the schema theorists is an active, constructive process involving the interaction between existing knowledge (schemata) and the text (the input data). Schemata are said to be central to the pervasive inferencing that reading comprehension demands.

Schema theory and learning

Accounts of learning in terms of schema theory are weak (Rumelhart 1980), and in need of further elaboration if schema theory is to continue to be of value (Spiro 1980b). Rumelhart (1980) describes from a logical point of view, three basically different modes of learning that are possible in schema theory:

1) accretion, which can be likened to 'fact learning', and in which the comprehended meaning is added to existing knowledge and able to be retrieved. No new schemata are formed. Accretion would occur in a situation in which currently available schemata are deemed adequate for the interpretation of the experience.
2) tuning, in which existing schemata may evolve or undergo change to make them more in tune with experience. The schemata are not dramatically changed but elaborated and refined. There are three ways in which schemata can evolve:
    i) our knowledge of variable constraints and default values are continuously upgraded as we use the schemata;
    ii) a constant portion of a schema can be replaced with a variable one, thus adding a new variable to a schema;
    iii) a variable can be made into a constant, thus specialising the use of the concept.

3) restructuring, which involves the creation of new schemata. In theory, Rumelhart proposed two ways in which new schemata are generated:

   i) pattern generation which involves the creation of a new schema by copying an old one with a few modifications, such as different variables, value constraints, or

   ii) schema induction in which a new schema is induced from experience. Rumelhart acknowledges that there is no real need for this in schema theory as it is already accounted for in terms of accretion, tuning and patterned generation.

Whilst appreciating that Rumelhart is logically analysing aspects of learning and schema theory, his ideas can be criticised in terms of not adequately accounting for and explaining the nature of conceptual change as discussed in sections 2.2.4 and 2.2.5.

Spiro (1980b) does, however, address this issue. He advocates that in addition to paying attention to how knowledge affects the processing and comprehension of text, we need to be concerned with how the processing of text affects the development of new knowledge. As current knowledge in this area is weak, he advocates two aspects of learning for further consideration - trans-situational integration and conceptual change.

1. Trans-situational integration occurs when the reader integrates the comprehended meaning to existing knowledge, with special attention to information that is new. That is, the goal of reading is to update your knowledge. An alternative would be compartmentalising of the knowledge, so that new knowledge is kept separate and with few links to the existing knowledge. Many school situations, such as testing, require the latter (Spiro, 1977; Wittrock, 1981a), while the integration of new and existing knowledge would seem preferable.
   Spiro comments that little is known about the integration process and how to promote it, and suggests this as an area for research.
2. Conceptual change. Spiro distinguishes between two kinds of learning. One is that which involves incorporating new information with existing knowledge, without substantially altering that knowledge. This kind is similar to what Piaget termed assimilation and those that Rumelhart (1980) termed accretion and tuning.
   The second is the kind of learning that involves a radical restructuring of existing knowledge, which could be called conceptual

change and which is similar to Piaget's accommodation. Spiro again states that little is known of the processes of conceptual change either in terms of schema theory or other psychological and cognitive models.

Recent developments in schema theory

Spiro (1980b), in reviewing areas of further developmental work in schema theory, suggests that a fruitful area is that of how schema theory can assist the classroom teacher in terms of teaching reading comprehension. A knowledge of the problems related to reading comprehension is seen as essential in prescribing strategies to overcome these difficulties. In particular, Spiro argues that a question worth investigating is how existing knowledge is used, i.e. the processes by which existing knowledge affects the comprehension of new knowledge. It follows that if there are problems in these processes, then reading difficulties may ensue. Suggested problematic areas surround these issues:

a) Schema availability. If a reader does not have an appropriate schema, then comprehension failure or difficulties may arise. Schema unavailability may be due to too few relevant schemata or to insufficiently generalised schemata, which tend to be overly tied to personal and idioscyncratic experiences.
b) Schema selection. If a schema is inacessible (e.g. emotionally blocked), it has the same consequences as if it were not available.
c) Schema instantiation and refinement. If a reader has difficulty assigning values to schema variables, and hence refining the constructed model of meaning, comprehension difficulties will arise.
d) Schema change and maintenance. Some readers may not be alerted to text cues to either change to another schema or to keep using the present one. If an inappropriate schema continues to be used or started to be used, during the reading of an extended piece of discourse, comprehension difficulties will arise.
e) Schema combination. At times a single schema's use may not be sufficient for comprehension. Schemata may have to be combined before the reader can make sense of the text.

f) <u>An over-reliance on either bottom-up or top-down processing</u>. Readers who over-rely on bottom-up processing, may concentrate too much on detail of letter and word recognition and fail to construct a meaning. They may use little or none of their own relevant existing knowledge to construct and evaluate a meaning of the text. A reader who is over-reliant on the top-down process misses details and only gets the gist of the author's intended meaning. This becomes an increasing problem, for example, in reading highly technical writing in a science textbook.

Discussion on these issues and how they relate to reading comprehension and reading comprehension instruction may be found in Spiro (1980b), Collins, Brown, Larkin (1980), Rumelhart (1980), Tierney and Pearson (1981), Townsend (1982), Pearson and Spiro (n.d., 1982).

<u>Critique of schema theory</u>

Schema theory has been a major force in explaining the role of a reader's existing knowledge ~~in reading comprehension,~~ and explicating the active constructive process of reading comprehension.

A major criticism of the early schema theory is its vagueness and lack of detail in terms of a description of the theory (Thorndyke and Hayes-Roth (1979) and in terms of its applicability in instruction (Pearson and Spiro n.d.), Spiro (1980b). The writings of Pearson and of Spiro have gone some way to answer the latter criticism.

But two major criticisms deserve further investigation. Firstly, a significant criticism of schema theory, including that by schema theorists themselves, is its reliance on a template view of the structure or organisation of existing knowledge. Anderson (1977) suggests that using a schema is not like using a template. Comprehenders do not have a schema for every situation, and therefore, one is left to conclude that the comprehension process must be constructive or reconstructive. However, it is not clear in his writing if what is constructed is existing knowledge structures or a constructed meaning.

A fluid view of memory is also proposed by Spiro (1980b), in a discussion of cognitive economy of representation. He argues that the minimising of representation, where possible, contributes to efficient discourse processing. Such efficiency and economy occurs when less cognitive effort is expended toward complete encoding. He suggests that if information can be derived from already encoded information (even imperfectly) then it may receive less processing attention and be derived later if needed, rather than time and processing attention given to over-elaborately encoding it, despite the cost of occasional inaccuracy in remembering. One thing that is seen as enabling accurate cognitive economy of representation is the development of highly ramified knowledge structures. That is, the larger the cluster of mutually implied information, the greater the number of opportunities to leave information to-be-derived later if need be. However, Spiro suggests that the knowledge structures (i.e. schemata) need not be viewed as precompiled (or already assembled) packages of information but as being stored in a more fragmented form to be assembled when, and as, needed. Hence, the knowledge structures are built and rebuilt to fit the needs of the situations requiring meaning. The analogy is drawn to the idea of 'posture', which is endlessly fluid, yet very accurately recognisable.

Iran-Nejad and Ortony (1982) attempt to further counteract the template criticism by distinguishing between two approaches to cognition - a structural and a functional approach. In the structural approach, cognition is seen as being based on long term knowledge structures (for example schemata) stored in memory. In a functional approach, as advocated by Iran-Nejad and Ortony, cognition is seen to involve not permanently stored knowledge structures, but only transient patterns created directly by the functioning of the 'biological' hardware (the neurons). Hence, a constructed meaning and knowledge can be conceptualised as a momentary pattern and, to comprehend a situation, people function not by selecting a template but by creating and recreating transient cognitive patterns. The label of 'schema-of-the-moment' is suggested for the 'knowledge' that is created and recreated for the time that the underlying neuronal elements are functioning.

Accounts of schema activation are also vague and imprecise. It may be that the detail of other models of comprehension, for example, the computational models of sentence understanding (Shoben, 1980), whilst not constructivist, may be useful points for consideration and adaption.

Another criticism of schema theory is the lack of consideration given to the connotative, affective, and feeling aspect of cognition. Spiro (1980b) argues strongly that those aspects of the constructive comprehension process that use existing knowledge must also be subject to the effects of attitudes or as he calls them, signature feelings. He writes of the existential aspect of experiences - that is, what an experience feels like. Experiences can be described analytically but they can also have a holistic property of feelings. These attitudes or feelings can be active in the reconstructive process. For example, they can form the basis for our feeling towards a construction, which may not appear to have any logical inconsistencies, but which nevertheless 'do not feel right' and are therefore rejected.

In summary, one information processing theory, which accounts for the constructive and interactive nature of reading comprehension, is schema theory. Schema theory not only describes the role of existing knowledge in the process of comprehension, but it also describes the way in which existing knowledge is encoded and stored.

As previously noted, Collins, Brown and Larkin (1980) view schemata as non-generative template or target structures that guide the comprehension process, or more precisely, the construction of meaning. This aspect of schema theory has been criticised and alternatives have been advocated. Other theorists, outside of schema theory, have also attempted to account for comprehension in terms of a constructive process, and their work is now reviewed.

2.3.6 Progressive-refinement theory

Collins, Brown and Larkin (1980) propose a progressive-refinement theory of text understanding. According to this theory, readers 'create a complex scenario or model, within which the events described might plausibly occur'. An initial model is refined and revised in an effort to construct a model that best accounts for the text data. The process of construction is guided by a 'target structure' and the process of progressively refining the model is seen as one of constraint satisfaction. Each of these two aspects of the theory will be elaborated on. In discussing the notion of target structure, the authors write:

> 'The theory states that people try to understand the actions and events in a text in terms of characters applying means-end analysis (Newell and Simon, 1963) to solve problems that occur in the text. Means-ends analysis operates as follows: if there is a method to reach a goal directly, and its preconditions are met, then generate a sub-goal to satisfy these preconditions. When a sub-goal is generated apply means-ends analysis recursively to reach that sub-goal. If there is no way to satisfy the preconditions for that method, then look for another method that can be applied to reach that goal, etc. (Collins, Brown and Larkin, 1980 p.387).'

The application of a means-ends analysis to a problem of constructing a meaning (i.e. a model) for the text, provides people with a target-structure, a grammar or set of procedural rules. This is tacit knowledge (that is, existing knowledge) about possible goals and sub-goals. Crucial to the way a target structure guides the construction of meaning is the notion of planning knowledge, which is knowledge about, for example, social goals and intentions. Thus, planning knowledge places large constraints on the way people construct a meaning as only certain permissable structures will inter-relate the events in the text. But even within these constraints there are still a potentially infinite set of plans and solutions to a problem depending on the particular sub-goals and methods generated. In this sense, existing knowledge - the target structure - is said to be the basis upon which a meaning for the text can be generated.

The process of 'progressive-refinement' is said to be one of constraint satisfaction in terms of the means-ends analysis. The terminology used by the authors is similar to that of schema theory and the planning knowledge (i.e. the target structure) can be construed as a type of schema. Readers construct an initial model but it is a partial one. It is then revised and each successive model incorporates more and more text elements. The revision occurs as readers try to assimilate new text elements into the model. Hence, there are progressive stages of understanding as readers refine and revise this initial model, guided by the target structure. New text data are incorporated by 'slot-filling' or instantiation of unspecified variables, as previously described in schema theory. If new text data are not able to be assigned to variables, the model may be restructured and the new model may have variables that can be instantiated by the text data. Hence, a model is refined and revised as the given text data are progressively used to instantiate the model, and a model is restructured if text data are unable to be 'slotted-in'. This conception of the process is allied to Piaget's assimilation and accommodation. The process of comprehension, overall, is seen as a problem solving one as the initial and partial models (or constructed meanings) raise questions to be answered by instantiation using text data (or default values).

An important part of the proposed theory is the description of the various problem solving strategies used by readers to assign values to to variables. Eight strategies are suggested from a research investigation. Briefly these are:

1. Rebinding occurs when a value originally assigned to a variable leads to conflict and a new value is generated for that variable.

2. Question default interpretation occurs when no value satisfactorily instantiates the variable and a new model is sought by redefining the problem or question to be addressed.

3. Question direct conflict. If a value generated for a variable conflicts with other aspects of the model, then the instantiated variable is reviewed.

4. Question indirection conflict. If a value generated for a variable conflicts with other aspects of the model, then other related instantiated variables are questioned.

5. Near shift of focus occurs when the reader cannot think of a value that satisfactorily instantiates a variable and shifts focus to find a value instantiating a related variable to constrain the current variable.

6. Distant shift of focus is similar to 5 but less relevant variables are focused on.

7. Case analysis occurs when there is a small set of possible values to instantiate a variable, and each one is tried to see how it fits with related instantiated variables.

8. Most likely case assignment is done when there are several possible values to instantiate a variable, and the most likely value is tentatively tried.

Another key aspect of the theory is that of evaluation of the constructed model (or meaning) by the readers as they try to make sense of the text. A number of evaluation strategies used by readers in the research sample are documented, and the authors describe how these strategies are linked to the conditions the readers use to accept or reject a model. These tests are to evaluate:

1. the plausibility of the assumptions and consequences of the model. As readers assign default values to the unspecified slots in the construction of the model, they test the default assumptions and consequences by answering the question 'Could this be so?' The reader's existing knowledge acts as the guideline against which these parts of the model are tested.

2. the completeness of the model to ascertain how well the constructed model accounts for all the questions that arise in making sense of the text.

3. the interconnectedness of the model. Different components of the model are evaluated with respect to how well they fit together with other components.

4. the match of the model to the text to see how well the model accounts for and explains the perceived information in the text.

Hence, comprehension is seen as an active construction of an initial mode (or meaning) by the reader. This initial model is then refined, revised or restructured by a process of constraint satisfaction and evaluation. A particular aspect of existing knowledge, planning knowledge, is of central importance in the construction of a meaning as are the cognitive strategies of problem solving.

Critique of the theory

The reader is seen as active and deliberate in constructing a meaning for the text. Hence, the activities of the reader - the problem solving strategies and evaluation - are described. Prominence is given to the reader's existing knowledge and to cognitive strategies. Also the theory, to a greater extent than schema theory, distinguishes the product of comprehension from the reader's existing knowledge. As mentioned previously, the distinction is questionable but it is felt to be useful in a theoretical and academic sense to better understand reading comprehension. The theory does not, however, clearly address text elements other than events, for example, the meaning of a scientific concept. Nor does it address the affective and connotative aspect of cognition. Finally, the idea of conceptual change or lack of conceptual change is not accounted for. Some students appear to be tolerant of cognitive dissonance (Osborne, Bell and Gilbert, 1983) and yet this theory assumes conflict will be resolved.

2.3.7 Generative reading comprehension

Wittrock (1974, 1978, 1980) proposes a generative learning model, in which learning is viewed as an active, constructive process. The key ideas of this model have been related to reading comprehension (Wittrock, 1981b) and to learning in science (Osborne and Wittrock, 1983). Hence, the ideas of generative learning will be reviewed in this section on reading comprehension as well as in the later one on learning in science.

Wittrock (1981b) proposes that reading comprehension is a generative process, that is, 'a process of generating a meaning for language written by other people'. Each reader is active in constructing her or his meaning of the text.

The term 'generative' is used to convey the notion of the reader's activity and effort in creatively constructing meanings by generating links between her or his existing knowledge and the text or between constructions of different parts of the text. The links and relationships must be made internally by the reader and without them, no comprehension occurs.

Wittrock (1981a,b) makes a later distinction between the reader's existing knowledge, the text, and the constructed meaning. As previously stated, the reader's existing knowledge and the constructed meaning are by no means mutually exclusive. Comprehension is seen as generating links between the reader's existing knowledge, including real world knowledge, experience, linguistic knowledge and logic, and the text, or between constructions of parts of the text.

The existing knowledge and text stimuli are the components for the construction of meaning but not all of it. The essential factor is the links generated between them, and these are the creative products of the reader. The constructed meaning exists in the reader's head - it is an internal or mental construct. While this generative model may appear simplistic and without detail, it is important as it emphasises the creative aspect in terms of generating links between the two components. The constructed meaning is not a simple algorithmic addition of the two parts - 'the whole is greater than the sum of the parts'. Also the constructed meaning may be viewed as an entity rather than just as a trace or a part of existing knowledge.

To some extent, comprehension (the process and product) is idiosyncratic as each person has a unique existing knowledge. But much of people's existing knowledge is commonly shared. A text will be 'comprehended' if the reader is able to generate links between the text elements and her or his existing knowledge. To varying degrees, this generated meaning will overlap with the author's intended meaning. Most authors try to ensure as much as possible that a reader's constructed meaning will be similar to their intended meaning (Grice, 1975). But given idio- syncratic components in existing knowledge and in the individual's generation of links in constructing a meaning, the overlap between the author's intended meaning, and the reader's constructed meaning will not be total. Hence, the text stimuli can be viewed as guides to the construction of meaning and the process of comprehension as the directed generation of meaning from the print. Wittrock (1981b) sees a parallel in the two processes of composition and comprehension of language (written and oral) in that both require creative, inferential, generative processes. In composition, the author constructs sentences to guide the thought processes of the reader in the belief that the reader will construct a mental representation as similar as possible to the one the author attempted to express in her or his own writing. But reading also involves more constraints than that. Reading comprehension involves not only constructing a meaning by generating links. The construction must take into account the associated meanings generated from the syntactic and phonological characteristics of the text, and it must make sense to the reader. Wittrock (1981b) describes reading comprehension as the 'disciplined generation of meaning for text'. The constructed meaning will be useful and acceptable only if it fits both the reader's logic and real world knowledge, and her or his real world knowledge, and therefore, makes sense. Three components of this view of reading comprehension have been detailed (Wittrock, 1981b):

1) motivation of the reader to construct a meaning for the text,

2) attention of the reader to the text, and

3) generation of associations and relationships during reading.

1. Motivation. If reading comprehension is viewed as an active process then readers themselves must be led to accept (consciously or not) that reading is not a passive, absorptive process, but that it requires effort on their part to comprehend - to construct a meaning. Comprehension is not automatic. Readers need to accept or attribute responsibility for comprehension, in part, to their own efforts. Students need to be willing to generate links during comprehension and believe that the effort invested in generating these links will enhance their comprehension.

2. Attention. In constructing a meaning, a reader is required to attend to the text stimuli on the page. This attention is selective, and the concentration on important and relevant stimuli and on the process of constructing a meaning is an important part of reading.

   Long term attention of the kind required to comprehend a story or science text, requires a sustained interest in the activities of comprehension. That is, it requires voluntary, purposeful and effortful attention.

   The role of attention in reading comprehension (and learning) was also highlighted by Marton and Saljo (1976). They suggested that a reader/learner either attends to the surface of the discourse (the text) in what is termed surface level processing, or attends to the intentional content of the discourse (what is signified by the text) in what is termed deep level processing.

3. Generation. To comprehend a text, the reader must invent a meaning. Attempts by the teacher to give or tell the meaning, for example, cannot of itself, result in comprehension. Each reader must invent or construct an internal representation of meaning for herself or himself. No one can do it for the reader. The act of generating links, ultimately, is the task of the reader, although others (teachers and authors) can facilitate these activities.

The view of reading comprehension as a generative process is useful in considering the process at any of the levels of word, sentence, paragraph or extended discourse. The reader can be conceived as generating links between her or his existing knowledge, and the text, or between constructions of different parts of the text, ranging from words to stories.

Research

A growing body of studies with school children and adults supports the generative model of reading comprehension (and learning), for example, Bull and Wittrock (1973), Doctorow, Wittrock, and Marks (1978), Wittrock and Carter (1975), Wittrock, Marks and Doctorow (1975). These and others are well reviewed in Wittrock (1981a,b) and in Linden and Wittrock (1981) and will not be reviewed again here. Table 1 taken from Wittrock (1981b) lists some of the ways, supported by research evidence, to promote motivation, attention and generation.

The lefthand side of the table lists ways in which the teacher (or author) can elaborate to exemplify to the students what they must also do for themselves to actively make sense of the text, and on the right-hand side are listed activities, which when done by the reader, will aid them in generating the links between constructions of different parts of the text, and between their existing knowledge and text, and thereby construct a meaning. These activities may facilitate and promote motivation, attention or generation.

TABLE 1: Ways to Promote Generative Learning, adapted from Wittrock (1981b)

Elaborations and Generations

Teacher or Text Elaborations		Reader/Learner Generations
Headings and subheadings	-	Compose headings and subheadings
Titles	-	Compose title
Familiar stories and words	-	Relate text elements to existing knowledge
Underlined, circled, or checked words and sentences	-	Underline, circle, or check words and sentences
Questions	-	Develop questions
Objectives	-	Write objectives
Summaries	-	Give summary
Main ideas, rules, and principles	-	Abstract main ideas, rules and principles
Relations (between parts of text and experience)	-	Relate text to experience
Explanations	-	Write or discuss explanations
Inferences	-	Draw inferences Predict next event, outcome
Interpretations (analysis and synthesis)	-	Analyse or synthesize
Metaphors	-	Compose metaphors
Analogy	-	Give analogy
Examples	-	Provide examples
Pictures and partial pictures	-	Image and draw pictures
Graphs and tables	-	Prepare graphs and tables
Maps	-	Draw maps
Blanks	-	Fill in blanks
Paraphrases	-	Say in own words
Applications	-	Solve problems Apply principles Discussion and related group work Discuss story Read story or partial story Act out story Retell story Evaluate story Write story

The main implications of the findings are in terms of how to help students generate the links for themselves, i.e. reading comprehension instruction. Wittrock (1981b) suggests a three-faceted view of teaching reading comprehension.

i) When readers are motivated to read the text, and when they can and do attend selectively to it, but cannot generate the links, the links need to be made explicit to them, and the students asked to elaborate on them and to construct them for themselves.

ii) Readers who are motivated and selectively attentive, can but may not spontaneously generate the links between constructions of different parts of the text, and between the text elements and existing knowledge. In this situation, teachers will have to ask, and set tasks, for the readers to generate the links to construct a meaning.

iii) When motivated and selectively attentive readers can and do generate relations intuitively, teachers may need to ensure that relevant alternative or more elaborated meanings are constructed.

Critique of the model of generative reading comprehension

The model has much to offer a cognitive view of reading comprehension. In this model of reading comprehension, the constructed meaning is treated as a separate (but obviously related) entity to the reader's existing knowledge. The value of this distinction is being able to conceive and investigate both the process and product of comprehension.

In studying both the process and product of comprehension we can investigate the use of existing knowledge and the use of text stimuli in the construction of meaning, the generation of links in the construction process, and the reader's product(s) of comprehension, which can be compared and contrasted to our version of the author's intended meaning. This model of reading comprehension emphasises the effort, control, accountability, and responsibility of the reader in the constructing of meaning. It also gives importance to the interaction of the reader's existing knowledge and the text stimuli in the generation of links - the model is an interactive one. In this respect it does not differ from schema theory but it does not have the restrictive template notion of schema theory. Generative reading comprehension can be considered as going beyond the 'schema of the moment' notion.

The model is concerned with the motivation of the reader. While Wittrock himself does not explicitly state so, motivation can be viewed as being related to beliefs, connotations and feelings - an aspect poorly accounted for in schema theory and progressive-refinement theory. In this sense, Wittrock does not consider cognitive and affective processing as occurring separately.

The model and its implications for teaching and improving reading comprehension, suggest a number of text devices, teacher elaborations and learner generation activities that could promote reading comprehension. Individual differences are accounted for (as they are in schema theory to a limited extent [Spiro, 1980b]). These differences in generation, may arise because of differences in:

1) readers' existing knowledge due mainly to different experiences, or
2) the strategies learners use to generate links. Wittrock likens these differences in strategies to those researched previously in terms of cognitive style (reflective and impulsive, analytic and global), personality (analytic and synthetic) and neurology (analytic and holistic).

The model may be criticised, however, in several respects.

Firstly, the model of reading comprehension as a generative process is less detailed than schema theory. However, much of the detail in schema theory is in connection with the template notion, which itself is a weak point of that theory. The Wittrock model would benefit from more detail on the nature of the generated links and from further studies exemplifying the nature of the process and products.

Secondly, the model does not provide explanations of the encoding and storage of existing knowledge and how this relates to comprehension. But this may be seen not as a deficiency but as an acknowledgement of the relative unimportance of this compared to the processes and products of comprehension. Descriptions of storage of existing knowledge may be related more to an information processing view of comprehension than to comprehension itself.

2.4 LEARNING IN SCIENCE EDUCATION

As with reading comprehension, there has been a growing body of empirical and theoretical research in science education, based on the view that learning is an active, constructive, and interactive process in which a learner's existing knowledge plays a dominant role.
Each aspect of this view of learning in science education will be discussed in turn. But firstly, earlier views on learning will be summarised.

2.4.1 Earlier views on learning in science

Driver (1982) distinguishes between three traditions in research in learning in cognitive psychology with respect to science education - developmental psychology, behaviourism, and constructivist psychology. Each of these traditions differs in its perspective of the learner's existing knowledge. The developmental psychology tradition assumes that learning will be restricted by age-related cognitive developments, and is heavily based on the work of Piaget and his colleagues in Geneva. Hence, the existing knowledge of the learner - the schemata and operations - is considered, but in terms of developmental differences between children, and between children and adults.
Curriculum developers (e.g. ASEP in Australia) and researchers in science education (e.g. Shayer and Adey, 1981) used the stage theory aspect of Piaget's work as a basis to match the types of experiences

given to children in science lessons to the general pattern of cognitive growth. But, as Driver (1982) points out, another major and important aspect of Piaget's work was that of documenting children's responses to a wide variety of tasks, many of them relevant to science education. This aspect of his work documented the qualitative differences between the content and processes of children's thinking and 'adults' thinking and these could conceivably be more experience-related than age-related.

The second tradition, the behaviourist tradition, does not take into account the learner's existing knowledge. The learner's mind is treated as a 'black box' and the learner is seen as reacting to and being controlled by external stimuli. Hence, the external stimuli - the instructional sequences - are given maximum attention in this tradition. For example, the work of Gagné is based on the assumption that increasingly complex sets of behaviours and skills can be built up through carefully constructed instructional programmes.

The third tradition, that of constructivist psychology, acknowledges the existence of a learner's existing knowledge and its use in making sense of the world. In particular, it acknowledges that where the content of the learner's existing knowledge differs from the accepted scientific view, it is not just an error or misconception but a difference in a fundamental way of viewing the phenomena. The learner actively constructs, for herself or himself, a meaning for a sensed experience and the construction of meaning involves the person's existing knowledge (Ausubel, 1968; Kelly, 1955; Wittrock, 1974).

This present investigation lies within this tradition and a constructivist view of learning in science will be further detailed.

2.4.2 Existing knowledge and the learning of science

Learning in science involves not just becoming acquainted with natural phenomena. It also involves learning about 'the theoretical entities which have become accepted within the scientific community (the disciplinary knowledge comprising the particular concepts, the relationships among them and their symbolic representations)', as Driver and Erickson (1983) put it. Students are required to construct or invent these theoretical entities for themselves. In fact, from an early age children (like scientists) have been constructing meanings, interpretations or understandings to account for these natural phenomena. So before they begin their formal science education, students may have a 'theory' to make sense of a particular phenomenon. A growing number of studies have described and documented the intuitive meanings and beliefs students have constructed to account for everyday experiences, and these are reviewed in Cosgrove, Osborne and Tasker (n.d.), Happs (1983), Gilbert and Watts (1983), Driver (1982), Osborne and Wittrock (1983). Studies particularly relevant to the present investigation are those relating to three biological concepts and indicate that children do have and use meanings for the words 'animal' (Bell, 1981a) and 'living' and 'plant' (Stead,1980) that differ from the accepted scientific concepts. The scientific and the alternative concept for animal, living and plant will now be outlined in detail.

The biologists' concept of animal and plant

Living things can be divided into different groups depending on which scheme one follows. Classification is superimposed on nature by humans, and as people do not always agree, any classification system is subject to changes. Kirk (1975) and Jones and Gaudin (1977) advocate a five kingdom system - Monera (the bacteria and blue-green algae); Protista (protozoa, diatoms, slime moulds); Fungi (the true fungi); Plantae (algae, Bryophyta, and Tracheophyta) and Animalia (the multi-cellular animals). Other systems are based on four kingdoms (Monera, Protista, Plantae, and Animalia); three kingdoms (Monera, Plantae, and Animalia); and two kingdoms (Plantae and Animalia). Whilst, the classification of the bacteria, algae, fungi, and protozoans changes with each scheme, the classification of the autotrophic plants, for example, the Bryophyta (the mosses) and the Tracheophyta (ferns and flowering plants), and the multi-cellular animals remains constant. Hence, the classification of the commonly known plants and animals remains stable. In this investigation, children's concepts of plant and animal are in terms of the Kingdoms of Plantae and Animalia as categorised in the five kingdom classificatory scheme.

Animals and plants may be distinguished on several characteristics, the main one being that of feeding. Animals usually require complex, synthesised foods, which are altered chemically by the animal, to provide materials for growth and energy release. This is known as heterotrophic feeding. Plants are usually able to use inorganic substances (minerals, water, carbon dioxide) and solar energy, during photosynthesis, to make organic substances for growth and energy release. This is autotrophic feeding.

This basic difference in feeding gives rise to three other differences. Most plants do not need to move in order to survive since the raw materials for photosynthesis are immediately at hand, and readily taken in. Plants are moved by outside agents in the form of seeds, spores, or cuttings. Animals usually have to utilise movement to obtain their food. Carnivorous animals must catch their prey, whilst herbivores have to move from plant to plant. Even the sessile animals, for example oysters and barnacles, have beating hairs or moving appendages to obtain food, and a free swimming larval stage.

Plants do not have sensitive organs linked to a nervous system like animals, although they do react slowly to light, gravity, and water. Animals, in comparison, often have highly developed sense organs to receive stimuli of sight, sound, touch, taste, and smell. Some animals, for example, the earthworm, do not have obvious sense organs, but they do have distinct and special sense cells. Therefore, animals, unlike plants, usually have some method of coordinating the sense organs and locomotion by a system of nerves. A few phyla of animals, for example, the coelenterates, do not have a central controlling area or brain. Besides the differences in nutrition and the associated ones in movement, sensitivity and nerves, the animal cell lacks the cellulose cell wall found in plant cells. No one of the criteria mentioned can be considered as adequate alone to distinguish an animal from a plant, as exceptions exist in all cases. Hence, like the concept living, the concept of animal is a conjunctive one. The categorisation of an instance depends on the joint presence of several, but not all, of the criterial attributes.

The everyday concept of animal

Many children (and adults) attach an everyday meaning or concept to the word 'animal'. The range of exemplars is more restricted than that of a scientist's and the distinguishing characteristics are different. Most students, particularly the younger ones, see animals as mainly the large, furry, land animals, such as those found on a farm (e.g. cow), in a zoo (e.g. lion), or in the home as pets (e.g. dog). These would have been the first animals they experienced and their concept of animal has remained restricted. The main distinguishing characteristics used by children are number of legs (animals have four legs), size (animals are large), habitat (animals live on land), skin covering (animals have fur), and noise (animals moo, bark, or call out). These characteristics - for example, four legs, terrestrial, fur, and size - whilst characteristic of some animals, are not characteristic of all. When used as distinguishing characteristics, they limit the range of concept exemplars and result in restriction of the accepted scientific concept.

There are, then, two meanings of the word 'animal' - the everyday and the scientific meaning. Most students have and therefore use only the everyday meaning (Bell, 1981a). But scientists, although they know of the scientific meaning, do not always use it. In some contexts they use the everyday meaning, for example, to interpret the food shop sign 'No animals allowed inside'. To a biologist, a person is an animal, but in the everyday sense of the word 'animal', a person is not. Hence it is not a case of which meaning is the correct one, so much as, which meaning is the better one to use in the given context. In a science lesson, it is hoped that students will use the scientific meaning rather than the everyday one.

The everyday concept of plant

Many students have an everyday concept of plant, which is more restricted in terms of exemplars when compared to the scientific concept. Some of the distinguishing characteristics used do not differ from accepted scientific ones, such as 'plants grow in the ground'; 'plants have leaves, flowers, stem, green colouring, roots'; 'plants need sunlight and water'; and 'plants do not move of their own accord'. But others are different, for example, size (plants are small), hardness (plants are soft, herbaceous), and cultivation (plants are the things we purposefully put in the garden). Hence, to many children, weeds, trees, and grasses are not plants. Many children also talk of vegetables as non-plants.

The biologist's concept of living

The biological definition of 'living' is complex. A biologist may define the meaning of 'living' by stating that any structure which metabolises and self-perpetuates is living. Metabolism is the total of those chemical reactions essential for life, for example, nutrition, respiration, and synthesis (the transformation of raw materials into structural components of living matter during growth and repair). Metabolism makes possible the self-perpetuative functions of homeostasis (the maintenance of a more or less stable internal environment in a fluctuating external environment), reproduction and adaption (Weisz, 1961; Jones and Gaudin, 1977). This definition may be used to distinguish the living from the non-living, and in a slightly different manner, to distinguish the dead from live organisms.

Living things share several features or attributes in common. Nearly all organisms consist of cells, which, either singly or in groups, can carry out certain activities that can be remembered by the nmemonic 'M.R.S.G.R.E.N' - movement, respiration, sensitivity, growth, reproduction, excretion, and nutrition. With respect to these 7 attributes, the concept of living is a conjunctive one - an instance is categorised on the joint presence of several of the attributes which may be considered criterial. Living things will carry out most of these processes. Most plants (that is the whole organism) do not move, but they do carry out respiration, reproduction and growth. Some non-living things may carry out several of these processes but not most of them. A cloud may grow in size, but it does not feed or respire.

There are difficulties in defining what is living or not, especially for junior biology pupils, for example, Forms 1 to 4 pupils (ages 11-15 years). The precise biological definition, involving metabolism and self-perpetuation, is too abstract and complex to be used by younger pupils. Many of the criterial attributes of living things are abstract and not observable, for example, metabolism, respiration, and synthesis. The use of 'M.R.S.G.R.E.N.' characteristics as criterial attributes encounters the problem of what characteristics of the 7 are necessary and sufficient criteria to define life. Whilst it is a conjunctive concept, it is also a family resemblance one, the relative importance of each criterial attribute, and the number of characteristics changing with each instance. The concept of living is an abstract and relational concept (Gagné, 1970).That is, the concept is defined in terms of other concepts. Before a pupil can learn the scientifically accepted concept, in terms of exemplars and criterial attributes, she or he must acquire the concepts of nutrition, and respiration, for example. Individuals may attach varying meaning to these labels, and hence, the criteria used to determine if an instance is an exemplar, or not, may vary. For example, many children consider a fire to feed, as it consumes fuel Thus their concept of feeding differs from that of a biologist.

The metaphoric meaning of 'living'

Many studies, Piaget (1929), Looft and Bartz (1969), Sedgewick, Lenke and Lucas (1978), Dennis (1953), Brown and Thouless (1965), Simmons and Goss (1957), Brumby (1979) have described the animistic thinking of children and adults. Stead (1980) found similar results for some New Zealand students. Many students had a wider range of exemplars of living things than would a scientist. For example, many called a fire, sun, candle, car, bike and vacuum cleaner living. The distinguishing characteristics used to decide if something is living or not are similar to those used by a scientist, for example, movement (clouds are living since they move), respiration and 'breathing' (a fire is living since it breathes oxygen), growth (a tree is living since it grows taller), feeding (a fire is living since it 'eats' wood). It would appear that many students use the word 'living' in a metaphoric sense-something is living since it behaves as if it was living. The difficulty is that students use only this meaning, both in and out of science lessons. Biologists on the other hand use both, but only the scientific one in the science laboratory.

Comment

According to the analysis of Gilbert and Watts (1983), the framework for analysis of the varying concepts of animal, living, and plant lies within the relational and classical views of a concept, implying that when a student does not use the scientific concept, that student's existing knowledge is flawed and contains an error. It is arguable that this notion of a concept reflects more the categorical nature of the concept say of animal than the researcher's value judgements on a student's alternative concept.

The concept of animal (either the scientific or everyday one) is a categorical one and as such differs from correlational and theoretical concepts (Pella, 1966). The groupings of living things are arbitrary constructs of the human imagination to simplify the range of variation of the world. This is different from inventions of the human mind designed to account for, and explain, phenomena such as a falling ball or ice melting. Hence, the use of terms such as exemplars and distinguishing characteristics reflects the nature of the concept. It is also contended that using this concept of a concept does not imply that the researcher sees alternatives to the scientific concept as deficiencies or inadequacies. Throughout the present study the alternative conceptions of animal are accorded value and status as the student's personal meanings are valuable to them. If a value judgement is to be made, it is a pedagogical one, for in science education, we are concerned with conceptual change - of helping students to learn, in this case, the scientific concept of animal. From a pedagogical viewpoint, a comparison is made between the personal meanings held by individuals and the accepted scientific meaning, to identify the 'departure' and 'destination' of the learning journey and to enable assessment to be made of the nature and extent of any conceptual change. The comparison is not intended to imply 'deficiencies' in students' personal meanings although it does reflect a value judgement that students would benefit from learning the scientific concept.

Summary of the biological concepts

There are two broad meanings for the words 'animal', 'plant', 'living' - the scientific meanings and the alternative meanings, called here the everyday and the metaphoric meanings. Here, science teaching is not so much involved in replacing the everyday and metaphoric meaning with the scientific one, in the students' existing knowledge. Rather it can be seen as beneficial and desirable for a student to have both meanings and to be aware of which context it is better to use each one in. This notion is not unlike that proposed by Solomon (1983). She uses the terms 'socialised knowledge' and 'life-world domain of knowledge' to label everyday notions and language. She too advocates that students benefit from retaining the life-world domain of knowledge as well as acquiring the symbolic domain of knowledge -the scientific explanations and theories. The life-world domain is said to have great social value and hence great persistence. On the other hand, the symbolic domain of knowledge, for many students, may have a weaker social currency as it is restricted to small specialised groups e.g. scientists, or to certain periods of time, e.g. within the school timetable. What we are then asking of pupils is not only to think and operate within the two different domains of knowledge but to also be capable of distinguishing between them. Does this occur?

A major finding of the studies, investigating the concepts held by children of animal, living, plant, is that these alternative concepts are held and used in a scientific context, by some older students who have had at least three years of formal science teaching

(Stead, 1980; Bell, 1981a). For example, approximately 65% only, of a sample of 34 Teachers' College students considered a spider to be an animal (Bell, 1981a). It would appear that either these students had not learnt the scientific concept or they did not see to use it in the scientific context.

2.4.3 The generative learning model and conceptual change

Within science education research there is now a strong and growing school of thought encompassing a 'contructivist epistemology' (Driver, 1982; Osborne and Wittrock, 1983; Pope and Gilbert, 1983) in which it is assumed that learners actively generate meaning from experience. The generative learning model (Osborne and Wittrock,1983) lies within this tradition and has been used as a framework for this investigation. The generative learning model, in the context of reading comprehension, has been discussed in Section 2.3.7. It is reviewed again here in the context of learning in science.

The basic notion of the generative learning model is that a person is not a passive recipient or consumer of information (Wittrock 1974, 1978), and therefore learning does not occur automatically when teachers give out information. Learning is largely under the control of the learner as she or he has the final responsibility for attending to the instruction and for the active construction of meaning. Each learner must discover or invent an understanding (and hopefully the intended one) for herself or himself. In doing so, they use their information-processing strategies, memories and attentional and motivational mechanisms. Comprehension is said to occur when learners use their cognitive processes to construct a meaning for stimuli by relating them to long term memory, i.e. existing knowledge. The stimuli have no meaning per se.

The central cognitive process in learning is the generation of the links between incoming sensory stimuli and relevant aspects of existing knowledge (Osborne and Wittrock, 1983),a notion that is unique to this particular model of learning. Learners generate these links to create a meaning or explanation that organises the perceived stimuli in a way that makes sense to them, that fits their logic, or real world experiences or both. Hence, learning, as construed in this model, is constructive and interactive, with the generation of links between stimuli and existing knowledge being of central importance. In this model of learning, the role of existing knowledge is multiple, namely:

1) Long-term memory and information processing strategies are used to generate the links between stimuli and existing knowledge, to code it and to store it.
2) Existing knowledge determines what, in the myriad of stimuli surrounding a person, will be selectively attended to. Hence, learning is not seen as beginning with an experience or stimuli, but with the person's existing knowledge. This tenet has far reaching implications for education, including science education.
3) A person's existing knowledge is also used to evaluate an initial and tentative construction, in a way congruent with that suggested by Collins, Brown, Larkin (1980). A construction is said to be checked for plausibility of assumptions, the consistency between the constructed meaning and other aspects of information available from long-term memory and from sensed experiences, and checked in terms of the predictions that follow from the constructed meaning. Evaluation is yet another activity done by the learner and under her or his control. Under the evaluation, a new construction may be rejected and the existing knowledge remaining substantially unchanged i.e. no learning occurs, or the construction may be be accepted, and the existing knowledge may in varying ways be changed or indeed restructured, i.e. learning to varying degrees, occurs.

Conceptual change was described earlier (p.14) as both a restructuring and minor modification of a person's existing knowledge. An important issue in science education is that many secondary students do not have or use the basic scientific concepts (Driver et al, 1982; Bell, 1981a). They do have strongly held meanings for words and interpretations of natural phenomena from an early age, but these tend not to be the scientific ones.

As Osborne and Wittrock (1983) point out it might be predicted from the generative learning model that young children would in fact generate links between selected stimuli and their existing knowledge. Long before they start formal science teaching, they have been constructing meanings to make sense of their natural and technological worlds - the everyday world. Also many words like 'work' and 'animal', for example, are used in everyday language as well as in science. Hence, children are active learners trying to construct a sensible and coherent view of their world based on their own experiences and use of language.

Osborne, Bell and Gilbert (1983) suggest a number of reasons why the meanings constructed by children differ from those of scientists:

' (1) Children tend to view things from a self-centred or human-centred point of view and tend to consider only those entities and constructs that follow directly from everyday experiences.

(2) Children's experiences of the world are limited and tend not to include contrived experimental situations e.g. frictionless situations.

(3) Children tend to be interested in particular explanations for specific events and tend not to be concerned with the need to have mutually coherent and non-contradictory explanations for a variety of phenomena.

(4) The everyday use of language tends to be subtly different from the language of science particularly with regard to basic and important words like 'animal', 'friction', and 'force', and these everyday meanings tend to shape children's constructions.

Learning in science is then a matter of changing these intuitive meanings towards or to include the scientific meaning. For most students this requires a restructuring of existing knowledge. It would appear from a growing number of studies - for example, Driver et al (1982), Bell (1981a) - that this required restructuring does not occur as frequently as might be expected in existing science lessons, with current teaching practices and current science curricula. Osborne, Bell and Gilbert (1983), drawing largely on the work of Gilbert, Osborne and Fensham (1982), have summarised some of the possible ways students' existing knowledge may be influenced by the scientific ideas put forward in a teaching episode in science. The outcomes proposed are:

(1) The new view (the scientific view) is simply rejected. The student prefers her or his present view and is unwilling or unable to accept the scientific view being offered and thereby change her or his existing knowledge.

(2) The new view is misinterpreted to fit in with, or even support, present views. The student incorporates the new ideas into the existing knowledge by misinterpreting the incoming stimuli.

(3) The new view is accepted but isolated from present views. The student's existing knowledge is compartmentalised and not integrated. As Spiro (1980a) points out, this may be advantageous in current school assessment techniques. The new (the scientific) view is used solely in the context of the science laboratory and not used to make sense of the everyday world. But it is characterised not just by an unwillingness but also by an inability to do so.

(4) The new view is accepted but leads to confusion. The student attempts to incorporate a new construction into her or his existing knowledge and thereby changing it, but is unable to form a coherent view. In other words, some but not all of the relevant conceptual changes are made to the existing knowledge.

(5) The new view is accepted and forms a coherent view of the world which may or may not incorporate aspects of the previously held views. As Solomon (1983) suggests, there may be advantages in students retaining, being aware of and using both views (the alternative and scientific views) but in different contexts.

The first four outcomes appear to characterise many current science lessons, even though the teacher intends that the fifth outcome occur. Recent research has attempted to describe and evaluate ways of promoting conceptual change, so that the possibility of obtaining outcome (5) is increased. These intervention studies are reviewed in Driver (in press). Firstly, she distinguishes between those research studies which have and do not have explicit, comprehensive models on which to structure the research. Included in the studies that do not have such a model is the work of Nussbaum and Novick (1981) who employed a teaching strategy embracing the notion of cognitive conflict. They advocate first making explicit students' alternative frameworks i.e. for each student (and the teacher) to be aware of her or his own view or word meaning - the ideas they bring to the lesson. Secondly, they suggest classroom or small group discussions and additional demonstrations to highlight the variety of views held by students in the class, and to create dissonance by exposing the inadequacies of the alternative ideas. Creating this conflict, or dissatisfaction with currently held ideas was deemed to be sufficient to motivate students to recognise the need to modify their views and to accept another view - namely the scientific view. Two intervention studies - Stead (1980), and Boe, Cox and Bell (1981)-to teach mainly the scientific concept of animal were modelled on this pattern. The results indicated that many, but not all, students, of varying ages, had learnt and used the scientific concept of animal in a completed post-intervention survey. Few data were available as to whether the scientific concept was used in several contexts besides that of the school science laboratory and whether it was used at all after several months. Also, no data were collected about students' thoughts, strategies and feelings about changing their existing knowledge.

The second group of intervention studies are those done by research groups, who are conducting a systematic research programme based upon a more explicit model of conceptual change. Included in this group is the work of Hewson (1981a, b, 1982). Briefly, he states that -

'when a learner encounters a new conception, (the scientific conception), the new conception can be

(1) rejected, or

(2) incorporated in three possible ways. It could

(a) be memorised by rote (i.e. not necessarily reconciled with existing conceptions);

(b) replace an existing conception and be reconciled with the remaining conceptions by the process of 'conceptual exchange'; or

(c) be reconciled with existing conceptions by the process 'conceptual capture'.

What in fact does happen to a new conception, depends on whether it is seen as:

(a) intelligible (I) in that it appears coherent and internally consistent;
(b) plausible (P) in that it is reconcilable with other aspects of the child's view of the world, or
(c) fruitful (F) in that it is preferable to the old conception on the grounds of perceived elegance, parsimony and economy.

Therefore, a conception can have

(a) no status (not intelligible, plausible or fruitful)
(b) status I (intelligible but not plausible or fruitful)
(c) status IP (intelligible, and plausible but not fruitful)
(d) status IPF (intelligible, plausible and fruitful)

A valuable contribution of this model of conceptual change is the aspect of evaluating the new conception - the scientific conception. It implies that conceptual change occurs only when the scientific view is given a higher status by the learner than the old one. Conversely, during conceptual change the status of the previously held view decreases. It is suggested that this change is gradual and may occur over years rather than over lessons.

Another group of intervention studies are those based on the generative learning model - Cosgrove, Osborne and Tasker (n.d) and Happs (1984). Cosgrove, Osborne and Tasker (n.d) outline a three-stage teaching model, exemplified with the topic of electric current. The first stage is one of focusing on the topic by providing opportunities for all students to become familar with the materials and the phenomena. In the second stage, students' personal ideas on the topic are made explicit and public, through discussion and debate, and these views are challenged as to their adequacy to account for all aspects of the phenomenon. A third stage, permits the students to apply new ideas to familiar and novel practical situations in a problem-solving model.

The central process of comprehension and learning, according to the generative learning model, is that of generating links between the existing knowledge and relevant stimuli in the environment. To promote conceptual change, the generation of new links to construct a new meaning is central.

In a formal teaching situation, a knowledge of the probable existing knowledge and the relevant stimuli is important, not only to the teacher but to also the pupil, for increasing the likelihood of conceptual change. The ways suggested to promote motivation, attention, and generation for reading comprehension (refer back to Table 1, p.52) are also relevant to promoting these processes in the learning in science situation.

<u>Summary of the generative learning model</u>

The key points of the generative learning model are:

1. The existing knowledge of the learner is viewed as the beginning point for the construction of meaning from any experience, not the experience itself. Existing knowledge influences what will be selected and attended to in the environment.
2. The sensory input selected and attended to by the learner, of itself, has no meaning.
3. In the construction of meaning from sensory input, links are generated by the learner between the stimuli attended to, and what is perceived as relevant existing knowledge. The links are central to and determinants of the constructed meaning.
4. The initial or tentative construction is evaluated against the existing knowledge and against the sensory input. This evaluation may result in a restructuring of the existing knowledge. That is, learning may occur.
5. The learner is active in constructing a meaning in terms of attending to selected stimuli, generating links to existing knowledge and evaluating the construction.

<u>Critique of the generative learning model</u>

The comments made with respect to the generative process of reading comprehension also apply here. The useful aspects of the generative learning model are construing of the constructed meaning as distinct from the larger body of existing knowledge; the learning process is seen as an active constructive one under the responsibility, in the final analysis, of the learner; it gives prime importance to the learner's existing knowledge in terms of selective attention, generation of links and of a constructed meaning, and evaluation of the construction.

The model can be criticised on several accounts. Firstly, to date, there are few supporting empirical studies to exemplify the model. In particular, there is little data on the pupils' thought processes as conceptual changes occur, or as the constructed meaning is evaluated. The why, how and what questions remain unaddressed. Osborne and Wittrock (1983) themselves suggest that this would be a fruitful line of enquiry. Secondly, the generative model does not explicitly address questions about the nature of conceptual change by which the comprehender generates new links between different aspects of existing knowledge without new sensory input. However, restructuring can be conceived as occurring without an immediate stimulus from the environment (Skemp, 1979, p.162). Thinking over a situation may give rise to a person constructing a new meaning from previously unrelated aspects of existing knowledge. The generative learning model is able to incorporate this additional aspect. Thirdly, there is little in the model to account for the affective side of learning. For example, how do pupils feel when their long-standing and supposedly useful notions are challenged and in public? The self-concept and esteem of the learner is acknowledged (Osborne, Bell and Gilbert, 1983) but very little is known of how pupils react to and perceive the conceptual change.

2.4.4 Self-concept, commitment, beliefs and emotions

Several writers have addressed the issue of affective factors to explain why learner's may resist conceptual change even in the face of contradictory evidence. Wyer (1977, p.264) suggests that the ease of conceptual change depends upon the degree of commitment to the beliefs involved and the interconnectedness with other beliefs in a cognitive system. Festinger (1964) also addresses the issue, in a wider context than science education, in terms of 'cognitive dissonance', which he defines as the 'existence of non-fitting relations among the cognition' (p.3). He contends that cognitive dissonance leads to activity orientated toward dissonance reduction, and that the degree of dissonance will be a function of the importance to the individual of the conflicting elements. The dissonance can be minimised by attempting to:

a) change one's existing knowledge and beliefs, in accordance with the environmental stimuli, for example, giving up smoking to lessen the chances of lung cancer;
b) change the environmental stimuli, for example, changing one's friends to those who do not keep telling you about the relationship between smoking and lung cancer;
c) add new elements of existing knowledge, for example, a smoker adds to his information of deaths due to lung cancer, information about the probability of death in a car accident.

These changes may or may not succeed in reducing the dissonance.

Associated with the above three ways to reduce dissonance are effort, and possible discomfort and unease with respect to self-esteem. It may be more comfortable to maintain the dissonance than undergo change, especially if the conflicting cognitive elements are perceived as unimportant, for example, scientific constructs.

Head and Sutton (n.d) establish a link between the existing knowledge of individuals and their personality and sense of commitment. They use three basic assumptions about cognition, language, and motivation.

1. A major motivating force for human beings is their need to make sense of their world.
2. Making sense of one's world is an important source of emotional satisfaction, or rephrased - the need to make sense of the world is essentially an emotional need.
3. Most of our mental constructs have a strong language component.

The assertion is made that commitment grows out of particular cognitions and in turn shapes further development of the existing knowledge. This is because commitment to certain constructs, rather than others, carries with it hidden values, and that this belief system influences what is attended to and what further constructions are made.

Claxton (1984) asserts that resistance to conceptual change may be due to a 'personal stake in believing that things are a certain way, that is, if I <u>identified</u> with a point of view then I cannot give it up without also giving up something of myself. If I am identified with my own competence, for example, then even to admit I might be wrong may be too scary. Learning in this case becomes a threat to myself'.

He adds that learning may also be a threat to a person's knowledge structure as it involves radical upheaval of everything the person knows. It may also be a threat to a person's social stability in that to change may put the person in conflict with society (including the church), family and friends.

These three views may be summarised by saying that possible reasons for resistance to conceptual change may be due to a perceived threat to the person's self-esteem, or because of perceived lack of importance of the change.

West and Pines (1983) challenge the position that learning is a rational process and that the rational aspect of learning cannot be studied in isolation from non-rational aspects. They argue that the non-rational components are instrinsic to conceptual change in the individual and that these should not be excluded in investigations of conceptual change. They feel that the basic unit of conceptual change should retain both the rational and the non-rational components of the process. They distinguish between the factors that may be important determinants of ability or willingness to learn, for example, motivation, and what they mean by the non-rational components of conceptual change, that is the learner's feelings. Does the learner feel good? Bad? Uncomfortable? They claim that the non-rational components -

> 'are integral parts of what learning is, and not simply motivational, attitudinal, or affective antecedents upon which learning depends.'

They list four groups of interrelated feelings (the non-rational components of learning) as feelings of power that come with the ability to identify, predict and make sense of the world; the feelings of satisfaction that come with patterning and ordering imposed on a complex world; the positive feelings associated with aesthetics; and the comfortable feelings of personal integrity and lack of dissonance.

2.5 SUMMARY

The issues outlined in the above review of the literature, and requiring further resolution by research and debate are:

1. the constructive and interactive nature of reading comprehension and learning;
2. the role of existing knowledge, particularly alternative conceptions, in the learning of a scientific concept;
3. possible explanations for the resistence to conceptual change in science education, from both rational and emotional perspectives; and
4. ways of promoting conceptual change.

2.6 RATIONALE FOR THIS INVESTIGATION

The present study was carried out to investigate, in detail, aspects of the generative learning model in terms of conceptual change and with particular reference to reading comprehension.

The generative learning model was selected as it (like schema theory and progressive refinement theory) views the reading and learning processes as being constructive and interactive; the reader/learner is conceived as being active in the pursuit of meaning (and not a passive encoder and retriever of information), particularly in evaluating a constructed meaning; and meaning is not viewed as inherent in language to be extracted of recovered, but as something each reader/learner must construct for herself or himself. In addition, of the three models, it best accounts for conceptual change, and has been specifically related to both reading comprehension and learning in science.

In particular terms, the investigation centred around the question:

> 'To what extent, and in what ways, do students, who have an everyday meaning of the word 'animal', use this existing knowledge to comprehend a science text about 'animal' and in what ways does this influence conceptual change?'

More specifically, it focused on:

1. For an individual, what is the nature of and to what extent do the following occur:
   a) the generation of links between the text stimuli (the print) and the learner's existing knowledge;
   b) the construction of the author's intended meaning or an alternative construction;
   c) the evaluation of the construction?

2. To what extent and in what ways is conceptual change promoted by the reading of a text in which the author writes about the scientific concept of animal:
   a) in a style and content typical of current secondary science text books;
   b) so as to challenge and conflict with the everyday concept of animal; or
   c) explicitly compares it to the everyday concept of animal?

CHAPTER 3 : THE RESEARCH DESIGN

3.1 OVERVIEW

As outlined at the end of the previous chapter, this investigation focused on two aspects of reading comprehension and conceptual change. One aspect was the nature of the comprehension process - the generation of links between the text stimuli and the learner's existing knowledge, the nature of the constructed meaning, and the evaluation of the construction. The second aspect was that of the text characteristics, which appeared to promote conceptual change when students read the text. The first aspect is primarily concerned with reader-based factors of the reading comprehension and learning processes, and the second is primarily concerned with text-based factors. However, it should be emphasised again, that in an interactive and constructive view of reading comprehension and conceptual change, both reader and text factors are seen as important. But it was felt that to investigate complex processes, such as reading and learning, only some aspects of the processes could be adequately addressed in any one phase of the whole investigation (although not to the exclusion of other aspects). Different methodologies were employed to research into the two different aspects - qualitative, interview methodologies for the reader-based factors, and for the text-based factors, quantitative survey measures, supported by small scale interviews to aid in the interpretation of findings.

To investigate the reader-based factors, two methodologies were used, namely the 'spot-the-mistake' (in Phase I) and the 'reading-to-learn' (in Phase II) interview techniques.

An overview of the research design is outlined in Table 2.

TABLE 2: An Overview of the Research Design

Central aspect of the Research	Type of Methodology used	Name given to technique used	Name of Research Phase
Cognitive processes of the reader during comprehension and conceptual change	Qualitative	'spot-the-mistake' interviews	I
		'reading-to-learn' interviews	II
Text characteristics that promote conceptual change	Quantitative	'classroom reading task'	III

In the remainder of this chapter, the issues in research in reading comprehension and conceptual change will be discussed (Section 3.2); the methodologies of the three phases (Section 3.3); the texts (Section 3.4); the surveys (3.5) and finally a summary for the chapter (3.6). The details of the procedures, used in each phase to collect the data will be outlined in later chapters.

3.2 ISSUES IN RESEARCH IN READING COMPREHENSION AND CONCEPTUAL CHANGE

Several issues in methodology were addressed in the design of the research.

3.2.1 Naturalistic research

In both fields of research into reading comprehension and learning in science, there is a recent, but well-established, trend to use naturalistic rather than classical experimental research. This current investigation is of the naturalistic type. It is not intended within the scope of this thesis to present a case for naturalistic research for it has been done convincingly elsewhere, for example, Carey (1980), Easley (1982), Posner and Gertzog (1982), LeCompte and Goetz (1982), and Smith (1982). The reasons for employing primarily naturalistic research methodologies in this investigation, are summarised as:

a) Descriptive data. Naturalistic research can elicit descriptions and explanations of the cognition of learners (Easley, 1982). This qualitative data aids us in understanding the mechanisms underlying cognition, rather than just making the predictions as offered by quantitative research. It is this understanding of the processes that may help teachers to improve learning and comprehension in the classroom. Easley (1982) suggests that obtaining qualitative, then quantitative data is an approach taken by natural scientists and one that may be of value to educational researchers as well. Others, for example, Tierney and Cunningham (1980) also advocate an integrative approach of naturalistic and classical experimental research.

b) Talking to students. Researchers cannot directly access the thinking of learners and readers. We can only make inferences from their oral and written language. In the interactive interview situation, the researcher is able to minimise incorrect interpretations and inferences drawn by the researcher from the student's language, if tentative interpretations and explanations are fed back to the student for personal validation.

An interview enables the researcher to obtain rich, indepth data because of the personal, face-to-face contact the interviewer has with the student.

In an interview situation, much control can be given to the interviewee as to the content and direction of the discussion. There is less chance for the researcher's perspectives and personal meanings to predetermine and dominate the flow of events.

c) Ecological validity refers to how representative the phenomenon and context under investigation is of the 'real' world. In naturalistic research, the maintaining of ecological validity is valued, and as far as possible, data collection is undertaken in natural, not contrived situations. In this way, the complexity of the phenomenon is maintained and not reduced to trivialised variables (Easley, 1982).

d) A grounded theory approach, as suggested by Glaser and Strauss (1967) and used by Battersby (1981), enables the gathering of data to be guided by an analysis of the data collected previously, rather than by a pre-planned programme as is more common with classical experimental research. The interaction of data collection and data analysis throughout the research allows for the opportunity to further investigate any unanticipated results and hypotheses as they occur and develop.

3.2.2 Thinking-out-aloud

In the last five years, there has been a growing acceptance of the value of verbal self-report data to describe and explain the thinking processes involved in reading and learning. This is more evident in the science education than in the reading field. Criticisms of verbal-report data in reading research are summarised in Garner (1982) and centre on two main issues of whether:

a. learners and readers can access the workings of their minds and therefore, know about their own thinking, and whether
b. the act of self-reporting changes or distorts the cognitive processing itself.

The first issue has underlying it, a judgement about the value of people's statements, beliefs and opinions. In this investigation, these are valued as they communicate the person's own personally constructed reality. However, caution is taken to note that self-reports may be incomplete, and that students with limited linguistic skills, lack of confidence, and shyness may not give as full or as expressive reports as others (Pines, 1980; Stead, 1980).

The second issue is an important one. It is acknowledged that verbalising thoughts for the elicitation of data on content and strategies of knowledge may result in changes to that knowledge. Barnes (1976, p.18) suggests that language is used not only for communication but for learning as well. Language (oral or written) is seen as a major means by which we construct meanings to make sense of the world. Language is not the same as thought. Language allows us to reflect upon our thoughts.

Barnes states:

> 'Talking and writing provide means by which children are able to reflect upon the bases upon which they are interpreting reality, and thereby, change them.' (p.31)

In using language, we actively participate in the construction of meaning, making sense of our world. This active involvement demands that existing knowledge be used. In using it, the nature of the knowledge and ways of using it, may be altered. Hence, a methodology involving verbal reports may maximise learning opportunities. In this respect, the research may not be naturalistic as this degree of verbalising is not typical of reading and learning in science education. However, it is felt justified in terms of enabling description and explanation of the phenomena being studied. It is noted that an interview situation, requiring self-reports, may provide an 'ideal' situation for self-directed learning, rather than what is possible in a typical classroom situation.

Another aspect, is that the task required by the researcher may not be the one normally required of the subject, and so the elicited data are not a reflection of normal processing. Ericsson and Simon (1980) suggest that verbalising about cognitive processes and products affects them only if the instructions of the researcher require verbalisations of existing knowledge and constructions not attended to otherwise. They, therefore, suggest the use of non-specific, non-cueing instructions. In an interview situation, the reader/learner can be given control over the direction and focus of the interview so as to elicit information seen as relevant and important by the student, rather than by the researcher.

The growing use of and acceptance of verbal reports as data has come about through increased research in the area of metacognition, for example Garner (1982); Hare and Smith (1982); Garner and Alexander (1982) Brown et al (1982), and an increased interest in finding out, not only the products of comprehension and conceptual change, but also the strategies and cognitive processes (e.g. inferencing, generation of meanings) used, for example, Newell and Simon (1963); Collins, Brown and Larkin (1980).

Another aspect of this issue, is whether the verbal reports are given concurrently or retrospectively (Brown et al, 1982; Chang, 1983). While the retrospective reports do not distort the actual comprehension and learning processes, they may not accurately reflect what was occurring as students are reporting from memory (Garner, 1982).

3.2.3 Pre- and post-measures of existing knowledge

Surprisingly, it is only recently that reading comprehension researchers have been concerned with assessing existing knowledge prior to reading and learning tasks (Lipson, 1982; Tierney and Cunningham, 1980). Previously, most researchers concerned themselves only with measures of post-reading comprehension and recall. In addition, as Lipson (1982) points out, the view of existing knowledge is often a dichotomous one - it either exists or it doesn't. But the existing knowledges of readers/ learners may differ in amounts and kinds.

The work in science education on alternative conceptions has highlighted the powerful influence of existing knowledge on comprehension and conceptual change, and that the existing knowledge of many students is often qualitatively different to that of a scientist. This field of science education research has placed value on students' personal constructions of meaning, and devised ways to elicit these constructions (Driver and Erickson, 1983).

In this investigation, pre- and post-reading descriptions of existing knowledge were considered an important part of the research, not only to eludicate the existing knowledge of the student, but to document any changes that may occur during the reading and learning task. The eliciting of existing knowledge was done by interviews, and by surveys based on previous interview findings from science education research. It was considered of value, not only to find out if the student has used or learnt the scientific concept (of animal) but also to find out the nature and use of alternative conceptions. In other words, the presence or absence of the scientific concept in the student's existing knowledge is only part of the focus of the research. The other part is a description of the ideas that are present and used as alternatives to the scientific concept.

3.3 THE METHODOLOGIES OF THE THREE PHASES

3.3.1 The Phase I methodology : 'Spot-the-mistake' interviews

This methodology may be categorised in the error-detection paradigm (Winograd and Johnston, 1982) and is an adapted form of one developed and used by Nicholson (1982, p.81-83). In a one-to-one interview situation, students were asked to read an expository text about the scientific concept of animal and asked to identify, verbally, small errors in meaning in the text. One or two deliberate errors had been included in the text, e.g. 'A lion eats stones', 'A carrot is an animal'. Of interest to the researcher was not whether the students identified correctly the deliberate errors, but to elicit the perceived errors from the student.

According to the generative reading and learning models, readers use aspects of their existing knowledge and the visual stimuli of the text to generate links and construct a meaning. This newly constructed meaning will be contrasted with various aspects of existing knowledge and some status given to the newly constructed meaning. Where existing knowledge and the newly constructed meanings are in conflict, the relative status of each will vary - from task to task, and from context to context. In the classroom situation, students may place greater emphasis on the new construction than on their own existing knowledge (or at least temporarily devalue their existing knowledge). If the existing knowledge used by students to construct a meaning and evaluate their constructions is to be elicited and investigated, then students have to be reassured that their existing knowledge is of higher importance, or more acceptable, than what they perceive the author's intended meaning to be. Knowing that the text contains errors may lower the status of the constructed meaning and raise the status of their existing knowledge.

In deciding if a text sentence contains an error or not, the students would have to match their new constructions with parts of their existing knowledge. In an interview situation, it was hoped that students would verbalise, and hence communicate to the researcher, their constructed meaning (and indirectly the existing knowledge and text stimuli linked to generate the construction) and the existing knowledge used to evaluate the constructed meaning. Of particular interest would be the use of the everyday meaning of 'animal', which is part of the existing knowledge of many students, to comprehend and learn from a text about the scientific concept of animal. It was expected that students, who had only an everyday meaning of animal would detect not only the deliberate errors, but others, depending on the degree of mismatch between the everyday meaning in existing knowledge and the scientific concept in the constructed meaning.

The demands on the readers in Phase I to detect errors are not normally a part of the reading process and in this aspect the methodology was not naturalistic. The amount of elaboration and discussion of the text, and the time taken to complete the reading are also not usual of reading in science lessons. However, it was hoped that despite these distortions, the methodology would provide a valued way of obtaining rich, in-depth qualitative information on the comprehension process.

3.3.2 The Phase II methodology : 'Reading-to-learn' interviews

The methodology of Phase II of the investigation was designed in the light of the Phase I methodology and results, to supplement them and to counterbalance the un-naturalistic aspects. Firstly, the texts used in this phase contained no deliberate errors, and in interviews the students were asked to read the text to learn the scientific concept of animal. Data on the generation and evaluation of meanings during the processes of comprehension and conceptual change, were collected by student self-reports. The students were asked to stop at the end of each sentence (or groups of sentences) to verbalise what they were thinking about, in a way not unlike that used by Olshavsky (1976-1977), Garner and Alexander (1982), and Hare and Smith (1982).

The interview situation enabled the researcher to validate her interpretation of the self-reports and to seek clarification of the self-reports if need be. It was envisaged that students would verbalise (and hence, communicate) their constructed meanings for the text, and thereby the nature of the links between their existing knowledge and the text stimuli. It was hoped that a discussion of their constructed meanings would also eludicate any conceptual change occurring and the evaluation of the constructed meaning. It was also expected that the verbal reports would be retrospective to a certain extent, with reference to a particular sentence. If students made changes to their constructed meaning and existing knowledge, it was anticipated that these would be verbalised almost concurrently, but not necessarily, with the thinking.

While the methodology of Phase II is more naturalistic than that of Phase I, it may be considered contrived on several counts. In a normal science lesson, students are not usually required to discuss and elaborate, to such an extent, their constructed meanings during reading (and learning). Also they do not take so long to read three pages of text, and usually they receive feedback as to the scientific acceptability of their constructions. These departures from what normally occurs were felt to be of less importance than the gains made in terms of the data collected on the construction and evaluation of meaning in reading comprehension and conceptual change. It was felt potentially valuable to find out what was likely to occur in 'ideal' conditions before investigating similar research questions in a more naturalistic setting.

3.3.3 The Phase III methodology : A classroom reading task

Unlike the other two methodologies, the Phase III methodology was quantitative, and was essentially a conventional pre- and post-reading survey design. The different methodology reflected the different purpose of Phase III of the investigation. Whereas the first two phases focused on the readers' cognitive processes, this third phase was designed to look at different text characteristics and conceptual change. On a group sample, rather than on an individual basis, the results of a survey on students' conceptions of animal before and after reading a particular text, were compared. (The details of the texts are given in section 3.4 and Appendices A, B, C, D). Of all the three phases, the task required of the students in Phase III approached most closely that required of students in a normal science lesson. After the pre-survey, the students in a normal time-tabled science lesson in a science laboratory were asked to read a text to learn the scientific concept of animal. They were alerted to their having to answer more questions at the end of the task. The reading task took approximately five to ten minutes, with little discussion between students. The atypical aspects included the reading being out of context with the current lessons, the lack of discussion between students over their survey answers, and the lack of feedback as to the scientific acceptability of their responses on the survey. In addition to the quantitative data collection, a small sample of students completed the same surveys and reading task in an interview, not a classroom situation. It was envisaged that the data elicited would help explanations and interpretations of the quantitative results.

3.4 THE TEXTS

The content and construction of the texts used in the research not only took into account research findings of the kind of writing that children comprehend with minimal difficulty (Bell and McGrath, 1983; Dilena, 1978), but also took into account recent research findings on children's alternative conceptions in science (Bell, 1981a) and conceptual change (as reviewed in Section 2.4.3).

Few textbooks contain sentences on the scientific concept of animal. The word is often used by authors without explanation and it is assumed that students 'know' of the word. That they have a meaning for the word is a correct assumption, but it tends not to be the scientific one (Bell, 1981a). Children's books, particularly the picture books, contain mainly exemplars of the prototypical animals, e.g. lions, cows, deer, cats, dogs, as these are also the more familiar animals to children. It is rare to find pictures and sentences of non-prototypical exemplars of the concept, e.g. insects and fish. Secondary textbooks are restricted with respect to given exemplars and non-exemplars, and rather than write on the distinguishing characteristics of animals, authors tend to write on the differences between animals and plants. Because of the above three reasons (research findings on reading difficulties and learning in science, and lack of suitable existing texts), the researcher was essentially required to create the text material for the three phases. Basically, there were three texts about 'What is an animal?'. A fourth one was included in Phase III to act as a control. The four texts were called -

a) The Challenge Text (Text 1)

b) The Dual Meaning Text (Text 2)

c) The Typical Text (Text 3)

d) The Control Text (Text 4) - used only in phase III.

Due to the grounded theory approach to data collection and analysis, the texts were rewritten, if need be, at the end of each phase. Hence, while, for example, the Challenge Texts in Phases I, II and III were very similar, they were not identical. The changes made are documented in Appendix A. The three texts used in Phase I may be found in Appendix B; the Phase II texts in Appendix C; and the Phase III ones in Appendix D. All the texts were similar in that they contained information to help the reader learn the scientific concept of animal. They differed with respect to the context in which the information was embedded. The basic characteristics of each text will now be elaborated on.

a) The Challenge Text (Text 1)

The purpose of using this text was to investigate the effect of students being helped to construct a meaning of the text which may challenge or conflict with their existing knowledge of 'animal'. Nussbaum and Novick (1981) and Hewson (1981a) have suggested that promotion of cognitive dissonance may be a necessary step toward cognitive change from an alternative to a scientifically acceptable concept.

The first paragraph of the Challenge Text was deliberately written to help readers construct a meaning that would conflict with an everyday concept of animal. Firstly, many exemplars of animals in the scientific sense (and sometimes in the everyday sense too) were included. These examplars were prototypical and familiar ones e.g. cow, goat,opossum, rabbit; and non-prototypical ones, e.g. spider, earthworm, whale, fly. The exemplars were also chosen, so that for any one sentence, prototypical and non-prototypical exemplars were given, e.g. 'Rabbits and grassphoppers are two animals that hop'. Hence, the familiar and possibly conflicting ideas were sequenced relatively closely in the text. Secondly, the author also encouraged the student to construct a meaning, in which the distinguishing characteristics of the everyday concept were challenged. The distinguishing characteristics of size, habitat, mode of movement, number of legs, and furriness were included. For each everyday characteristic, prototypical and non-prototypical exemplars were used to elaborate and exemplify. For example, for the characteristic of 'legs', 'A weta is an animal with six legs. A cow is an animal with four legs'. A student's constructed meaning for the first sentence may conflict with her or his everyday concept, namely, that wetas are not animals, although they do have six legs. However, the constructed meaning for the second sentence may match an everyday concept of animal.

b) The Dual Meaning Text (Text 2)

In this text, the two meanings of the word 'animal' - the everyday and scientific meanings- were explicitly mentioned. The rationale for this was that students with only an everyday meaning could construct from the text a meaning, of which part would match their existing knowledge, and of which part would be new (the scientific meaning). It was felt that by helping students to clarify their own existing knowledge, they would better be able to relate the construction of the scientific meaning to their existing knowledge.

The sentences in the text on the everyday meaning contained ideas to help the reader construct the everyday meaning with respect to exemplars, groupings and the use of the everyday meaning. There were similar sentences for the scientific meaning. In the summary at the end of the text, a set-subset diagram was included by the author to help the reader further clarify the similarities and differences of the two meanings with respect to exemplars. As with Text 1, this text takes into account what we know about children's possible existing knowledge of animal.

c) The Typical Text (Text 3)

This text was written as being representative of the ones available for use by junior secondary science students. It was constructed by collecting sentences from five published texts: Ewington and Moore (1971); Junior Secondary Science Project (1968), McChesney (1968), Petchell (1982), and Wong and Dolmatz (1971). The sentences were then co-ordinated together by researcher-written sentences. The exact composition is given in Table 3. With the exception of McChesney (1968), the authors of the books included only 1 or 2 sentences on each of the key ideas relating to the concept of animal. Therefore, additional paragraphs on food chains, modes of feeding and animal movement were included to make the length of this text (approximately 770 words) comparable to the lengths of the other two texts. These additional paragraphs were compiled from sentences in the five different published texts, and the ecological topics in the paragraphs are identical to those in the published texts, in which the concept of animal is mentioned (if at all). Hence, the concept of animal is embedded in Text 3 in an ecological context. Also, the concept exemplars mentioned in these texts tended to be prototypical as were the ones given in the published texts.

d) The Control Text (Text 3)

This text was used only in Phase III. It was similar to the Typical text except that there were no elaborations on the exemplars or on the distinguishing features of an animal.

TABLE 3: The Composition of the Typical Text

Source of Sentence	Sentence in Text 3	Page in Source Book
Petchell (1982)	1 39, 43, 44	48 57
McChesney (1968)	25, 26 34, 35, 36 17, 18, 19, 20, 21 22, 23 27, 28 29 31, 32	146 132 143 144 147 149 150
J.S.S.P. (1968)	37, 38	2
Ewington and Moore (1971)	5, 12, 14	8
Wong and Dolmatz (1971)	45	241
Researcher	2, 3, 4 6, 7, 8, 9, 10, 11 13, 15, 16 24, 30, 33 40, 41, 42	

In summary, the distinguishing features of the three texts were the contexts, in which the scientific concept of animal was embedded, namely:

1. the Challenge Text contained a paragraph, which aimed at helping the reader construct meanings that may conflict with the everyday meaning of 'animal';

2. the Dual Meaning Text contained sentences, which aimed at helping the reader construct a meaning of both the everyday and scientific meanings of 'animal';

3. the Typical Text, contained, as do many published texts, sentences about the ecological role of animals.

The texts, were, however, similar in several ways. As mentioned previously, the Typical Text was composed essentially of sentences taken from five published texts. These sentences were made into a more cohesive text with sentences written by the researcher. The sentences from the published texts were altered slightly to help students construct a meaning from the text. The changes made were in response to those suggested by Dilena (1978) and Wittrock (1981b) and were to remove:

a. complex sentence constructions,
b. any irrelevant technical or scientific terms,
c. unnecessary logical connectives, and
d. referents involving pronouns and the general 'there'.

Other changes were made to take account of research findings on improving learning by reading. These were:

a. inserted questions to alert the reader/learner to the importance of the construction of the next sentence(s),
b. paragraphing to identify distinct logical sections,
c. underlining of key concept words to alert the reader/learner to these words,
d. diagrams to present a pictorial and alternative presentation to the text,
e. a title to direct the reader's attention,
f. the inclusion of personal sentences to ease the otherwise impersonal expository style, for example, 'the main ideas we have read about', and
g. a summary of the key ideas at the end of the text.

These factors, which are known to promote comprehension for readers, were incorporated in the Challenge and Dual Meaning Texts, as well as the Typical Text.

The key concept sentences in all three texts were the same. These were:

a. 'An animal is a living thing that eats other animals and plants for food.'

b. 'Animals are also called consumers.'

c. 'Animals which eat plants or parts of plants are called herbivores.'

d. 'Animals which eat other animals or their remains are called carnivores.'

e. 'Animals which eat both plants and animals are called omnivores.'

The concept of consumer was included because of its close relationship to the scientific concept of animal. The concepts of herbivore, carnivore, and omnivore were included because of the students' familiarity with these concepts (most students had met the terms in Forms 1 and 2) and because of their close relationship to the concepts of animal and consumer.

All three texts also contained a sentence (although not identical) about living things being divided into two main groups, animals and plants. All three texts had the heading 'What is an animal?' and were approximately 770 words in length.

The Challenge and Dual Meaning Texts were similar in that both were based on research findings about children's concepts of animal. Specifically, they had also the following in common:

a. After the sentence 'All living things are either animals or plants' was the sentence 'There is no other group.' The inclusion of this sentence was based on the research (Bell, 1981a) in which it was found that many students do not view groups such as insects and mammals as subsets of animal but as comparable groups. They do not appear to have a hierarchical classification. The author's intention in including the second sentence, was to challenge the students to possibly construct the first level in the hierarchical classification.

b. The examples of animals and the reasons for calling them animals were elaborated on by the author, for example, 'A spider is an animal as it eats flies for food.' This was to explicitly illustrate the use of distinguishing characteristic of consumer feeding as a rule to distinguish between animals and non-animals. At the same time, it also provided an opportunity for the students to learn what the various animals eat.

c. Non-exemplars of animals were mentioned in the text. For example, 'A car is not an animal as it is not living and it does not eat plants or animals.'

d. A paragraph and a diagram were included on the set-subset aspects of animal. This was to challenge students' existing knowledge of the everyday meaning, and to help them construct a hierarchical classification as would a scientist.

As already mentioned, the texts were modified and improved at the end of each phase. The initial trialing and changes made are described in Appendix A. Also in Appendix A, in Tables (31) to (33), is the composition of the Phase III texts with respect to number of words, exemplars and unique and shared paragraphs. A Fry readability measure and an Elley noun count (Nicholson, 1982) were carried out on the Challenge Text used in Phase III. The Fry readability measure gave an average of 10.2 sentences and 132.3 syllables for the three 100 word passages indicating that the text is suitable for some primary and intermediate children. The Elley noun count gave a mean noun frequency of 4.56 for the three passages, and a Performance Achievement Test of reading

reading comprehension level score of 5. Both measures indicate that the 13-year-old students in the samples could be expected to 'read' the text without difficulty in terms of the nouns, and sentence and word lengths. There is nothing to suggest that the other texts were significantly different in terms of readability as many of the paragraphs were similar to those in the Challenge Text.

3.5 THE SURVEYS

a. The science surveys were based on those used by Bell (1981a). They were developed from the results of qualitative research and investigated whether the student categorised an instance as an animal or not. In Phases I and II, pre-surveys (see Appendix E) were used to elicit information on which to select the interview sample, that is, students using an everyday meaning of 'animal'. The instances used were those ones known to discriminate between students using an everyday and those using a scientific meaning (Stead, 1980). Similar questions on 'living' and 'plant' were also included to provide additional information on students' existing knowledge.

The post-survey for Phase II (see Appendix F) contained parallel instances e.g. dolphin instead of a whale, to aid the researcher in assessing any change in a student's existing knowledge.

The surveys included illustrations and required the students to circle a 'Yes' or a 'No' to indicate if they considered the instance to be an exemplar or non-exemplar of the concept.

The Phase III pre, post and post-post surveys (see Appendix G) were similar in that the student was required to categorise the instance as an exemplar or not. However, the number of questions was larger; there were no illustrations to save space; there were no questions on 'living' or 'plant'; the instances were related to the exemplars in the texts read (see Table 16 for details); and a final question (41) required a written answer on the perceived distinguishing characteristics of animals.

b. Progressive Achievement Tests (P.A.T.): Reading Comprehension

This test (as part of a series) was designed to assess attainment in general reading comprehension skills - both factual and inferential comprehension of prose material (Elley and Reid, 1969). The tests are designed for use with pupils early in the school year and the level scores indicate the instructional level at which each pupil is performing in the skills tested, regardless of age or class. The reading comprehension levels indicate the difficulty of material that a pupil can read with 'adequate comprehension'. On the whole, the pupil samples of Phase I and II were chosen since they had scored average results (a level score of 7,8 for Form 3 pupils). In other words, the samples did not contain pupils with reading difficulties or those very skilled in reading.

c. Test of Scholastic Abilities (T.O.S.C.A.)

The samples of Phases I and II were selected, in part, on their results on T.O.S.C.A., Secondary, Form B. This test reportedly:

> 'measures those verbal and numerical reasoning abilities deemed to be requisites for success in academic aspects of the New Zealand school curriculum. Thus, performance on the range of tasks sampled by the test provides : (i) a broad measure of the learned or developed abilities which may be termed 'scholastic abilities' and (ii) an indication of the pupil's capacity to cope with the abstract manipulation of the verbal and numerical symbol systems typical of mainstream New Zealand society. The T.O.S.C.A's single total score summarises the pupil's stimulus materials and test tasks chosen for their contribution to the assessment of scholastic abilities.'
> (Reid, Jackson, Gilmore and Croft, 1981, p.4)

Most of the Phase I and II sample were selected from a large class sample as being those whose scores were 'average', i.e. in stanines 4, 5 or 6.

3.6 SUMMARY

The research was characterised by:

a. three separate phases, each with a different methodology and with varying degrees of naturalism,

b. qualitative interview data, and quantitative survey data,

c. a grounded theory approach, and

d. three different kinds of texts about the scientific concept of animal, two of these texts incorporating research suggestions on promoting conceptual change.

CHAPTER 4 : THE RESULTS OF PHASE I

4.1 INTRODUCTION

As outlined in Chapter 3 (section 3.1), the focus of Phase I was to investigate, using a qualitative methodology, the nature of some of the cognitive processes involved in reading comprehension, namely, the generation of links between the text stimuli and the learner's existing knowledge, the nature of the constructed meaning, and its evaluation. Of particular interest was the role of the reader's existing knowledge of 'animal', especially if the reader's concept of animal was initially an everyday one rather than the scientific one.

The methodology used was a 'spot-the-mistake' interview (see section 3.3.1 for details), which was characterised by a one-to-one interview situation, concurrent verbal self-reports on the part of the student, and a task which required the reader to identify perceived errors in the text. The texts contained one or two deliberate errors, for example, 'A car is an animal', and during the interview, the researcher elicited the nature of the perceived errors and the reasons why they were considered errors. While not entirely naturalistic, the methodology was designed to elicit the existing knowledge used in comprehension (both in the construction and in the evaluation of the meaning) and to act as a catalyst for discussion.

The sample was composed of two students from each of three Form 3 classes (aged approximately 13 years) from a large, city, coeducational school, and they were selected on the basis of P.A.T. comprehension scores, T.O.S.C.A. scores, science survey responses and sex. Each class was taken by a different science teacher. Details of the six students are given in Table 4. All six students scored average results on the P.A.T.

TABLE 4: The Details of the Phase I Sample

Student	Sex	Level Score P.A.T. Comp.	Stanine TOSCA	Science Pre-survey - Is it an animal? Cow	Person	Whale	Spider	Worm
Class 1								
301	F	8c	6	Y	Y	N	N	N
302	M	8a	4	Y	N	N	N	Y
Class 2								
303	M	8a	6	Y	Y	N	N	N
306	F	7c	6	Y	N	Y	N	N
Class 3								
304	F	7c	6	Y	Y	Y	N	N
305	M	8c	4	Y	Y	Y	N	N

Key Y = Yes N = No

comprehension and T.O.S.C.A. tests, and to varying degrees had used an everyday meaning of the word 'animal' to answer the science survey (given in Appendix E). The school's reading resource person had administered and scored the P.A.T. comprehension tests, and the researcher the T.O.S.C.A. and science surveys.

The texts used are to be found in Appendix B, and are described in detail in section 3.4. To summarise, all three texts were about the scientific concept of animal, but they differed in the contexts in which the scientific concept was embedded:

The Challenge Text contained a paragraph, which aimed at helping the reader construct meanings that may conflict with the everyday meaning of 'animal';

The Dual Meaning Text contained sentences about both the everyday and scientific concepts of animal; and

The Typical Text contained, as do most published texts, sentences about the ecological role of animals.

The Challenge and Dual Meaning Texts were written by the researcher to take into account recent research findings on promoting conceptual change. In addition, small deliberate author errors were included in each text as part of the methodology. These were:

Challenge Text:	'A carrot is an animal'
	'Lions eat stones'
Dual Meaning Text:	A car was given as an exemplar of an animal
	'Lions eat stones'
Typical Text:	The tiger was given as an exemplar of a herbivore.

These errors in the text were such that a student could easily conceive them as being a mistake in wording on the part of the author or printer.

One such mistake was placed at the beginning of each text, so that students would be likely to comment on what they considered to be an error, early in the interview. With Texts 1 and 2, the second error was included approximately two-thirds into the text. Only one error was included in the Typical Text, as the abstract nature of the text made it difficult to insert simple errors.

Procedures. The sample of students was selected after three science classes had been given a P.A.T., T.O.S.C.A. and science survey to complete. The selected students were then taken out of normal, timetabled science lessons and interviewed in a one-to-one situation in a small bookroom or storeroom adjacent to the laboratory. The student's consent was obtained for her or his participation in the research and for the use of the tape recorder. All students were interviewed on two separate occasions, and some for a third time. All students were initially interviewed as to the reasoning behind their choice of answers in the science survey to obtain a fuller description of the existing knowledge of 'animal' used to answer the survey. This initial interview was called the existing knowledge interview. Then, all the students were interviewed a second time using the 'spot-the-mistake' method, with one of the three texts. The introduction given to each student was about the nature of the research:

> 'I am interested in reading in science lessons. In particular, I'm interested in what we think about when we read.'

and about the purpose of their reading:

> 'I'd like you to think out aloud while you are reading. I can't read your mind so that you will have to tell me what you are thinking about! There are small errors in meaning in the reading and as you go through the reading, I'd like you to tell me if there is anything you feel is wrong, unusual or strange.'

The students were then given a practice in spotting errors during the reading of the nursery rhyme 'Jack and Jill', which was familiar to all students, and which had two minor errors in the text.

Students 301, 302, 303 and 306 read either the Challenge or Dual Meaning Text initially, and in a third interview read the other one. Students 304 and 305 read only the Typical Text. (The interview schedules for each student are given in Table 5). Hence, two students read each text and the Challenge and Dual Meaning Texts were read in a third interview by four of the students. Originally, the research design for Phase I intended that only the findings of the first two interviews (the existing knowledge and a reading interview) of each student be considered for data analysis. The reading of the other experimental text by students 301, 302, 303 and 306 in a third interview was a trial to see if the reading of two texts influenced the students' reading comprehension in any way. Overall, in the third interview, the students were more at ease in talking with the researcher and the students gave answers similar to those in the second interview (i.e. the first reading interview). Only student 301 changed her existing knowledge substantially, and these changes occurred in the first reading interview. The researcher therefore, decided to include the findings of both the second and third (reading) interviews.

The interviews lasted for 30 to 50 minutes depending on the willingness of the student to talk, and they were audio-taped and transcribed for later analysis.

TABLE 5: The Interview Schedule for Phase I

	Existing knowledge interview	'Spot-the-mistake' A reading interview	
Student code	First interview	Second interview	Third interview
301	31. 5.82	23. 6.82 Text 2	29. 6.82 Text 1
302	31. 5.82	5. 7.82 Text 2	14. 7.82 Text 1
303	10. 6.82	10. 6.82 Text 1	21. 6.82 Text 2
304	22. 6.82	28. 6.82 Text 3	-
305	8. 7.82	14. 7.82 Text 3	-
306	15. 7.82	19. 7.82 Text 1	22. 7.82 Text 2

Key
Text 1 : Challenge Text
Text 2 : Dual Meaning Text
Text 3 : Typical Text

4.2 RESULTS OF PHASE I

As already docmented in section 3.3.1, the 'spot-the-mistake' methodology was used to elicit data on the nature of and the ways in which existing knowledge is used to construct and evaluate a meaning for the print. The methodology was designed to raise the status of a student's existing knowledge so that some of the existing knowedge, likely to be used in the construction and evaluation, would not be suppressed in an interview situation, but that students would be reassured that their existing knowledge was worthy of comment. It is only when students feel confident enough to discuss their ideas that the researcher can elicit otherwise hidden data.

In documenting the analysis of the qualitative data, only key examples have been given here. Other examples may be found in Bell (1982b).

The 'spot-the-mistake' task, to a large extent, determined the form of the data and data analysis. The elicited data about the role of existing knowledge were, therefore, primarily on what and how the existing knowledge was used to evaluate the constructed meaning. However, data were also obtained on the nature of the existing knowledge linked with the text stimuli in the generation of a construction, and on the nature of the construction itself. The following documentation of the data and its analysis reflects the primary emphasis on the existing knowledge as it was used in the evaluation of constructed meanings.

4.2.1 The use of the everyday meaning of 'animal'

Five of the six students (and to a lesser extent student 301) made statements indicating that they were to varying degrees, using an everyday meaning of the word 'animal' in constructing a meaning based on the text stimuli, and in evaluating that meaning. They perceived the constructions as not matching their existing knowledge, and hence, perceived the constructions as errors. These 'errors' included author inserted errors and others. This is illustrated in terms of:

a. <u>Exemplars of animals given in the text</u>

In the everyday meaning of 'animal', only the large, four-legged furry creatures are considered to be animals. Students 302, 303 and 306, who read the Challenge and Dual Meaning Texts constructed the author's intended meaning (including the scientific concept) but rejected it in favour of their own existing knowledge. A few representative quotations are:

1	2
A spider is an animal found in a crack.	'And a spider, that's not an animal, it's an insect 3(...the sentence "An animal can be found in a crack" What would be a better example for you?)4 A mouse would live in a crack.' (303/1)5
An earthworm is an animal as it eats decaying leaves in the soil.	'An earthworm isn't an animal, it's an insect - ah, I don't think you'd call an earthworm an insect, it hasn't got any legs, and it just rolls around on the ground. It slides along'. (306/1)
A person is an animal found in a house.	'A person's not an animal, a person's a mammal. We are made like animals, doesn't mean we're animals'. (302/1)

---

1. The text statement.
2. The student's comment on the text.
3. ...indicates a pause in the student's comment.
   ---indicates a break in the transcript in data editing.
4. ( ) indicates interviewer talk
   [ ] indicates those words added to the transcript to help the reader construct a meaning.
5. The reference number for the quotation, (303) - student number
   (1) - indicates text read 1: Challenge Text
   2: Dual Meaning Text
   3: Typical Text

A whale is a big animal and a fly is a small animal.	'A whale and a fly isn't an animal. A whale's a mammal, and a fly's an insect'. (306/1)
Some animals like a beetle are hard.	'No, beetle's not an animal' - it's an insect. (What about 'some animals are hard'. If a beetle's not a good example for you, could you give me an example of an animal that is hard). Like a turtle, with its hard shell, and a hippopotamus and rhino - they've got rough, tough skin.' (303/1)

The two students, who read the Typical Text, in general, found few perceived errors with respect to exemplars, as these were rarely explicitly given in the text. However, questioning by the interviewer clarified that they were using the everyday meaning of 'animal' in the construction of a meaning:

Many animals actually burrow their way into the leaves, stem and roots of plants by eating the materials as they go.	'...weta's live in the wood and that. Not quite sure what they eat---(Are weta's animals to you?) Um...they're insects... because they've got 8 legs...they're insects, not animals.' (304/3)
All caterpillars found in your garden are herbivores and all have mouthparts for biting and chewing plants.	'(Would you agree that caterpillars in your garden are herbivores?) Yeah, because they only eat plants---they chew and that. (Would you call caterpillars animals?) No, they are insects'. (305/3)

In the everyday meaning of 'animal', only the large, furry, land animals are considered to be animals. (They are also animals in the scientific sense of the word.) As text statements about cows, for example, were not perceived as errors, the students infrequently commented on them. However, some did:

A cow is an animal.	'A cow's an animal. And it's just an animal'. (302/1)
An opossum is an animal that may be found in a tree.	'...an opossum is an animal---it can be found in a tree'. (306/1)

Student 301, who learnt and used the scientific meaning of the word 'animal', commented similarly but she also made comments, in contrast to the others, such as:

A spider is an animal as it eats flies for food.	'Oh, that sentence is true but then a spider's also an insect. All insects I suppose are animal but then...spiders don't only eat flies'. (301/2)

A summary of each student's view on the text exemplars and non-exemplars (and the reasons) is given in Tables 6 a - e. In these tables are given, in summary, the students' categorisations of the instances as animals or not ('Yes', 'no', or 'unsure') and their reasons for the categorisation (for example, 'not a plant' or 'lives in the sea').

TABLE 6a: The Categorisations and Distinguishing Characteristics used in the Phase I Interviews by Student 301

IS IT AN ANIMAL?

	Science Survey	Existing knowledge interview	Spot-the-mistake interviews Dual Meaning Text	Challenge Text
Cow	Yes	Yes, not a plant, classed as an animal	Cat, dog, yes Lion, yes, four legs, fur, eats to stay alive, breathes, cells	Cow, lion, cat, rabbits, yes
Person	Yes	Yes, not a plant	Yes	———
Whale	No	No, unsure, mammal, lives in sea, large	Whale,dolphin,mammals yes, not a plant Fish,sharks,yes,lives in sea cells, internal organs, sleeps	———
Spider	No	No, insect, small, 6 or 8 legs	Spider (1) unsure,then (2) yes, all insects are animals Butterfly, mosquito,yes	Spider, beetle,yes Fly, aphids,yes
Worm	No	No, insect, small, doesn't look like an animal	Worm, unsure, insect?	———
Others	-	———	Bird, yes	———

TABLE 6b : The Categorisations and Distinguishing Characteristics used in the Phase I Interviews by Student 302

IS IT AN ANIMAL?

	Science Survey	Existing knowledge interview	Spot-the-mistake interviews Dual Meaning Text	Spot-the-mistake interviews Challenge Text
Cow	Yes	Yes, knew it is an animal	Cow, dog, cat, yes Lion,horse,goat,yes Mouse, yes	Cow, yes, been told about it
Person	No	No, mammal, warm blooded	No, mammal	No, mammal
Whale	No	No, warm blooded, lives in the sea	Fish, no, mammal, lives in sea, unsure	Shark, no, mammal, lives in sea, warmblooded Dolphin, no, mammal, warmblooded Whale, no, mammal
Spider	No	No, unsure, in-between? insect, small no, hasn't got 6 legs	Spider, snail, no Butterfly, beetle,no insect	Spider,unsure, no Snail, no, mollusc no backbone
Worm	Yes	Yes, no, unsure can only kill by drowning	No, unsure	———
Others	-	———	Sparrow, no, mammal Birds, no, mammals	Bat,unsure if animal or mammal Snake, yes

TABLE 6c : The Categorisations and Distinguishing Characteristics used in the Phase I Interviews by Student 303

IS IT AN ANIMAL?

	Science Survey	Existing knowledge interview	Spot-the-mistake interviews Challenge Text	Dual Meaning Text
Cow	Yes	Yes, has milk, is a mammal	Mouse, yes Rabbit, yes, a mammal, Cow, goat, sheep, cat, yes	———
Person	Yes	Yes, has features of an animal	Yes, knows we are animals	People, yes
Whale	No	Yes, is a mammal, has lungs	———	Dolphin, no, mammal
Spider	No	No, is an insect knows it is not animal	Spider, no, insect Fly, no, insect Grasshopper, no, insect Butterfly, no Weta,beetle,aphid,no	Spider, no Butterfly, no Snail, no
Worm	No	No, is an insect	No, is an insect	No
Others	-	———	Shark, no, a fish Bat, yes, has bones and heart Oyster, no, a plant Snake, yes, bones, brain Frog, unsure, lives in sea but breathes air Tui, yes, lungs, heart, breathes	Shark, no, then maybe yes Sparrow, yes Fish, yes Animal, lives on land, breathes air

TABLE 6d : The Categorisations and Distinguishing Characteristics used in the Phase I Interviews by Students 304, 305

IS IT AN ANIMAL?

	Student 304			Student 305		
	Science Survey	Existing knowledge interview	Spot-the-mistake interview Typical Text	Science Survey	Existing knowledge interview	Spot-the-mistake interview Typical Text
Cow	Yes	Yes, back-bone	-	Yes	Yes, mammal 4 legs	-
Person	Yes	Yes, back-bone	-	Yes	Yes, mammal	Yes
Whale	Yes	Yes, back-bone	-	Yes	Unsure, brain	-
Spider	No	No, no backbone	Aphid, no, insect Insects, no Weta, no, insect unsure	No	No, insect, 8 legs	Spider, no Cater-pillar, no, insect
Worm	No	No, no backbone	-	No	No, insect, small	-
Others			Thrush, yes			-

TABLE 6e : The Categorisations and Distinguishing Characteristics used in the Phase I Interviews by Student 306

IS IT AN ANIMAL?

	Science Survey	Existing knowledge interview	Spot-the-mistake interviews Challenge Text	Dual Meaning Text
Cow	Yes	Yes, produces milk, warm-blooded	Cow, yes, gives milk Goat,cat, dog, yes opossum, yes	Cat, dog,lion, yes
Person	No	No	No, human being, bones	No
Whale	Yes	No, mammal,lives in the ocean	Whale,no,mammal, cold-blooded Dolphin,no,unsure	-
Spider	No	No, is an insect small animal	Spider, no, Fly, no, insect Butterfly,beetle, weta, no	Spider, no
Worm	No	No, small	-	No
Others	-	-	Shark, no, mammal, cold-blooded Oyster,barnacle,no, no legs, and they are molluscs Bat,unsure,mammal or animal	Bird, yes

b. <u>Characteristics of animals</u>

The students used the everyday meaning of 'animal' to accept or reject their constructions of the text statements about the characteristics of animals.

For example:

An animal can be as big as a ship or as small as a pin.	'That's exaggerated a bit---a ship's a great big thing that carries alot of people, and there's no animals that would be that big. And "as small as a pin". - it's not really because that's only tiny. I suppose a pin - you might be able to squash an insect into that size. (You'd call an insect an animal?) I would now.' (301/1)
An animal can be as big as a ship or as small as a pin.	'Yeah, you could say that but not all animals are as big as a ship, like the biggest animals would be an elephant, and that's not quite as big as a ship, be like a small boat, not a ship. I don't think you can get an animal as small as a pin. I don't know---a little mouse,the smallest I've seen. You get all those microscopic like things,that are sort of around in the water. (Would you call them animals?) I don't know. Most of them are larvae of something like an insect.' (302/1)
A spider is an animal that may be found in a crack.	'I don't know if a spider's an animal. Not sure about that. They don't live just in cracks. They live in the roof, the ceiling, inside like trapdoors. Some live in trees, and all sorts of places. Under rocks'. (302/1)
A person is an animal with two legs.	'Oh, humans are mammals - it's got two legs, same as other things have four legs, but they only stand on two legs, like kangaroos.' (302/1)

The students also appeared to use the everyday distinguishing features of 'animal' as they had in the existing knowledge interview (see Tables 6a-e).

i) <u>Internal organs</u>

Butterflies and bats are both animals that fly.	'Butterflies [are] not animals either. (What about a bat?) Yeah, that's an animal. (What tells you it's an animal?) It's got bones, and a heart, and all that.' (303/1)

ii) Blood temperature

Sparrows, goats, spiders, earthworms and sharks are also animals.	'Not all of those are animals--- Shark's a mammal---cold-blooded' (306/1)

c. Exemplars volunteered by the students

The use of an everyday concept by the readers was also evident in the exemplars of animals given by the students when elaborating on their constructions. These exemplars are additional to the ones mentioned in the text. Tables 7a, b, c, list the text exemplars and additional exemplars given by the students. All, but one of the animal exemplars volunteered by the students with the three texts, are exemplars in the everyday sense of the word 'animal' : for example, four-legged mammals, (giraffe, monkey, koalas, pig, elephant), four-legged reptiles (turtle, crocodile, alligator), and a bird (vulture). One student (304) gave the exemplar of shark in a discussion of a food chain. No invertebrates were given as animal exemplars.

The exemplars of herbivores, carnivores and omnivores were, in the main, animals in the everyday sense of the word, for example, cheetah, hyena, beaver. However, invertebrate examples were given (spider, mosquito, weta) as were other vertebrates (boa constrictor, shark). That invertebrate exemplars were given by two students for the words 'herbivore' and 'carnivore', but not for 'animal', may suggest that herbivores and carnivores were not perceived as subsets of the set of animals.

The number of exemplars given by each student is not so much a reflection of the student's existing knowledge, but of the interview and the text read. The students (304, 305), who read the Typical Text, were encouraged to give exemplars as none were given in the text. The students who read Texts 1 and 2 spent more time discussing the exemplars in the text from the perspective of possible errors, than offering further examples.

TABLE 7a: Exemplars of Animals given by Students 304 and 305 while reading the Typical Text (Text 3)

	Exemplars read from the Typical Text	Exemplars volunteered by students when reading the Typical Text	
		304	305
Animal exemplars		cow deer giraffe chimpanzee tiger crocodiles antelope lion apes koalas opossum shark rabbit field mice dog	cow elephant pig lion cat
Herbivore exemplars	rabbit horse aphid caterpillar leaf miner cow	lamb beaver giraffe mosquito weta	sheep
Carnivore exemplars	snake owl thrush tapeworm lion, tiger	leopard alligator turtles spider	shark leopard spider
Omnivore exemplars	people	-	-

TABLE 7b: Exemplars of Animals given by Four Students while reading the Challenge Text (Text 1)

	Exemplars given in the Challenge Text	Exemplars volunteered by Students when reading the Challenge Text			
		301(2nd)*	302(2nd)*	303(1st)*	306(1st)*
Animal	Cow Sparrow Goat Spider Earthworm Shark Whale Fly Person Opossum Dolphin Rabbit Grasshopper Butterfly Bat Oyster Barnacle Weta Snake Cat Frog Beetle Lion Zebra Tui Moth		Mouse Otter Water Rat Kangaroo	Mouse Turtle Hippopotamus Rhinoceros	Dog Elephant Monkey Giraffe Pigs
Herbivore	Cow, aphid Earthworm Rabbit, snail Sparrow	-	-	Goat Sheep	Baboon
Carnivore	Cat, hawk Spider, lion Shark	-	Vultures Hyenas Wild dog	-	-
Omnivore	Person Mouse	Cat	Cat		

*Indicates order that the Challenge Text was read, in the interview schedule.

TABLE 7c: Exemplars of Animals given by Four Students, while reading the Dual Meaning Text (Text 2)

	Exemplars given in the Dual Meaning Text	Exemplars volunteered by Students when reading the Dual Meaning Text			
		301(1st)*	302(1st)*	303(2nd)*	306(2nd)*
Animal - 'every-day' para-graphs	Cat Horse Dog Lion Cow Mouse Goat		Water Rat Bear Wild Pig Wild Dog	Pig	Monkey Elephant
Animal - 'scien-tific' para-graphs	Lion Zebra Spider Fly Earthworm Sparrow Beetle Butterfly Fish Snail		Deer Anteater	Vulture	Anteater
Herbivore	Cow Aphid Earthworm Sparrow Rabbit				
Carnivore	Cat Spider Lion Shark		Cheetah Hyena Wild Dog Boa Con-strictor	Cheetah Dog	
Omnivore	People Mice		Cat Baboon		

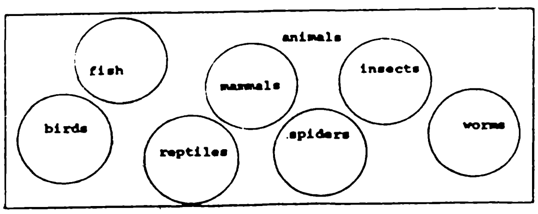
*Indicates the order in which Text 2 was read.

d. Animal groups

The students also appeared to use the everyday meaning of 'animal' to construct and evaluate a meaning for text sentences about the groups of animals. In the everyday meaning, the groups of insects, fish and mammals are seen as comparable sets to the set of animals, not as subsets. Some examples are:

Other groups of animals are the fish, mammals, insects, worms and spiders.	'Well, an animal wouldn't be a mammal because that's two different things... groups...fish, insects aren't animals. Worms are inbetween. So do spiders really. But it's sort of hard to. They're so small when they're compared with animals.' (306/2)
Other groups of animals are the fish, mammals, inspects, worms and spiders.	'Mainly I was thinking, put them into groups. A fish wasn't put into anything, just fish. Then mammals and then insects. And worms and spiders. I just sort of put in with insects. And then the birds were another group---Fish, I don't know, I sort of didn't think about it but it was just, there were just fish, but then everything, I suppose, when you look at it, they're all animals--- I don't really know what a dog or a cat would be. I suppose it would be a mammal but mammals are usually great big things. Not great big but the bigger things---Birds I sort of put in with animals and then cats and dogs, I sort of had as a group of just animals. (So you would like to see another group added, one called animals and you could put things like cats and dogs in it?) Yeah.' (301/2)

Similar comments were made in the comprehension of the second diagram in the Challenge Text:



'Just spiders and worms and insects - they aren't animals...' (303/1)

e. The two groups : animals and plants

The students used the everyday concept to construct and evaluate meanings of the text sentences about living things being either animal or plant.

In a general sense, this is scientifically correct. Biologists, advocating the five Kingdom classification system would say living things may belong to one of the other 3 Kingdoms: Monera (bacteria, and blue-green algae), Protista (protozoa, diatoms, slime moulds), or Fungi. However, the two Kingdom classification system of animals and plants is a useful dichotomy in junior science classes to distinguish between animals and plants and to promote the wider scientific concept of animal. Five of the six students used the everyday meaning to generate a construction and to evaluate it. For example:

All living things are either animals or plants.	'Animals are living or plants are living---there's other things that are living as well ---insects, people, lots of things, not just animals and plants'. (306/1) 'Yeah, not everything is an animal or a plant. Somethings...mammals' (302/1) 'Oh, I think there's fish too. And insects'. (303/1)
To a scientist, living things can be either animals or plants. There is no other group.	'...but there can be other things living, not just animals and plants---I wouldn't agree with that..."there is no other group".' (306/2) 'Yeah, but humans can also be living things...and sea eggs. Things that live in the sea---they are mammals. They all live'. (302/2)
The world of living things can be divided into two main groups: animals and plants.	'Yes...but there are also plants - living things that aren't...insects'. (304/3)

Despite the knowledge that there were errors in the text, student 301 began to change her existing knowledge of 'animal', thereby giving more importance to her construction of text meaning than to her existing knowledge. The sentence, that living things can be either animal or plant, acted as a catalyst for her thinking and for her challenging of her own ideas:

To a scientist, living things can be either animals or plants.

'We've got to the stage now that in science we have done it, but you've been given a list of things and you've either got to say it's either an animal or a plant. But then most things are either animal or plant. It's sort of true the way they say it, but then just when we were in the younger school we were told - everything's an animal or a plant. But when you get older you're told that they're insects and they're mammals or whatever. And then you get a bit later on, and at this age you're a bit older, and then you are told that everything is just an animal or a plant. They're wasting time, where they say that they're splitting everything up. And then they're just putting everything back together at the end again'. (301/2)

She did not appear, at this stage, to have constructed the scientifically acceptable hierarchical classification. The next quotation illustrates her own thinking to challenge her construction:

'When you think of a desk or something it's made out of wood, which was a tree, which was living. But then, if you say it's a table or a desk. But in ways it's still a plant, part of a plant. So anything in the world could be classed as animal or plant---'

'Oh, there is in ways because there's man-made things. You know, some of the things they made - like some materials which they make and that, which I reckon would be another group - wouldn't be a plant or animal.' (301/2)

She was however accepting of her construction which was the author's intended one.

f. The scientific definition of 'animal' in the text

Some of the students made a construction along the lines intended by the author, but then rejected it in favour of their own existing knowledge. For example:

To a scientists, animals are living things that eat other animals or plants for food.

'It can't be an animal just because of what they eat. We eat meat like animals do, and plants, things like that, but that doesn't mean we're animals---Can't call an animal an animal, because of what it eats.' (302/1)

A lion is an animal as it eats other animals, like zebras for food.	'They [animals] eat other animals for a source of food. They like and need to live...well, a lion isn't just an animal because it eats other animals for food. It's sort of detail, what they do for food, and not just what an animal is.' (306/1) (306/2)

Student 301 constructed and accepted the scientific definition, indicating that she was no longer using the everyday meaning to construct or evaluate a text meaning:

An animal is a living thing that eats plants or other animals for food	'It's true really because most animals or whatever things, they eat plant or other animals. We're sort of animal and we eat cows and that, and we also eat plants or vegetables and the fruit.' (301/2)

The two students, who read the Typical Text, made constructions using the everyday meaning of 'animal', particularly with respect to the exemplars. They accepted the constructions as they matched their existing knowledge. The constructions, however, were not the author's intended constructions as they were restricted in terms of exemplars. There were no atypical exemplars given in the text, and so their constructions were unchallenged.

An animal is a living thing that eats other animals, plants, or their remains for food.	'Yeah, I think I agree with that because, like, the remains of food...like the left-overs and things like that...you could feed it to the pig...or bones...like it - a lion leaves the remains of the beast, the vultures, they come down and pick over'. (305/3)
An animal is a living thing that eats other animals, plants, or their remains for food.	'---Um...tiger needs food, say a deer, a deer eats grass, which then, a tiger needs a deer or other kind of animal to eat, so he kills the deer for his food. And mainly they are the sick ones..can't run very fast. (What about an animal that eats a plant?) 'Well, apes, oh, we eat plants, carrots or berries from a plant, which provides food for us. And some animals like the giraffe, it eats the trees, some koalas and opossums, they eat the trees but sometimes they get a bit gnawing with the trees and then the trees go...so farmers...have to kill some opossums so they can have trees on their land.' (304/3)

g. <u>The sentences unique to each text</u>

Selected examples from the transcripts are given here to illustrate the use of the everyday meaning to construct a meaning based on the unique parts of each text.

The main feature of Text 1 was the initial paragraph challenging the exemplars and criteria of the everyday meaning of 'animal'. Students accepted or rejected these statements to varying degrees, depending on the perceived match between the constructed meaning and their existing knowledge. For example:

How do animals move?...	'(How do animals move?)...with their legs and arms and whole body - just like us. Person-people aren't animals but cows are. They can walk like us...yeah, rabbits are an animal that hop. Grasshoppers hop as you hold it. Sharks don't - not an animal ...whales...not sure if the shark and a whale is a mammal or not, sort of not too sure on those ones. I think they're either an animal or a mammal. But they seem the same. And sharks swim---oysters and barnacles aren't animals---they're in little shells in one place...and they haven't got any legs to walk on---it's sort of got their own - the sea can carry them.--- Butterflies are not animals, they're an insect...And bats...I think a bat's a mammal, I don't know...they fly...Yes, probably call it an animal. Oh, I don't know. Can't see the differences between a mammal and an animal---one's cold blooded and one's warm blooded.' (306/1)

The main feature of Text 2 was the explicit discussion of the two meanings of the word 'animal'. Again, students accepted or rejected their constructions of these text statements, depending on the perceived match with their existing knowledge. For example:

They are large, furry, four-legged creatures that live on land.	'They don't necessarily have to be large. You can have small animals. Some are furry some aren't. (What are some of the small animals to you?) Cat, dog or monkey. We compare it to a lion or an elephant... Elephant's got rough skin, and a cat's got furry skin, but they still have four legs.' (306/2)

They are large, furry, four-legged creatures that live on land.	'It's right. They're large and they have got four legs, live on land.' (303/2)

That insects are non-animals because they are small, was also challenged:

We may not call worms, spiders and butterflies animals as they are small.	'That's not...just because they're smaller, doesn't mean they are not animals. (So you can have small animals?) Yes...a mouse. (What about those 3 - the worm, spider and butterfly?) They're insects.' (303/2)

and with the sentences about the shop sign:

In the everyday sense of the word, people are not animals so we can go in to buy food.	'We're not animals at all. We can go in. We're mammals.' (302/2)

This student's construction matched his existing knowledge.

With the sentences about the everyday groups:

Some animals are found on a farm. Other groups of animals are zoo animals, wild animals, sea animals and pets.	'You don't find all animals are on farms. You find some of them in the wild---Pigs. Wild pigs...you can get wild dogs. Wild horses.---zoo animals are not just found in a zoo. They are mainly wild, and taken in the wild to live in the zoo, to breed and populate because usually they are rare or going extinct.' (302/2)

and with the sentences about the use of the scientific meaning of

'animal':

A science teacher may ask you to collect several different animals and bring them into the classroom.	'Oh, we've had to do what they say there. They ask us to bring animals inside. But they didn't say animals---they said insects. And which they say beetles and worms---because they said insects, you think of the little things. But then if they had said animals, it could have been a wide range---I would have probably wondered what sort of animals would be out on the playing field. Wouldn't think there'd be many cats and dogs---but now---they're all the animals.' (301/2)
A science teacher may ask you to collect several different animals and bring them into the classroom	'They [the creatures] may not like it. Not used to it. But you could---They like it out in the fresh air and grass---small animals like a cat or something, or a mouse. Small and detailed. But you wouldn't bring an elephant in.' (306/2)

A science teacher may ask you to collect several different animals and bring them to the classroom.

'...some sort of animal like the sort you've got at home. Cat or a dog. But you can't actually bring a lion or a rhinocerous.' (302/2)

4.2.2 <u>The use of other existing knowledge</u>

In the last section, the students' constructed meanings and evaluations using the everyday concept of <u>animal</u> were documented. However, it was also evident that existing knowledge, other than the everyday meaning, was also used. The existing knowledge used in either constructing a meaning or in evaluating the construction could be:

a) <u>past experiences</u>

Mice eat seeds from plants or dead animals.

'You don't find them eating dead animals as much as they do seeds and other things. I have got them at home. Not as pets. I'm trying to get rid of them. They'll eat the seed...I put them [the seeds] in my aviary and they eat all the seed and they kill the birds. They don't sort of chase after them. They urinate in the seed and it kills them. The birds die from that.' (302/2)

b) <u>based on past vicarious experience</u>

Other carnivores live inside the body of other aninals and feed on the juices. These carnivores are also called parasites. A tapeworm is a parasite.

'I've never heard that before. Where it says "carnivores live inside the body of other animals and feed on the juices". They are called par-, is that parasites? A tape-worm is a parasite. Oh, would they be sort of like, say a-worms, that go through the sheep when they eat all the insides out of a sheep...oh, sometimes on TV, they showed you...you have to feed your sheep these vitamins or something...kind of medicine thing to get rid of worms inside them because it showed you this sheep and it was alright and then [it] got thinner and thinner. Looked all horrible. That was a tapeworm I think.' (304/3)

c) <u>general knowledge of animals</u>

A spider is an animal as it eats flies for food.

'Yes. Well, they make the web which catches the flies. And then they eat them when they're dead.' (301/1)

In all the above three examples, the students were generating links between the text stimuli and perceived relevant existing knowledge.

The constructions generated by students using other existing knowledge, were not always those intended by the author nor scientifically acceptable. This happened if students used alternative meanings for scientific terms such as 'consumer':

Animals are consumers.	'Well, I think of consumer, I think because we do in economic studies, we've been taught that it's somebody that buys, the person that goes out and buys the food or whatever, but then, animals. It depends. If it lives out in the wild, it's got to collect its own food, but then, animals in the zoo, or whatever, house pets. They don't need to because the people are feeding them because they don't need to - so they don't need to fight for food or whatever,---sort of makes sense depending on which animals you're talking about. Farm animals, you've got the grass there, so they don't really have to hunt for it. And then the zoo, and house pets have the food given to them, but wild animals would have to go and hunt for it, so be pretty much the same as a person going down to the shop hunting for whatever they wanted for their meal.' (301/1,2)

or alternative meanings to the one intended by the author for a common word such as 'feed':

Some living things are into the group of animals because of the way they feed.	'...we live in houses and we dress and we use knives and forks and cups and that, and we're also like a cow or deers or giraffes .they live in...wild countries which other predators are always killing and using them as their food. And we don't kill each other for food...they don't use knives and forks...oh, except for chimpanzees, they use their hands...as humans do.' (304/3)

The author had not elaborated on the word 'feed'. The student constructed a meaning using the word 'feed' in terms of the mechanics of feeding, rather than in terms of trophic level.

Similarly, the word 'remains' was interpreted as 'remains of a meal' rather than as 'remains of a living thing':

An animal is a living thing that eats other animals, plants or their remains for food.	'Well, they say that an animal is a living thing that eats other animals, plants, or their remains - or their remains. Doesn't make sense...sounds like they eat...oh, some animals, oh, yeah, some animals eat - like on 'Our World' the other day, there was this male ape,...and he ate all the food, and then the female one came around, and picked at the bones...she doesn't get much food but she has other things like cactus, and grass, and shrubs, and that.' (304/3)

A text necessarily leaves out information so as not to bore the reader or state the obvious. However, the reader may or may not use the appropriate existing knowledge in the attempt to construct a meaning. For example, the text, 'Some animals, like oysters and barnacles, stay in one spot and never move away', does not explicitly state that, although the adult oyster or barnacle is sessile, the larval oyster or barnacle is free-moving before it attaches itself to a rock and matures. One student, not knowing this, was unable to use the intended existing knowledge, and using her own existing knowledge, constructed a different meaning for the text:

Some animals, like oysters and barnacles, stay in one spot and never move away.	'Oysters and barnacles, they sort of do move, - don't know how they move, but barnacles move along the rocks---when they're on the rocks, like sometimes a ship might come in and be there, or be on a reef or something. But then if the ship stays there for a long time, they end up on the ship, so they must move to get there, otherwise there wouldn't be any on the ship...' (301/1)

4.3 REVIEW OF THE METHODOLOGY

The methodology of 'spot-the mistake' was useful to elicit aspects of the existing knowledge being used by students to generate a constructed meaning and to evaluate it. It also provided a catalyst for discussing their constructed meanings, the generation of the construction, and its evaluation. The students appeared to find the task non-threatening, easy, and enjoyable. They all identified the deliberate errors easily. For example:

Lions eat stones.	'Lions don't eat stones...' (302/2) (301/1) (303/1)
	'---lions don't eat stones---far too hard to swallow them, and they wouldn't taste like anything either.' (306/1)
A carrot is an animal.	'No, carrot's not an animal. It's a plant. It's a vegetable.' (302/1) (301/1)
	'And carrot's not an animal. It's a vegetable.' (303/1)
	'A carrot's not an animal. Doesn't move about or anything.' (306/1)
Usually when we think of an animal, we think of a cat, dog, lion or a car.	'Car, that's wrong, Car, I wouldn't say was an animal.' (301/2) (302/2) (306/2) (303/2)

As the data illustrated, the students were at times confident about identifying other perceived errors (that is, when there was a perceived mismatch between their construction and their existing knowledge). Sometimes they expressed doubt and discussed why they found it difficult to, or were unable to, accept or reject their construction. Often they expressed a perceived lack of existingknowledge, against which they could compare the constructed meaning. Lack of existing knowledge about feeding habits was mentioned:

Earthworms eat decaying leaves in the soil.	'---because they live under the earth, so they'd get all their protein from the plant---but they haven't got a mouth, have they?---haven't really seen an earthworm close up.' (306/1)
Snakes, owls and lions are carnivores.	'Don't know about owls---like in some films I've seen, like you see owls attacking people, and then they - don't know if they eat animals.' (305/3)

Despite the contrived nature of the methodology, it was felt to be a valuable way to elicit data on students' use of existing knowledge in comprehension. However, the data collected needs to be interpreted in light of the limitations of the contrived situation.

4.4 SUMMARY AND CONCLUSIONS

The findings suggest that while reading one of the texts, and under the constraints of the 'spot-the-mistake' task:

1. Students did use their existing knowledge to generate a construction, along with text stimuli, and to evaluate that construction.
2. The existing knowledge used was the everyday meaning of 'animal' as elicited in the science survey and existing knowledge interviews, as well as other aspects of existing knowledge, such as past experiences with and general knowledge of animals.
3. Students, who had only the everyday meaning of 'animal', tended not to construct the author's intended meaning, given the methodology and task. The students were able to make sense of the text by constructing an alternative meaning. Only rarely was no construction made of a sentence.
4. Some students, who had only the everyday meaning of 'animal', did construct the author's intended meaning, but did not necessarily accept it. In other words, the construction appeared not to match their existing knowledge. It should be noted that the methodology, whilst not influencing the existence of a mismatch, may have influenced the decision as to whether it was to be accepted or rejected.
5. Points 1-4 apply to all three text types.
6. In the Typical Text, there were few animal examples and elaborations given by the author. The students used their existing knowledge of

the everyday meaning to construct an elaborated meaning. Often this construction was restricted when compared to the author's intended one. The students tended to accept this construction as the same existing knowledge was used to evaluate it as was used to construct it. The students were often unaware that their construction was not the author's intended meaning.

7. The 'spot-the-mistake' task did not encourage the students to learn the scientific concept of animal, that is, to change their existing knowledge. One student (301) did however. She accepted the constructions made, and rejected her existing knowledge, even though she was aware that the author had inserted deliberate errors in the text.

A question unable to be answered by the findings of Phase I was 'can students, who have only an everyday concept of animal, learn the scientific concept by reading a text?' That is, are they able to construct the author's intended meaning, accept it, and include it as part of their existing knowledge? And, in what ways is existing knowledge used in comprehension and conceptual change in the context of reading-to-learn?

CHAPTER 5 THE RESULTS OF PHASE II

5.1 INTRODUCTION

The findings of Phase I described some of the ways students used their existing knowledge, in particular the everyday concept of animal, to make sense of a text. The findings illustrate that the students used their existing knowledge to construct a meaning by generating links between text stimuli and existing knowledge, and to evaluate that construction. However, the reading task did not require the students to learn.

In Phase II of the research, the role of existing knowledge in reading comprehension and conceptual change was investigated, that is, the role of existing knowledge in generating a constructed meaning, the nature of the construction, the evaluation of the construction and also the changing of existing knowledge. As in Phase I, the existing knowledge of the concept of animal was of central interest.

The methodology was a 'reading-to-learn' interview (see section 3.3.2 for details), which was characterised by a one-to-one interview situation, concurrent verbal self-reports, and a task that required the students to learn the scientific concept of animal while reading the text, and to stop at the end of each sentence (or group of sentences) to tell the interviewer what they were thinking about. The researcher was primarily interested in the use of the everyday concept of animal in their existing knowledge, and in the changes made to that existing knowledge.

The sample consisted of seven students (aged approximately 13 years) from each of three Form 3 science classes in a large, city coeducational school - a total of 21 altogether. Each science class had a different teacher. With the aim of obtaining a sample of average ability students, two tests - T.O.S.C.A. and P.A.T. reading comprehension - were used.

The main part of the sample consisted of students with average scores in the T.O.S.C.A and P.A.T. tests, and this was supplemented with seven students with above or below average scores. The students in the sample were also categorised, on the basis of their responses on a science survey on the concept of animal (see Appendix E) into one of three groups: those having, with respect to the concept, an everyday meaning, a scientific meaning, or an in-between meaning. Students in the first group categorised only the cow as an animal; students in the second group categorised all the instances (cow, whale, person, spider, butterfly and worm) as animals as would a scientist; and students in the third group categorised between two and five of the instances as animals. There were 10 girls and 11 boys in the sample. Further details are given in Tables 8a, b.

The texts used in Phase II can be found in Appendix C, and were discussed in detail in section 3.4. As stated earlier, all three texts were about the scientific concept of animal, but they differed in the contexts in which the scientific concept was embedded:

The Challenge Text had a paragraph containing specific exemplars and distinguishing characteristics of the scientific concept of animal in an attempt to challenge the everyday concept held by students;

The Dual Meaning Text contained sentences explicitly describing the similarities and differences between the everyday and scientific concepts of animal'; and

The Typical Text contained, as do most published texts, sentences about the ecological role of animals.

The Challenge and Dual Meaning Texts were written by the researcher to take into account recent research findings on promoting conceptual change. There were no deliberate author errors as in the Phase I texts.

TABLE 8a: The Phase II Sample

	Classification based on the categorisation of instances as an animal or not, in a science survey		
Score on P.A.T.: comprehension	Everyday meaning of 'animal'	In-between meaning	Scientific meaning of 'animal'
Above average	311	313 320 326	321
Average (Level score of 7,8)	319 323 324	307, 308, 309 316, 317, 318 322, 327, 328 329	325
Below average	310	312	

TABLE 8b: Further Details of the Phase II Sample

Text Read	Student Code Number	Sex	T.O.S.C.A. (stanine)	P.A.T. : comprehension (level score)
Typical	307	M	6	7d
Text	308	F	6	8b
	309	F	4	8a
	310	F	4	6a
	311	F	8	(not available)
	312	M	3	6b
	313	M	8	9b
			(10.6.82)	(March, 1982)
Challenge	316	F	4	8a
Text	317	F	4	7a
	318	M	5	7d
	319	M	6	8a
	320	M	8	9c
	321	M	9	9a
	322	F	4	8d
			(1.3.82)	(March, 1982)
Dual Meaning	323	M	4	8c
Text	324	M	4	7d
	325	F	6	8b
	326	F	7	8c
	327	F	6	7b
	328	M	4	7d
	329	M	5	8c
			(12.3.82)	(March, 1982)

Procedures The sample of students was selected from three science classes on the basis of results on the P.A.T., T.O.S.C.A. and science survey. Having agreed to take part, each student was interviewed twice in a small room in a normal-timetabled science lesson. The interviews were audio-taped with the consent of the student. The first interview of 5-10 minutes (the existing knowledge interview) elicited from the students their reasons for their choice of answers in the science survey. In the second interview 30-50 minutes, (the reading-to-learn interview), the students were asked to read the text and:

a. to learn how a scientist would answer the question 'What is an animal?', and

b. to stop at the end of each sentence to tell the researcher what they were thinking.

The introduction to each student (except 321 and 325) was:

> 'As we went over the survey the other day, it became clear to me that you have a slightly different meaning of the word 'animal' from that of a scientist. What I would like you to do today is to read these 3 pages to learn how a scientist would answer the question "What is an animal?" I'm also interested in what people are thinking about when they read, and as I can't read your mind, I'm going to ask you to stop at the end of each sentence and to tell me, what you are thinking about. You don't have to read the sentence out aloud.'

As students 321 and 325 did in fact have a scientist's meaning of 'animal', their introduction was:

> 'As we went over the survey the other day, it became clear to me that you have a meaning of the word 'animal' that is similar to that of a scientist. I'd like you to read these 3 pages and to stop at the end of each sentence to tell me what you're thinking about. I'm interested in finding out what people think about when they read science material.'

Throughout the interview, the researcher asked probe questions to clarify statements made or implied by the reader. Such questions were:

'What do you understand by that sentence?

'What are you thinking about now?'

'Does the sentence make sense to you?'

'Do you agree with that sentence?'

When the student had finished reading the text, she or he was asked if there was anything that was difficult, easy or new in the reading. Then the students were given an informal interview-about-instances (Osborne and Gilbert, 1980). They were asked if each of the following instances was an animal or not, and the reasons for their answer: horse, a marine mammal (either whale or dolphin), a person, small animal (e.g. mosquito, weta, snail, slug or worm) and sometimes the lesser known ones of sponges, mussels. This part of the interview was to assess if any learning had occurred during the reading-to-learn interview. The interview recordings were transcribed for further analysis. Finally, after a period of 2-4 weeks, all 3 science classes were given a final and parallel science survey (see Appendix F) to ascertain any change in the concepts of <u>animal</u>, of the sample students, since the interviews. Details of the survey and interview schedule are given in Table 9.

TABLE 9: Survey and Interview Schedule for Phase II

Class	Science Survey at the beginning of year		Science Survey in the middle of year **	Text read		Science Survey at end of year
One Students: 307-313	- o		8.6.82	3	*	13.10.82
Two Students: 316-322	25.2.82	*	14.9.82	1		4.11.82 #
Three Students: 323-329	3.3.82	*	17.9.82	2		5.11.82 #

Notes

1. * denotes the teaching of biological 'classification' in normal science lessons.

2. # in survey 3, the students 316-329 were asked to chose Yes or No, and write the reasons for their choice of answer in the spaces besides the pictures. This was to monitor the reasons used by students in the smaller samples and to slow down the rate of doing the survey. When it had been administered to class 1, they hurriedly did it and concern was felt that they may not have given the task enough thought.

3. o a third class (class 1) was not selected until the end of the trialing of the texts.

4. ** The responses of students to this survey were the basis of the existing knowledge interviews, and used as a factor in the sample selection.

Key to Text Read :
1. Challenge Text
2. Dual Meaning Text
3. Typical Text

5.2 RESULTS OF PHASE II

In documenting qualitative research, there is a tension between giving enough data to validate the analysis and conclusions, and the editorial task involved in authoring a logical argument. Phase II of the research produced a large amount of transcript material, all of which could not be included in this document. The quotations in this chapter are intended to serve both purposes of evidence and illustration, although for the reader, they possibly serve the latter purpose more readily.
The data analysis centred around two uses of existing knowledge advocated by Osborne and Wittrock (1983), that is, in the generation and evaluation of a constructed meaning as a result of reading a text.

5.2.1 Making a construction

To make an initial or tentative construction based on the text, the students had to generate links between the text statements and what they perceived as relevant existing knowledge (Osborne and Wittrock, 1983). The nature of the links - in particular, what existing knowledge was linked - determined the construction made. This construction may be compared to that intended by the author, and as a result categorised into one of four groups: the students' constructions, when compared to the author's intended construction, may be regarded as similar (categories a, b, c); irrelevant (d); not acceptable (e) or not made at all (f) (Table 10). These categories arose out of the analysis of the transcripts and were not predetermined by the researcher. Examples of transcript quotations to illustrate the constructions categorised in each category are documented below:

TABLE 10: Construction Categories

Links to existing knowledge	Tentative construction
a. The links made by the reader are consistent with the author's intention.	The reader's construction is as the author intended, and: 1) the construction is not elaborated on by the reader who simply rephrases the text statements in her or his own words. 2) the reader adds relevant existing knowledge to the discussion of the construction. 3) the reader's construction indicates the use by the reader of a rule or generalisation. sation. 4) the reader constructs the author's intended meahing by linking recent constructions obtained by reading other text statements.
b. The links made by the reader are in some respects as the author intended but the existing knowledge used is restricted.	The reader's constructed meaning is partially scientifically acceptable only, as the construction is restricted or less extensive than the author's intended construction, and: 1) the restricted construction is not elaborated on by the reader. 2) the reader adds relevant existing knowledge to the discussion of the construction. 3) the reader's construction indicates the use of a restricted rule or generalisation.
c. The reader's links are in some respects consistent with the author's intention but the existing knowledge used is over-generalised.	The reader's construction is scientifically acceptable in part only as the construction is over-generalised.
d. The reader's links are in some respects consistent with the author's intentions but the existing knowledge used is considered by the author as irrelevant to the main ideas in the intended construction.	The reader's construction is scientifically acceptable, but it is irrelevant.
e. The reader's links are not consistent with the author's intentions as the existing knowledge used is scientifically unacceptable.	The reader's constructed meaning is not as the author intended because of the meaning used by the reader for: 1) key concept words e.g. living 2) other scientific words 3) common words 4) other symbols
f. No links are made by the reader between the text statements and her or his existing knowledge.	The reader fails to generate a construction.

Construction a : The links made by the reader are consistent with the the author's intention.

1 : The reader's construction is as the author intended. The construction is not elaborated on by the reader, who simply rephrases the text statements in her or his own words.

For example: 6

A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants.	'So it [the spider] is an animal... it's classing a worm, eats, um, rotten leaves in the soil, so it's classed as an animal too. A sparrow is an animal as it eats seeds from plants.' (323/2)

This student added no new information to that given, but used 'rotten' in place of 'decaying' and stated the function of the sentence: 'it's classing a worm...as an animal too'.

Another example, illustrates this also:

All living things are either animals or plants. There are no other groups.	'There's two groups of things on this planet. Either plants or animals---everythings divided into two groups, every living thing.' (319/1)

This student added no new information but his phrase 'everything's divided into two groups' indicates that he had constructed the author's intended meaning.

---

6. On the left-hand side of each quotation is the relevant text sentence the student was discussing.

--- indicates an editorial break in the transcript.

... indicates a pause in the student's talk.

The quotation from the student's learning-to-read interview transcript, is coded in the brackets at the end:

323 indicates the student's code number.
2 indicates that the student read the Dual Meaning Text
(1: Challenge Text 2: Dual Meaning Text 3: Typical Text)

Construction a : The links made by the reader are consistent with the author's intention.

2 : The reader's construction is as the author intended. The reader adds relevant existing knowledge to the discussion of the construction.

In the following two examples, the readers used additional existing knowledge that they perceived as being related to the initial construction. The extra existing knowledge is relevant to the author's intended meaning.

Other carnivores live inside the body of other animals and feed on the juices.	'Yuk! (Have you heard of that before?) Yeah, but I thought they only meant sort of in caterpillars. There - is this bee that - wasp or something that comes along and it's got this big long needle, sort of on its back and it injects - right down inside the caterpillar; and lays its eggs in there. And then takes off, and after a while the eggs hatch, and little things eat away the inside of the caterpillar, and soon the caterpillar dies. And they eat their way out and go into an adult.' (307/3)
A frog is an animal that is slimy to touch Some animals like a beetle are hard.	'...yeah, frogs are slimy to touch, I reckon because he lives in the sea and water, and I don't think things are in the water, too long, go all slippery.---like a fish, he's all sort of slippery, and you can't pick them up every easily. So that's sort of their protection, so they can get away. Animals like a beetle are hard, because then they can live in soft places in the sand, and they're not so hard to kill because they're so hard.' (318/1)

Construction a : The links made by the reader are consistent with the author's intention.

3 The reader's construction is as the author intended and the construction indicates the use by the reader of a rule or generalisation.

Student (309), in the existing knowledge interview, was unsure if a human is an animal or not. On reading the first sentence, she immediately resolved her uncertainty by constructing the author's intended rule:

The world of living things can be divided into two main groups: animals and plants.	'All living things can be divided into two main groups animals and plants.' Suppose a human's an animal then---you can't really call a human a plant, so, if the world is divided up into living things, and humans are a living thing, you can't really call a human a plant, must be an animal. (Have you thought about that before? Thought about it in that way?) Not really.' (309/3)

The next two quotations illustrate the readers having constructed the author's intended meaning of sets and subsets.

A tui is a bird and it is also an animal.	'Um, it means one big set of animals and there's a few smaller groups inside it. One of the groups is a bird, and a tui is in that group of birds. So it could also be an animal.' (319/1)
Cows, aphids, earthworms, sparrows and rabbits are animals and herbivores.	'They're animals and herbivores, are sort of a subset of animals. Not all animals are herbivores, but all herbivores are animals.' (326/2)

Construction a : The links made by the reader are consistent with the author's intention.

4 : The reader constructs the author's intended meaning by linking recent constructions obtained by reading other text statements.

Student (311) did not know of aphids but was able to construct to some extent, the author's meaning by linking the constructions of two text statements recently read:

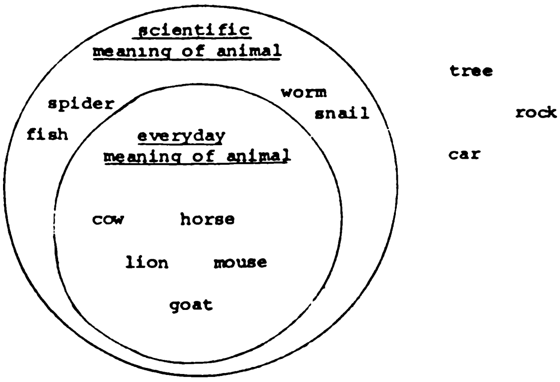
Herbivores that eat liquid food have mouthparts like a tube for sucking up the sap or juices of a plant. Aphids are herbivores that suck the sap of plants.	'I dont know about af-f-ids (Have you any idea about what an aphid is just from reading that?)--- oh, it's just a mouth that's like a tube' (311/3)

Construction b : The links made by the reader are in some respects as the author intended but the existing knowledge used is restricted.

1 : The reader's constructed meaning is partially scientifically acceptable only, as the construction is restricted or less extensive than the author's intended construction. The restricted construction is not elaborated on by the reader.

In the following example, the reader constructed the author's intended meaning of the set and subset relationship. While the author's intention is to communicate the difference between the set and subset in terms of the range of exemplars, this student constructed the difference in terms of the likelihood of seeing the exemplars. This is valid for some exemplars of the everyday meaning, e.g. cow and horse, but it does not hold true for other everyday exemplars of tiger or bear.

The everyday and the scientific meanings are two meanings of the word animal...



'...it's saying there's two meanings for animals - you can either put them in...two different sets...one's the scientific meaning and one's the everyday meaning. That [the everyday meaning] is what most people would class as animal.---see those are animals [points to subset] I know that those are animals too [points to set] and when you put them together, still all animals. (So what do the circles in that diagram tell you?) Oh, that they are all animals and that's an everyday meaning of an animal...you're more likely to see one of them [cow, horse, etc.] than see these [worm, snail, etc.].'
(323/2)

Construction b The links made by the reader are in some respects as the author intended but the existing knowledge used is restricted.

2 The reader's constructed meaning is partially scientifically acceptable only as the construction is restricted or less extensive than the author's intended one. The reader adds relevant existing knowledge to the discussion of the construction.

In this first example, the student used an everyday meaning of 'animal' to generate a construction, and the author's intended construction of two and only two groups was not constructed. The reader's construction was restricted as the group of animals was not seen as including the spider and the worm.

The world of living things can be divided into two main groups: animals and plants.	'Oh, yeah, but some things wouldn't come under one of them. (What sort of things?) At the moment, a spider's not an animal, wouldn't come under plant, and a worm, and things - insects.' (312/3)

The second example also illustrates a restricted construction by the reader as the everyday meaning of 'animal' was used to generate exemplars of small animals.

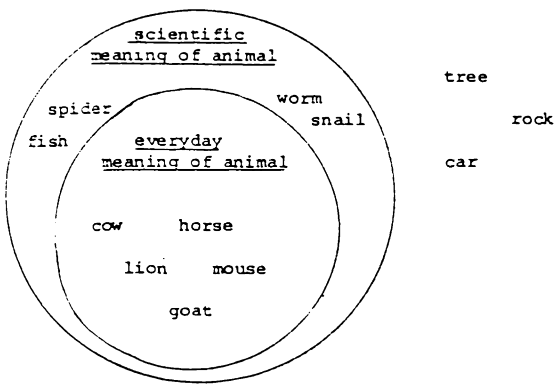
A science teacher may ask you to collect several different animals and bring them into the classroom.	'It says at the end there...it actually means the smaller animals thinking sort of practicals, be a bit stupid to bring a cat to school, maybe little mice but to bring a cat it would be.' (326/2)

The small animal suggested was a mouse, not insects, slaters or snails.

Construction b The links made by the reader are in some respects as the author intended but the existing knowledge used is restricted.

3 : The reader's constructed meaning is partially scientifically acceptable only, as the construction is restricted or less extensive than the author's intended one. The reader's construction indicates the use of a restricted rule or generalisation.

Student (327) used the criteria of detail to distinguish between the everyday and the scientific meanings. While this was to some extent acceptable to the author, the other criteria of physical appearances, e.g. legs, fur, size, habitat, and also feeding were not used to generate the construction.



ings
We can use both mean^ of the word animal but we use each meaning at a different time.

'I'm not sure exactly - the everyday meaning of animal. Everyone takes a cow, horse, lion, mouse or goat as an everyday animal but they don't really think about the spider, fish worm and snail as such, unless it's in a scientific meaning. A tree, rock, and car aren't animals at all...like in the everyday one we say that's an animal but you aren't exactly classing it as a certain type of animal. You just say it's an animal in general. You don't exactly say what area of an animal it is. (And the last sentence?) Um...it's hard to say really... in science you use the technical detailed meaning---but if you're just going, saying something about an animal in general, you just say it as an everyday animal. You don't go into details of worms and stuff.'
(327/2)

Construction c   The links made by the reader are in some respects consistent with the author's intention but the existing knowledge used is over-generalised.
The construction is scientifically acceptable in part only, as it is over-generalised.

Examples of over-generalised linking and construction were given only in connection with the sentences about animals as consumers. To a scientist the biological meaning of 'consumer' is a subset of the economic meaning. While an economist would use the word 'consumer' as a user of goods, or fuel, the biologist uses the word to mean a user of organic molecules for food (an energy source). The text did not explicitly give the limits of the biologist's meaning of 'consumer'. Some students considered other living things to be consumers. For example:

All animals are consumers.	'Well, that says a similar thing because they have to eat. All animals eat things, and if it doesn't eat anything it's not an animal, like a flower doesn't eat things things so it's not a consumer. Well, it is a consumer but not of food. Doesn't eat animals or plants. Gets the minerals in the soil and goes up. (So would you call plants consumers?) Yeah, sort of. Yes, because they use the rays of the sun and minerals in the soil.(307/3)

Others appeared not to attend to the phrase 'consumers are living things', and called non-living things, consumers. Student (307) belonged to this second group of students also:

Animals are also called consumers.	'Oh, consumers, mainly they eat other things. (You've met the word before?) Yeah---well, there's a consumer of of energy. Person uses energy. (What about that next sentence).---Oh,says consumers are things which eat other things for food. (Could you give me some examples of consumers for you?) Cows are consumers because they eat grass. All animals are consumers. (Can you think of some more examples of consumers?) Well, all other animals really...well...tape-recorder and that - they use energy from the batteries and that. Heaters, and normal house appliances and that. They use energy (Would you call a car a consumer?) Yes, because it uses petrol.' (307/3)

Construction d : The reader's links are consistent with the author's intentions but the existing knowledge used is considered by the author as irrelevant to the main ideas in the intended construction.

The reader's construction is scientifically acceptable, but it is irrelevant.

For example, student (320) made many irrelevant links when constructing meanings from the text. He appeared to be side-tracked from the key points about the scientific meaning of 'animal , by his wealth of knowledge of and experiences with animals.

Rabbits and grasshoppers are two animals that hop.	'---we've got a couple of rabbits at home---that's what I think about with that one about rabbits...things which are hard to catch---it's surprising how stupid they are sometimes---they sort of instinctively think clearly but,it sort of comes - like one of our rabbits has a crush on one of our cats for some stupid reason. The cat's scared of the rabbit. We've got 2 cats and 2 rabbits, and we let the rabbits out for a run. They are pretty tame except when it comes around to putting them back in a cage They're all over the place.'(320/1)

Note that he did not initiate discussion on whether he classified grasshoppers as animals.

In the second example, student (327) used the idea of some animals carrying diseases to explain why people and pets are treated differently, although both are animals. The notion of disease transmission is irrelevant to the author's distinction between exemplars of the everyday and scientific concepts of animal.

An example of when we use the word animal in the everyday sense is when we go shopping.	'Oh,yeah,that means like pets and stuff like that, when you go into shops---you can't take pets or anything when you're buying food because they may infect the food or do anything'. (327/2)

Construction e : The reader's links are not consistent with the author's intentions as the existing knowledge used is scientifically unacceptable.

1 : The constructed meaning is not as the author intended because of the meaning used by the reader for key concept words, e.g.plant, living, animal.

In the first quotation, student (323) used the heart and brain as distinguishing features of living things, although he also knew of the scientific ones.

A tree is not an animal as it does not eat other living things.	'Oh, tree could be living because it's got a heart system, things flow around it's body---a tree is living because that MRS.GREN thing - it's got all of them, respiration and all that. It can breathe---it's living, because we were told if MRS.GREN fits into it, they'd be living and it eats vegetable substances. (So you'd call the tree living?) Well, I wouldn't even looking at it they wouldn't---a young child wouldn't call it a tree and call it living. Think that hasn't got a heart, or a brain.' (323/2)

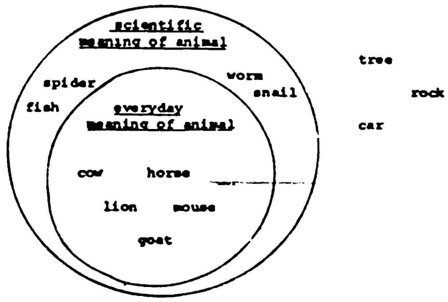
In the second quotation, the criteria of inability to make houses was used to distinguish people from animals (sic). Hence, the student's construction differed from the author's intended one.

Animals must eat other living things for food.	'That's how animals live, they're different from us because they eat other living things to live--- they [the animals] don't live in houses, and they don't build houses, and they don't have the sort of knowledge we have to build houses, and that sort of thing. We sort of rule them really.' (310/3)

Construction e : The reader's links are not consistent with the author's intentions as the existing knowledge used is scientifically unacceptable.

2 : The constructed meaning is not as the author intended because of the meaning used by the reader for other scientific words.

In the first example, the student's meaning of the word 'eat' was different to the author's intended meaning, and hence the construction (that plants are herbivores) was unacceptable.



'Oh,...well that's a herbivore [tree] and those--- aren't animals. (A tree's a herbivore, could you explain that?) Oh, they eat plants, and... they're living and they eat plants. (Trees eat plants?) Because a plant dies and see, it would be a fallen tree, and all the leaves would fall off---[other trees] grow in it, and that's living off plants. Might have to rot a bit. So the tree's living off other plants. It breathes and it can move and it's got movement. And it eats---.'
(323/2)

The same student also used a different meaning of the word 'remains' to the author's intended one of carcass.

Some animals eat only other animals or their remains and are called <u>carnivores</u>.

'Like some animals will eat the animals. Some animals will eat the, um, the excretion or something...oh, what eats a cowpat? A duck or something. That's a herbivore and it eats cowpats. Say a cow eats grass, what comes out the other end is still grass, different form though. It should be called a herbivore, shouldn't be called a carnivore just because it has ready made. It doesn't eat - if it was hungry might eat meat.'
(323/2)

Construction e : The reader's links are not consistent with the author's intentions as the existing knowledge used is scientifically unacceptable.

3 : The constructed meaning is not as the author intended because of the meaning used by the reader for common words.

For example, student (318) used the word 'fed', not in terms of what was being eaten, but in terms of the <u>source</u> of the food. He did not appear able to reconcile his own idea of domesticity and carnivorous feeding, which he linked with hunting.

Cats, spiders, lions and sharks are all carnivores.	'Yes---yes, I suppose, now they say cats eat birds. They probably would but I don't reckon they'd eat it as much as ---the spiders or the lions. Because they sort of get a feed of their own by someone, someone else does feed them too usually. But a spider sort of doesn't get fed...and a lion doesn't get fed, and a shark doesn't get fed by a person who likes them.' (318/1)

A second example illustrates an unintended construction being made when the student used an unintended meaning of the word 'make':

Plants can make their own food using the sun's energy but animals are unable to make their own food.	'Well, animals don't have hands and things that they can make their own food with, because they've just got four legs. That's very awkward. They aren't able to do things like we are because we have fingers and hands to help us. (So people can make their own food?) Yeah---they could grow their own crops, they could buy things or like grow things to make things - biscuits and that. And animals just have to use their mouths. Unless it's a monkey.' (308/3)

In the third example, the logical nature of the connective 'as' was not appreciated by student (318). He did not construct that a sparrow is an animal <u>because</u> it eats seeds, but he construed that a sparrow is an animal <u>and</u> it eats seeds.

A sparrow is an animal as it eats seeds from plants.	'(What does the "as" in the sentence mean to you?) It means that...to me, it just eats seeds and plants---It sort of says it is - that's what it eats and that's all it eats.' (318/1)

Fourthly, a student failed to construct the author's intended meaning as the intended meaning of 'either' and 'or' was not generated.

To a scientist, living things can be either animals or plants.	'...They are saying to a scientist we can either be living things or can either be plants - animals or plants. There's no other group.--- there's animals and...animals, oh, living things - animals and plants. And see they either go in that one or that one (Go into one of those three - living, animal, plant?) Yes, an insect, if it's not an animal, it wouldn't go in either, it's not a plant so it won't go in plant, and it's living so it would go in there. But if it's dead...it can't go in there if it's a dead insect. (So where would you put it then?) Oh, needs another group - not living or was living or something.' (323/2)

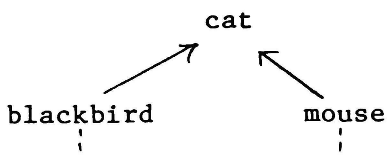
In the last example, student (318) was unable to find a referent for 'that' and 'those', and was unable to construct the author's intended meaning.

To a scientists, animals are those living things that are not plants.	'...means that they're a bit wrong because sort of feel, they're a bit wrong because they say that animals are those living things that aren't plants...---I'm a bit confused--- those bits "to a scientist, are those living things". Don't really understand those - those living things. That little bit. And where it says "They're...that are not plants." It's a bit hard I think (Is it the words 'those' and 'that'?) Yes---that. They're saying that, to me, it's telling me that animals are things that are living and plants aren't. Plants aren't living and animals are. (But you think plants are living?) Yes.' (318/1)

Construction e : The reader's links are not consistent with the author's intentions as the existing knowledge used is scientifically unacceptable.

4 : The constructed meaning is not as the author intended because of the meaning used by the reader for other symbols.

In constructing a meaning of the food web diagram, student (311) interpreted the arrows not as the direction of energy transfer during feeding, but as the direction of attack!



'In the diagram, puts the cat, yes, the cats would be pecked on for eating things.'
(311/3)

Construction f : No links are made by the reader between the text statements and her or his existing knowledge. The reader fails to generate a construction.

No linking and construction was made if the reader lacked the necessary existing knowledge:

Animals which eat plants or parts of plants, are called herbivores.	'I don't know the next word either... herb-i-vores or something. Never heard of it. Shall I go on?' (310/3)

No construction was made if the reader was unable to generate links between the text information and her or his existing knowledge:

An example of when we use the word animal in the every-day sense is when we go shopping.	'...don't know how they get shopping out of that first one there...when we use the word animal in an everyday sense is when we go shopping---How [do] they get an animal into an everyday sense with shopping...(324/2)

Some readers could not generate the links and construction because of the sentence given in the text:

Animals are those living things that are not plants.	'...don't even get what that's supposed to mean...---it seems backwards...---doesn't make sense.' (324/2)
Something is an animal if it is living and if it eats other animals, plants or their remains for food.	'...means that...is sort of saying an animal, if it's living...and it eats other things...other animals or their remains for food---one thing thats confusing, it's---"if it is" and "if it". Sort of a bit confusing because it's sort of all two letter words, and it's a bit confusing for the reader---doesn't really make too much sense---because I reckon it's because all those little words and it's got commas.' (318/1)

Other readers could not make links and generate a construction because of decoding problems:

Animals are those living things that are not plants.	'...says that animals are those living things that aren't planets. Doesn't really seem to make sense to me---I don't think that there's anything to compare really between them because they're---oh, it says plants, I thought they said planets [laughs] I was getting real confused.' (326/2)

5.2.2 Making a decision about the status of the construction

The second activity undertaken by the student involved an implicit or explicit decision about the status of his or her construction. The learner either accepted or rejected the construction, or was unable to make a decision. In all three instances, the decision was made (or attempted) by comparing the construction with the reader's existing knowledge. Students' comments about the status of the constructions were categorised into one of eleven groupings (see Table 11), which arose out of the data analysis and were not pre-determined by the researcher. Examples of transcript quotations categorised into each category are given.

TABLE 11: Status Categories

X	The reader accepts the construction. 1. No specific information is given by the reader. Acceptance is inferred by the researcher. 2. The reader knew of the information already. The construction matches the reader's existing knowledge. 3. The reader accepts the construction over her or his existing knowledge. Higher status is given to the new construction. 4. The reader accepts the construction but the acceptance is qualified. 5. The reader accepts the construction because any construction made from print must be right.
Y.	The reader is unsure as to whether to accept or reject the construction because: 1. the reader is unsure about the validity of her or his existing knowledge when compared to the construction made from the text. 2. the reader is unsure about the validity of the construction made from the text, when compared to her or his existing knowledge. 3. the reader is unsure about both the existing knowledge and the construction - neither is given more validity than the other.
Z.	The reader dismisses or rejects the construction because: 1. of conflict with existing knowledge, which can be made explicit. 2. of conflict with tacit existing knowledge. 3. a more plausible and intelligible alternative construction is generated.

Status X : The reader accepts the construction.

1 : No specific information is given by the reader.

Acceptance is inferred by the researcher.

One student's acceptance is indicated in the quotation by the use of additional information to support her construction of the text statement. She mentioned the names of the two meanings; gave examples of animals in the everyday sense (cow, lion, horse); and gave an indication of the different times for using each meaning.

We can use both meanings of the word animal, but we use each meaning at a different time.	'---like we use the everyday - cow, horse, and lion and all that everyday but the scientific meanings are - when we're doing studies or something - like in a lab.' (326/2)

Status X : The reader accepts the construction.

2 : The reader knew of the information already.

The construction matches the reader's existing knowledge.

In the first two examples, the student indicated acceptance of the constructions, validating the constructions with her prior experiences:

All caterpillars found in your garden are herbivores and all have mouth parts.	'Caterpillars, I've often seen caterpillars chew their way round leaves.' (308/3)
Cows are herbivores and have teeth for crushing and grinding plants.	'...cows eat, when they chew the grass - mouths go from side to side.' (308/3)

In the third example, the student explicitly stated her acceptance of the construction. That she knew of the information already was implied:

What is the everyday meaning of animal? Usually when we use the word 'animal', we think of a cat, dog, lion, or a cow. They are large, furry, four-legged creatures that live on land.	'Yeah, I agree with that when it says "We usually think of a cat, dog, lion, cow"---they are large, furry, yeah, that makes sense...' (326/2)

Status X : The reader accepts the construction.

3 : The reader accepts the construction over her or his existing knowledge.

Higher status is given to the new construction.

The world of living things can be divided into two main groups: animals and plants.	'That they could be divided just into two groups---(Is that new to you?)---Oh, in a way. Because I thought there were quite a few groups but I didn't realise that there were just those two main groups, animals and plants.---they don't really talk about it's mainly animals and plants and nothing else.' (308/3)

Student (308) accepted the two kingdom classification system and at the end of the interview, she correctly classified the exemplars in the informal interview-about-instances as would a scientist.

Status X : The reader accepts the construction.

4 : The reader accepts the construction but the acceptance is qualified.

In this example, the student accepted the construction but saw the need to qualify it.

An opossum is an animal that may be found in a tree.	'Opossums don't always just live in trees...they may be found there, but they live on the ground, and at night they come out.' (318/1)

Status X : The reader accepts the construction.

5 : The reader accepts the construction because any constructtion made from print must be right.

A whale is a big animal and a fly is a small animal.	'Yes [a fly is an animal] I used to think [it] as insect, not being animals...I think it is now. (What changed your mind?) This is sort of official, you know.' (320/1)

This quotation illustrates the student's willingness to change his existing knowledge to what he saw as the authoritative view.

A second example illustrates further his willingness to accept a construction over his existing knowledge because of the perceived authoritative nature of the text construction.

Some animals, like oysters and barnacles, stay in one spot and never move away.	'...I was just thinking about oysters and barnacles. I haven't really thought about them as an animal before ---suppose I'd call them, sort of a meaty vegetable---you know they don't seem to react to you much, you know, you can just grab them---these shellfish try and grab the landscape, - oh yeah, that's right, a limpet. Touch them and they just go [slurps] and seals off and you can't get them off without a proper knife. Suppose that's a reaction, I don't know. (Would you agree now that oysters and barnacles are animals?) Suppose I'd have to - can't argue with that, can't argue with half the world's scientists.' (320/1)

Status Y : The reader is unsure as to whether to accept or reject the construction.

1 : The reader is unsure about the validity of her or his existing knowledge when compared with the construction made from the text.

Student (312) perceived a lack of sufficient existing knowledge about an owl's food to accept or reject the construction that an owl is a carnivore. (An owl is a carnivore, eating, for example, mice.)

Snakes, owls and lions are carnivores.	'(Would you call those 3 things carnivores?) No, I don't think I would. A snake I would, but I don't know what an owl eats.' (312/3)

The second quotation illustrates the student's inability to accept or reject the construction as he was unable to recall, from his prior experiences, the number of legs that spider and wetas have.

Spiders are animals with eight legs. A weta is an animal with six legs.	'I'm not quite sure if they have 8 or 6 --- I haven't really studied a spider. I've studied a weta, then I'd know if it had 6 or 8, but I'm not quite sure...
A cow is an animal with four legs.	A cow is an animal with four legs. Yes, because there's sort of see a cow everyday, not everyday, but it's something much bigger than a spider so you'd sort of see it more. (318/1)

Status Y : The reader is unsure as to whether to accept or reject the construction.

2 : The reader is unsure about the validity of the construction made from the text when compared to her or his existing knowledge.

In the first example, student (308) expressed difficulty in reconciling her construction from the text, about thrushes eating snails, with her existing knowledge about the function of the snail's shell.

The thrush seeks out snails and eats the soft meat of the snail.	'I didn't know a thrush ate snails, and it eats the soft meat---the shell of the actual snail protects it from birds like the thrush'. (308/3)

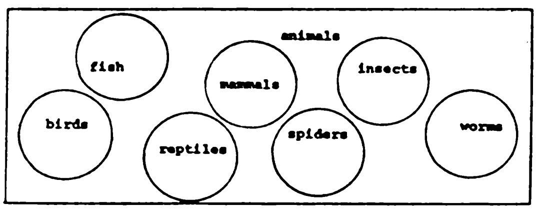
In another example, student (318) appeared to be uncertain about the construction (people are animals) as he considered people to be humans, not animals. He did, however, by the end of the interview, accept and use the construction that people are animals.

A cow is an animal. A person is an animal.	'I didn't expect a person to be an animal. Think they're human. And a cow, I'd thought that would be an animal.---(Do you think that might be correct? A person is an animal) Sort of, because I thought everybody says you're a human so I'd expect a person to be a human, not just an animal, not an animal.' (318/1)

Status Y : The reader is unsure as to whether to accept or reject the construction.

3 : The reader is unsure about both existing knowledge and the construction made from the text. Neither is given more validity than the other.

In this first quotation, student (320) challenged his construction from the text by thinking of possible exceptions or irregularities ('just trying to think of one that doesn't go into one of those groups'). However, his existing knowledge about the classification of the platypus and the snail was held in doubt also. He did not view the diagram as incomplete as would a scientists, as the subset of molluscs, had not been included.



'Oh, it just shows you all the different types of animals you can get...groups. Just trying to think of one that doesn't go into one of those groups. Where would the duckbill platypus go---have to go in the mammals.---well, it's certainly not a fish,... it's not a bird because it can't fly... or it never actually had wings as far as I know. Might have had back in evolution or something. Doesn't have it now. (Are there any other animals you're not quite sure about where they go?) What's a snail? I don't know what I'd stick that under. It's not a mammal. It's not a reptile. ---I don't know where I'd put it because it's sort of doesn't seem like an insect, like they are usually but---I suppose it's obviously the same sort of thing as an insect does... except that it will be in the same sort of category as what you call a bug like an aphid.' (320/1)

(cont'd.......)

In a second example, student (323) perceived a mismatch between his existing knowledge (people are animals) and his text construction (people are not animals).

In the everday sense of the word, people are not animals. So we can go in to buy food.	'...oh, that one says when you go shopping you use the word 'animal' because in shops it says 'No animals allowed' and that ...but if we read it we know not to take those things in the shop... ...it's saying that people aren't animals so we can go in to buy food. (Does that make sense to you?) I thought a person was an animal---we don't class ourselves as animals or if we are animals, we don't class [ourselves] as animals, or maybe we're not called animals.' (323/2)

His uncertainty as to whether to accept his construction or his existing knowledge was stated in the last sentence. This uncertainty appears to have arisen as he did not construct the author's intended meaning for the first phrase - 'in the everyday sense of the word'.

Status Z : The reader dismisses or rejects the construction because of:

1 : conflict with existing knowledge which can be made explicit.

Some examples are:

Student (326) rejected the use of size as a distinguishing characteristic of animals in the everyday sense.

We may not call worms, spiders and butterflies animals as they are small.	'It says that they're small...and that they're not animals...but I don't think---being small has got really anything to do with them not being animals. (Would you call them animals?)---oh...don't really know.' (326/2)

Student (310) rejected the text criterion of feeding.

Some living things are put into the group of animals because of the way they feed.	'Doesn't mean anything really because I don't think it's right---because you don't judge things [on] the way they feed. What they are. (What sort of things would you look at instead?) I don't know.' (310/3)

Student (324) rejected his construction made from the text. His construction was not the author's intended one of herbivorous feeding.

Some animals eat only plants or parts of plants.	'...I don't agree with that. It says that plants are just food for other things---it's not living on its - not living for itself, it's just a living thing, other things come to eat it.' (324/2)

Status Z : The reader rejects the construction because of:

2 : conflict with tacit existing knowledge.

Student (324) rejected the text construction (spiders are animals) but could not articulate his reasons. A possible explanation may be that the construction did not match his existing knowledge of a prototypical animal.

A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil.

'...I still think spiders are insects, not animals. Don't know why. I just don't feel a spider's an animal---I don't really agree with that one either. ---I don't agree with it because I don't think an earthworm's an animal either.'
(324/2)

Status Z : The reader rejects the construction because:

3 : a more plausible and intelligible alternative construction is generated.

In the first example, the initial construction was rejected and a new one was formed when the student read the next sentence.

An example of when we use the word animal in the everyday sense is when we go shopping.	'...and an example... I don't understand that---...I don't use it when I go shopping. Oh, yeah, I get it---that when we go into a shop or anything, they usually have a sign saying that 'No animals aren't allowed in'. Everything, only sort of humans. And it sort of means we can't take, bring our dog or horses in there.' (325/2)

Student (326) rejected her initial construction when she realised her decoding error.

Animals are those living things that are not plants.	'...says that animals are those living things that aren't planets. Doesn't really seem to make sense to me---I don't think that there's anything to compare really between them because they're---oh, it says plants, I thought they said, planets, [laughs] I was getting real confused.' (326/2)

(This quotation was also used to illustrate a construction category.)

5.2.3 Summary of the model

The generative learning model (Osborne and Wittrock, 1983) suggests that during reading comprehension and learning, students use their existing knowledge to generate a tentative construction, and to evaluate that construction to decide whether to accept or reject it as part of their relatively permanent existing knowledge. The findings of Phase II suggest that these two processes -the construction and its evaluation - were actively done by the students in the reading-to-learn interviews. To this extent, the generative learning model is supported by the data collected. The two step model is also useful to account for, and explain other findings. To illustrate this, two case studies will be detailed.

5.2.4 Using the model to explain two case studies

The model outlined in sections 5.2.1 and 5.2.2 provides a useful framework for analysing and interpreting individual 'reading-to-learn' interviews. Those with students, 316 and 317, were two such interviews.

One student (316) after reading the Challenge Text, changed her concept of animal towards the scientific one, while the other student (317) did not. Both students were in the same science class, having the same science teacher. Both were initially surveyed for their concept of animal at the beginning of the school year (25.2.82) along with the rest of the class, and for a second time (14.9.82) before the reading-to-learn interviews. In the intervening seven months, the class had done a unit of work on classification. Both girls had similar scores on the T.O.S.C.A. and P.A.T. reading comprehension tests, (see Table 8b). Each student's interview will be discussed in turn.

Student (316)

In the first survey, Student (316) categorised only the cow as an animal. It would appear that she was using an everyday or restricted meaning of the word 'animal'. In the second survey, both the cow and the worm were categorised as animals.

In the existing knowledge interview, she commented on her choice of answers in the second survey:

> 'I just think it's [the cow] the animal, just classified as an animal. There's sheep and dogs. (Is there anything about a cow that tells you it's an animal?) Well, it sort of eats, breathes.' (316/1)

> '(Is a worm an animal?) Oh, yes, there's probably another name for it but I'm not quite sure on it. Yes, I probably think it would be an animal because they eat...yes, they eat and...is there another name? There might be another name for the worm but you couldn't call it an insect, because insects are supposed to have six legs, so I just call it an animal.' (316/1)

The cow, sheep, and dog may have been considered animals as they intuitively matched the prototypical animal - four legs, large, furry and terrestrial. The worm appeared to be categorised by default - it wasn't considered an insect so it was called an animal for want of another group name. It is unclear if she was using the characteristic of eating (and breathing) as a distinguishing characteristic of living things or of animals. In discussing her categorisation of the other survey instances as non-animals, she commented on the group membership of each instance:

> '(The person?) Well, they are warm-blooded, I classify them as a mammal. But again, it could be an animal. (What tells you it's a mammal?) Warm-blooded. I think they feed their babies on milk. (You said it could be an animal?) Well, same as the cow. Eats, and it's got the same things inside, like a stomach and that.' (316/1)

> '[No, a whale is not an animal] it's a sea mammal. I just classify that as a mammal because most of them that live in the sea, air-breathing - they use lungs. I mean gills, just slightly different. And they breathe oxygen out of the air'. (316/1)

> '[No, a spider is not an animal]. A spider, I classify that as, it's not actually an insect, but it's sort of a creature I suppose, just a beetle, I just - it's a spider. It could be an animal, I suppose. The fact that it drinks blood. It's just slightly different.---Yes, I suppose it could be an animal---they need something to nourish them, to eat. That they're alive, movement.' (316/1)

This student did not appear to appreciate the hierarchical classification and hence, the dual membership of the set and sub-set. Group membership was discussed in each case and the characteristic of eating was also mentioned often, along with other characteristics such as breathing, warm-bloodedness, movement and internal organs. It could be that she was discussing her known characteristics of living things. However, in the survey she correctly categorised the instances in the 'living' section and in the interview she commented:

> 'The fire. [is not living] Well, they have to have someone to light it or start it,...could be called alive but nor from my point of view. You've got to stay alive, be born and stay alive ---just energies.' (316/1)

> 'A person is living - yes. Because it's moving, it's been born, and it's growing, and then it dies.' (316/1)

> 'No [a car is not living] it needs something to start it and it needs things, needs someone to actually start it.' (316/1)

The discussion of her categorisation of these three instances did not elicit the same characteristics (except movement) as in the discussion on the 'animal' instances.

In the discussion on her categorisation of the carrot and the tree in the plant section of the survey, she commented on the nutrition of plants, although she did not explicitly state an awareness of the significance of the different modes of feeding as distinguishing characteristics of plants and animals.

> 'Yes [a carrot is a plant] you can classify it as a vegetable but all plants need water and sunlight to grow, and carrots need those - so, and it grows. I'd classify that as a plant.' (316/1)

'(and the tree?) Same thing, it needs the sun - all plants, anything - - just stays in one place but it still grows.' (316/1)

At the end of the interview she was asked 'Is there anything else you'd like to say?' She replied:

'Animals and mammals are mostly classified as the same thing but just, they are put into different groups. It would be...in one big group I suppose, it would kind of be the same. (What is the difference between an animal and a mammal to you then?) Oh, there isn't much difference really except that, it's maybe just another name because those ones are probably warmer - the whale and that are warm blooded'. (316/1)

She appeared to be questioning her own existing knowledge of animals and mammals. She also commented that her mother had lived on a farm and that the family went to the farm on many occasions. In other words, she has had many experiences with farm animals.

In summary, while this student categorised the instances in terms of the everyday meaning of 'animal', she did not appear to use the everyday distinguishing features such as four legs, fur, size and habitat, but used instead characteristics such as eating, breathing, internal organs, and movement.

In the reading-to-learn interview, this student constructed and accepted the author's intended meaning of the first two sentences:

All living things are either animals or plants. There are no other groups. C = a2 7. S = x3	'Oh, it's just two different groups of living things---that [the second sentence] is not strictly true, that's only the living things---yeah, that would be the only two things--- ---Oh, there's rocks and that sort of thing, but they are not actually living.' (316/1)

This quotation may be categorised as an (a2) construction as the student constructed the author's intended meaning (that there are two and only two groups of living things) and added additional existing knowledge to the discussion (rocks are not animal or plants and they're not living).

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7. A summary of the construction (c) and status (s) categories is given in Table 12 for ease of reference.

TABLE 12: Summary of the Construction and Status Categories

Construction	Status
a : Intended construction and: a1 : no elaboration a2 : relevant elaboration a3 : rule used a4 : linking of two constructions	x : Acceptance of construction: x1 : assumed by researcher x2 : as it is already known x3 : and change to existing knowledge x4 : but the acceptance is qualified x5 : based on external authority
b : Restricted construction and: b1 : no elaboration b2 : relevant elaboration b3 : restricted rule used	y : Indecision as unsure of: y1 : existing knowledge y2 : construction y3 : both existing knowledge and the construction
c : Over-generalised construction	
d : Scientifically acceptable but irrelevant construction	
e : Not intended construction because of meaning used for: e1 : key concept word e2 : other scientific words e3 : common words e4 : other symbols	z : Rejection of construction because: z1 : of conflict with explicit existing knowledge z2 : of conflict with tacit existing knowledge z3 : a better alternative constructed
f : No construction made	

At first the student rejected her construction of the second sentence, 'that is not strictly true', but then focusing on the phrase 'living things', generated another construction, which she then accepted- 'that's only the living things---yeah, that would be the only two things.' Therefore the status of the quotation, in the end, would be categorised as x3. Further evidence to support this x3 categorisation came towards the end of the interview when she was asked if there was anything in the text that was new for her and that she felt she had learnt. She replied:

> 'About how they say that living there are either animals or plants,---' (316/1)

In response to reading the next text sentence, a question, she commented:

What is an animal?	'An animal's just a living thing that is moveable'. (316/1)
C : b2 S : x2	

Her reply was in keeping with the existing knowledge elicited in the existing knowledge interview. In terms of the scientific meaning of the word 'animal', the construction is acceptable in that all animals are living things but it is restricted in that not all animals move, for example, barnacles. While the information that animals are living things was in the first sentence, the information about animals moving was not. Hence, the construction may be categorised in b2 category. As the answer to the question was not in the text, but constructed mainly from the student's existing knowledge, it can be inferred it was accepted by her. Also she did not feel the need to discuss her answer further. The status of the construction may be categorised as x2.

She used her constructions of the first two sentences when comprehending the next two sentences:

A cow is an animal. A person is an animal.	'A cow, it's more of a,- it's living. Same as the person.' (316/1)
C : a2 S : x3	

As she had categorised the person as a non-animal in the second survey, she was asked:

> '(You'd call a person an animal?) Yes, because it says 'Living things are either animals or plants'. (316/1)

In the existing knowledge interview, she had expressed doubt about her categorisation of the person:

> 'But again, it [a person] could be an animal'. (316/1)

It would appear that she was able to use her construction of the first sentence to construct the author's intended meaning of the sentence 'A person is an animal'.

With the next sentence, she expressed an awareness of the different animal groups but not of the hierarchical classification.

Sparrows, goats, spiders, earthworms and sharks are also animals. C : b2 S : x4	'There's spiders and that, they would be, but there's more besides names and groups for them and that. (What do you mean by that?) I'm not quite sure,---spiders,I just know that they are insects, and sharks are fish.' (316/1)

With the following sentences, the student constructed the author's intended meaning and was generally accepting of her constructions:

An opossum is an animal that may be found in a tree. C : a2 S : x4	'And an opossum doesn't always live in a tree---they don't always live in trees, suppose that's the main thing. Because you quite often see them up power poles'. (316/1)
A dolphin is an animal found in the sea. C : a2 S : x4	'Yeah, animals are found in the sea - they're found in water [too] because some of them are only freshwater'. (316/1)
A spider is an animal that may be found in a crack. C : a2 S : x4	'Yes. Spiders don't live in a crack. Places that are suitable for them to feed on. (What sort of places?) Oh, sometimes in a corner, on the corner of a house or something.' (316/1)

She did not however, initiate discussion on whether she considered the opossum, dolphin, spider, shark or whale to be animals. At this point she was asked to clarify her thinking:

> (Would you call sharks and whales animals?) Yes, but again there's different preciser names.'
> (316/1)

Again her comments imply an awareness of the subset names, but not of the hierarchical classification. This issue was met again:

Some animals like a beetle are hard. C : a2 s : x3	'and a beetle, which is hard, to protect it from it's predators. (Would you call a beetle an animal?) Well, I probably classify it as insects, with their six legs. I think of them as insects (So would you call them animals?) Oh, if it came to it, yeah, they are animals. But mostly I just think of them as insects.' (316/1)

For the first time, she had explicitly stated that an animal such as a beetle could belong both to the group of insects and the group of animals, although she has a preference for one rather than the other. She accepted the construction on the meaning of 'animal', as she had earlier in the reading:

To a scientist, animals are those living things that are not plants. C : a2 S : x2	'Oh, I've heard of a scientist. Just anything could be an animal so long as it is not a plant --- they need things to live on, like plants or grass for food.' (316/1)

She also indicated she had constructed, accepted and used heterotrophic feeding as a distinguishing feature of animals, as in the following four examples:

A lion is an animal as it eats other animals like zebras for food. C : a3 S : x1	'And so a lion is an animal because it eats animals. Just because it eats more, or other animals. They are really saying that so long as it eats plants or animals, it's an animal.' (316/1)

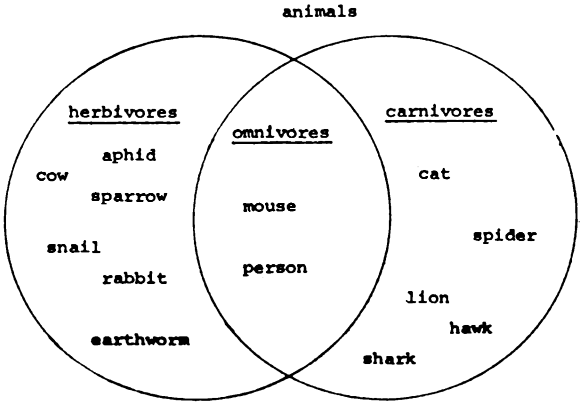
Note she interchanged 'as' in the text with 'because' thereby implying an awareness of the significance of the use of the logical connective.

A tree is not an animal as it eats other animals like zebras for food. C : a2 S : x4	They say a tree isn't an animal. Say a tree wouldn't be an animal because it doesn't eat meat, although some of them do. Venus fly trap, they eat.' (316/1)
A car is not an animal as it is not living and it does not eat plants or animals. C : a3 S : x2	'...so a car wouldn't be any of them because it doesn't eat or it doesn't need the sun or anything.' (316/1)
Something is an animal if it is living and if it eats other animals, plants, or their remains, for food. C : a3 S : x2	'If it eats plants [or] meat it would be an animal, but if it has the other way, like the sun. It's a plant.'

She appeared to be able to relate the biological and the economics use of the word 'consumer' to her own satisfaction:

Animals are also called consumers. C : a1 S : x2	'They are saying all animals are... consumers because they eat...(Have you met the word consumer before?) Oh, in economic studies. (What do you understand by the word 'consumer'?) Oh, used up---Yes [it makes sense to me] because it's just eating and consuming food.' (316/1)

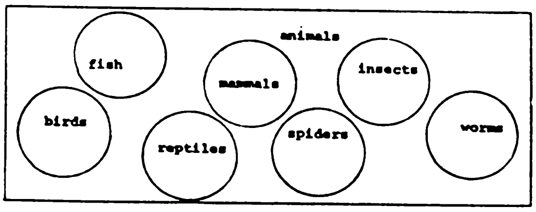
The paragraph on herbivores, carnivores and omnivores was read with apparent understanding and acceptance. This was illustrated in her discussion of the diagram:



C : a2
S : x1

'There's just the three groups and some are both. So put into one group ...the intersection (The intersection. What do you mean by that?) Oh, both sort of...there's two things or how many things which are in both groups (What do you mean both groups?---) Like the carnivores and herbivores - this one's got it all - they've both got two which are in both the groups---(What about this up here? It's got 'animals' up here. What does that mean to you?) That all these are subgroups of animals. (You'd call all these things animals?) Yes.' (316/1)

It would appear that she constructed and accepted the author's intended meaning of sets and subsets, for that diagram and the next one:



C : a2
S : x1

'Then they get into smaller groups, like the birds, and there's all sorts of birds, of all types and breeds. Then they have got mammals. These are just another group of animals. All just sort of sub-headings to classify them all...there's another one - the insects, which just -they're all just small sub-headings of the animal...that's all from the one big thing. Then it said there'd be smaller ones, and insects, and then get down to beetles and...'
(316/1)

<u>The informal Interview-About-Instances (I.A.I.)</u>

In answering the questions at the end of the interview, the student indicated that she had learnt the scientific concept of <u>animal</u>, with respect to the:

(i) definition:

'(So if you were a scientist, how would you answer the question "What is an animal?") An animal which is a living and moveable, that consumes - uses up food.' (316/1)

Note that she continued to use the existing knowledge she had used in the first interview, that of living and movement, and had added her construction of the text statement on consumer feeding:

(ii) applying the rule

'I'd say yes [a cow is an animal] because they consume...living' (316/1)

'Yes, [a person is an animal] because it's just the same as the cow. We are living. And we eat food.' (316/1)

'Yes [a caterpillar is an animal], it eats plants, and animals are the meat eaters or plant eaters. And that's a plant eater, so it would be an animal'. (316/1)

'Yes, [an ostrich is an animal] it's still eating animals and things like that'. (316/1)

(iii)	and the hierarchical classification	'Yes [a caterpillar is an animal] but there's probably other names it could be - it's an animal still'. (316/1)

She commented on her learning of the hierarchical classification:

> 'Oh, when I really thought about it, I had them [person, whale] as mammals but when I read that, that's just another name, it's smaller down. So really it would be an animal.' (316/1)

> '---I was really thinking of the groups, the more precise groups, like them being all mammals.' (316/1)

Final survey

In the final survey, she categorised all the five instances as animals as would a scientist, and gave as reasons for her answers 'Because they need nourishment' and 'They can move around'. This indicates that she had retained the scientific concept in terms of exemplars, but not in terms of distinguishing features. This student, to some extent, learnt the scientific concept of animal. In her reading-to-learn interview, she, on the whole, constructed and accepted the author's intended meanings.

Student (317)

In the first survey, student (317) classified only the cow as an animal, indicating a use of the everyday meaning of 'animal'. In the second survey, she classified both the cow and the person as animals.

In the existing knowledge interview, she gave these reasons for her cow and person categorisation:

> 'Yes, I think it [the cow] is an animal---because it gives milk and ---has calves. I think it's an animal.' (317/1)

> '(And the person?) I don't know why I put yes, but I think it is--- I've just heard that a person's an animal.' (317/1)

She commented further on the person at the end of the interview:

> 'I don't know if a person's an animal or not---animals being killed and that. I feel sorry for the animals when they get killed.' (317/1)

For these two instances, no scientific distinguishing features of an animal were used. The two characteristics volunteered for the cow's categorisation appear to be those for a mammal.

The other instances were categorised as non-animals on the basis of other group membership, size and habitat - distinguishing features of an animal in the everyday sense:

> '[A whale] Mammal, I think it is a mammal, not an animal because it, most of the sharks and that are called mammals because they live in the sea.' (317/1)

> '(A spider?) No [it's not an animal] that's an insect. It's not as big as the other ones, but I think it's not an animal'. (317/1)

> '(A worm?) No [it's not an animal] that's an insect too, because spiders and that live underground, and most things actually live on the ground, animals live on top of the ground. Most of them--- some animals live in burrows but most of them do...Yep, insects live underground.' (317/1)

She also used an alternative meaning (the metaphoric one) to the scientific meaning of 'living', in classifying the instances in the 'living' section:

> 'A fire is living because it breathes and it eats'. (317/1)

> 'A person is living because the heart beats, the blood pressure goes around.' (317/1)

'A car's living because it moves around. It's got an engine, has petrol.' (317/1)

She categorised the plant instances as would a scientist but she did not use the scientific distinguishing features of a plant.

'I reckon a carrot's a plant because a carrot lives underground, some plants do, like vegetables. But I thought that was a vegetable, but I'm not sure if it was a plant or not. I put yes.' (317/1)

'A tree's a plant. Just like a shrub, and that. I thought shrubs are the same as trees so I put the plant.' (317/1)

The reading-to-learn interview

To some extent the student constructed the author's intended meaning of the first sentence but she did not accept it:

All living things are either animals or plants.

C : b1
S : z2

There are no other groups.
c : f
s : -

'Um...I don't think animals are living. Oh, everything is. Yes, an animal - could be - (What are you thinking about when you read that?) If they're living, if they are animals or plants (Is that something that is new to you?) Oh, I've heard it before, but it's got like - something new. (What sort of things are new?) I don't know, I just think that...when I read that I knew - didn't think that living things are animals or plants. (What about the second sentence?) I don't know - 'no other group'. I don't think anything.' (317/1)

She did not verbalise a construction for the second sentence.

She accepted her construction of the next text statement about a person, maybe as it was similar to her statement in the existing knowledge interview:

A person is an animal.
C : a1 (?)
S : x2

'A person is an animal. Makes sense...' (317/1)

But with the next sentence:

Sparrows, goats, spiders, earthworms, and sharks are also animals.

C : b2
S : z1

'I don't think a sparrow, earthworms, or sharks are also animals...I didn't - I thought a shark was a mammal. (What about sparrows?) Oh, sparrows and goats are animals, but I thought spiders and earthworms and that, are insects...it's hard to see them as animals...when they say animal, I always think of cows. We used to live on a farm. Animals, like I picture a cow, something like a cow...'(317/1)

She continued to use an everyday meaning of the word 'animal' ('A shark is a mammal, not an animal') as she had in the existing knowledge interview. She rejected the construction as it did not match her existing knowledge ('when they say animal, I always think of cows').

The next two statements made by the student indicate the use of her existing knowledge of the everyday meaning and at times her rejection of her construction of the text:

An animal can be as big as a ship or as small as a pin. C : b1 S : z1	'Oh, can't be as big as a ship, depends how big the ship is. (What about as small as a pin?) I think - more it was a little insect...' (317/1)
Where are animals found? C : b2 S : x1	'Animals are mostly found in the wilderness, in the jungle and that, most animals---elephants, leopards.'(317/1)

She also made statements that conflicted with statements made in the existing knowledge interview.

Animals can be found in a house, in a tree, in the sea, or in a crack. C : b2 S : x1	'Found in a house, I was thinking of our cat. And a tree, I was thinking of monkeys, and in the sea, I was thinking of whales and sharks, and in a crack I was thinking of fish'. (317/1)

She had previously said that she felt sharks and whales were mammals and not animals because they lived in the sea. She may have been influenced by her construction of an earlier text statement about a whale being an animal. The other animal exemplars offered, (the cat and monkey) are everyday exemplars of animals. She continued on, not focusing on whether the instances are animals but:

A person is an animal that may be found in a house. C : b1 S : z1	'...Doesn't make sense---a person lives in a house all the time, they mostly live in the house, says may be found in a house.' (317/1)

With this statement she focused on what the author would consider a minor point. It is unknown if she accepted her construction of 'a person is an animal'. She accepted her constructions of the next text statements:

An opossum is an animal that may be found in a tree. C : b1 S : x1	'... possums can live in trees, most do'. (317/1)

A dolphin is an animal found in the sea. C : b2 S : x4	'They live in the sea, so...I don't know if they get out. Catch them and take them to an aquarium or something.' (317/1)

Again she focused on a minor point (to the researcher) and discussed the idea of where else we could find dolphins. She disagreed with her construction of the next statement:

A spider is an animal that may be found in a crack. C : b2 S : z1	'I've never seen a spider in a crack so... ...so, it's unusual. (317/1)

and likewise rejected her construction of the next sentences:

Rabbits and grasshoppers are two animals that hop. C : b2 S : z1	'Well, grasshoppers, they're just like all the other animals except they hop, some fly. (Would you call grasshoppers animals?) No, they're insects. (And yet here it's got grasshoppers are animals. What are you thinking about when you read that?) Oh, I was thinking of a little insect. You don't picture them as an animal.' (317/1)
Butterflies and bats are both animals that fly. C : b2 S : z1	'...I don't know (Would you agree with that?) Butterflies fly, so do bats... butterflies aren't animals though, I think they're insects. (What about bats?) They're mammals.' (317/1)

When reading the next sentences she again agreed with her constructions for some text statements but did not focus on the text statements about 'animal'.

Some animals have many legs and some have no legs. Spiders are animals... C : b2 S : x2	'...I agree with (this)---sharks, they don't have any legs...I agree that spiders have eight legs, I don't know how many legs a weta's got, so...I agree with a cow is an animal with four legs ...a person's an animal with two legs. I agree with that one. I agree with a snake is an animal with no legs because I said that before.' (317/1)
A frog is an animal that is slimy to touch. C : b2 S : x2	'I'd agree with a frog is slimy because if you're holding one, they jump out of your hand and you can't catch them. They slip away...' (317/1)
Some animals like oysters and barnacles, stay in one spot and never move away. C : b2 S : x2	'Oh, I think, not sure, because I don't think - my Dad gets them - oysters and that. Gets them off the rocks, I thought they stuck to the rocks'. (Would you agree with that sentence?) [nods] (317/1)

The second paragraph was about the scientific meaning of 'animal.' She continued to use an everyday meaning of 'animal' to generate a construction from the text:

What is an animal?
C : b2
S : x1

'Well, I read "What is an animal?" I just think...in a jungle, cheetahs, those sorts of things, monkeys and that.' (317/1)

These are examples of animals in the everyday sense.

As with the first sentence in the first paragraph, the next sentence seemed to be confusing for her also:

To a scientists, animals are those living things that are not plants.
C : f
S : -

'...doesn't make sense. (What's confusing you?)...I don't know. It's just that...doesn't make sense...it says animals are those living things that are not plants. (Sounds a bit strange to you?) Yes.' (317/1)

It is doubtful if she made a usable construction.

When reading the next sentence the student felt she had comprehended the text but the exemplars suggested that she may have been using the word 'animal' in the everyday sense:

Scientists also say that animals are living things that eat other animals or plants for food.
C : b2
S : x2

'...and I agree that animals are living things that eat other things. Like a whale, they eat other fish and that... cow, they eat the grass, goats eat some plants.' (317/1)

Note that she considered, at this point, a whale to be an animal. She continued:

A lion is an animal as it eats other animals like zebras.
C : b2
S : x1

'...I haven't seen a lion, even in a zoo, they eat, if they aren't too big, they eat all the other zebras, and deer and things like that'. (317/1)

Her construction for the second part of the next sentence was accepted, although that cannot be assumed for the first part was as well:

A spider is an animal as it eats flies for food.
C : b1
S : x2

'...a spider eats flies. I agree with that one. (317/1)

Her construction of the next sentence was held in doubt as she appeared to have had no experiences on which to verify it:

An earthworm is an animal as it eats decaying leaves in the soil.
C : b2
S : y1

'...an earthworm eats leaves - it sounds a bit strange to me. Haven't seen earthworms yet eating leaves in the soil, so it sounds strange (Do you think it might be possible?) Don't think so, because they most live underground...' (317/1)

For the next two sentences, the author's intended meaning was not constructed:

A tree is not an animal as it does not eat other living things.
C : b2
S : y2

'A tree's not an animal but...it sounds strange but in a way it sounds true---trees, they don't need other living things...the roots would be through the ground, don't think they eat much.' (317/1)

A car is not an animal as it is not living and it does not eat plants or animals.
C : e1
S : x1

'...a car is not an animal, I reckon it's living because it eats like petrol, needs stuff to keep it going.' (317/1)

In the first interview, she had said a car was living because it moved. She appeared to be using that same knowledge to make a construction. Further on, she again appeared to be using the word 'animal' in an every-day sense to elaborate on her construction of the text:

Something is an animal if it is living and if it eats other animals, plants or their remains for food.
C : b2
S : x1

'Oh, I was thinking of animals eating other animals---like I said before - a lion eats zebras and that. Cats eat birds if they can catch them. They catch mice and rats---' (317/1)

The sentences on 'consumer' were confusing to her:

Animals are also called consumers.
C : f

'...I don't know. Sounds strange... haven't seen it before---Yes [I've seen the word before] but I haven't seen a meaning for it yet - don't know what it is.' (317/1)

She did not discuss the last two sentences and she did not appear to make the construction on the explanation the scientific meaning of the word. She did not construct the definition from another sentence also:

Animals that eat only plants are called herbivores.
C : f

'That one sounds strange because we haven't had that before---I don't know [what herbivore means] Can't think of anything.' (317/1)

Later, she verbalised the construction she had made, which was not the author's intended one:

C : e2 '(What does that word "herbivore" mean to you?)
S : x1 Just...they eat one kind of food---like only meat or plants or only grass.' (317/1)

The word 'carnivore' was not very familiar to her either:

Some animals eat only other animals, or their remains and are called <u>carnivores</u>.
C : e2
S : y3, x2

'I don't really how. Can't think of anything. (Have you met that word carnivore before?) Yeah,...on TV. There was something, and they said carnivores eat people.' (317/1)

Neither was 'omnivore':

Animals that eat both plants and animals are called <u>omnivores</u>.

C : e2
S : y2

'...that seems strange there...people eat plants. I know we eat lettuce and that, but it sounds strange, say that we eat plants. (What's a plant to you?) A shrub like a tree. (Would you call a lettuce a plant?) It is a plant in the garden that we eat.' (317/1)

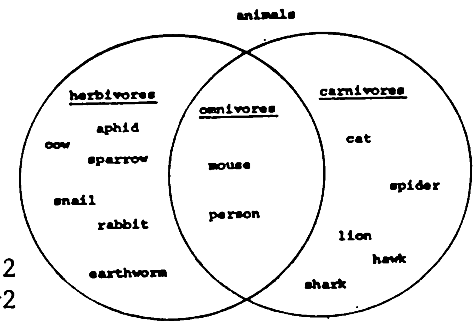
It would appear that her construction was that people eat <u>any</u> plant, not just some types of plants.

She continued on, again making use of her existing knowledge.

People and mice are omnivores.
C : b1
S : y2

'That one there sounds a bit strange. That mice eat seeds. You mostly hear [of] them eating cheese.' (317/1)

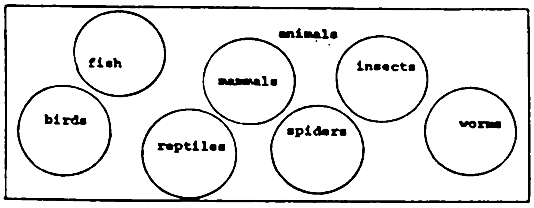
She passed comment on the first diagram:



C : b2
S : y2

'(What about "animal" here? What does that mean to you?) Means all those are animals. (Would you call all of those things animals?) Um, no, I wouldn't call a spider an animal.--- don't know, just think of an insect.' (317/1)

Her comments indicate that even towards the end of the interview, she had not learnt the scientific meaning of 'animal'. This was also illustrated in her comments on the second diagram.



C : b2
S : y2

'...It sounds strange, there up the top. They've put another main group, put within another main group. The same bird. Doesn't make sense to me...I knew a person was an animal but I didn't think it was a mammal. (What's a mammal to you?) Something that lives in the sea---a whale is a mammal but I don't think it is an animal. Oh, suppose it still is an animal---(It says here insects are another group of animal---[looking at the diagram] they've all been put into separate groups, like the fish and the mammals. They're all in the sea but they're all being put into separate groups.' (317/1)

As this last quotation indicates, she was still using an everyday meaning of the word 'animal', e.g. she continued to call mammals the sea animals. Also she could not accept the hierarchical classification of animals, ('They've put another main group, put within another main group. The same bird. Doesn't make sense to me.'). She commented further indicating that she did not fully interpret the diagram as a set/subset diagram.

C : e4
S : x1

'(What about this rectangle around the outside, what does that mean to you?) Oh, closed in.' (317/1)

Informal Interview-About-Instances (I.A.I.)

Throughout the interview, student (317) tended to use an everyday meaning of 'animal'. She did not appear to have made effective changes to her existing knowledge. At times the author's intended meaning was not constructed, and at other times she did generate the intended construction, which she then rejected. That she had not learnt the scientific meaning of 'animal' was further illustrated at the end of the interview.

> '(If I asked you the question "What is an animal?" What would you say now that you've read that?) Um...it's just an animal...lives out in the jungle or bush---(Whereabouts in the text does it tell you what an animal is?) Um, it's mostly about down here. [The sentences about herbivores, carnivores, omnivores].' (317/1)

She had not attended to or given high importance to her constructions of the text sentences communicating the scientific definition of an animal. As in the first interview, she categorised cows and people as animals in the informal I.A.I, and continued to use the reasons used before, rather than use the distinguishing characteristics mentioned in the text:

> 'Yes, [a cow is an animal] produces milk' (317/1)

> 'Yes, [people are animals] because they are living.' (317/1)

With the spider, weta, and caterpillar, she categorised them as animals but was hesitant about it:

> '[A spider] it's an animal and an insect. (Could you explain that a bit more?) Not really.' (317/1)

> '[Caterpillar] maybe. Insect. Could be an animal as well.' (317/1)

Final survey

In the final survey, she used a restricted concept of animal. The horse and the person were classified as animals because they bred; the dolphin was a non-animal because it is a mammal; the worm was a non-animal as it lives underground; and a butterfly was a non-animal as it was considered to be an insect. These answers and reasons match very closely those given in the first survey and in the existing knowledge interview.

Summary

Students (316) and (317) were similar in terms of their recent classroom experiences in science; scores of the P.A.T. test; and their concept of animal as measured by the survey. However, student (316) was willing to accept the constructions made from the text and to modify her existing knowledge. Her statements made in the reading-to-learn interview, could be classified mainly in the categories of C : a, b, indicating constructions made that were similar to those intended by the author, and S : x indicating acceptance of the constructions. In contrast, the statements by student (317) were mainly classified in categories C : b, c, e, f indicating constructions that were not entirely as the author intended, and S : y, z indicating non-acceptance of the constructions. When the constructions of student (317) were categorised in the S : x category, they were mainly based on existing knowledge rather than text constructions, e.g. in answer to questions in the text.

Noteable differences between the students were:

1. Student (316), in the existing knowledge interview, used characteristics, e.g. breathing, of the different animals as distinguishing features. Student (317) did not use, to the same extent, the idea of 'rules' to distinguish between two groups, e.g. animals and plants. Student (317) did not appreciate the significance of her constructions of the text sentences describing the distinguishing features of animals.
2. Student (316) had a more fluid perspective on her own existing knowledge than did student (317). Student (316) seemed prepared to acknowledge inadequacies and gaps in her knowledge, and to correct them. This tends to support the idea that learning is not solely a rational activity.

5.2.5 <u>Changing ideas is a gradual grocess</u>

Aspects of the Phase II data also illustrate how slowly conceptual change can occur. Difficulty in constructing and accepting the scientific meaning of 'animal' was illustrated by the interview with student (322). After the formal (in terms of data collection) interview was over, student (322) questioned the researcher about the word 'animal'.

In the preceding informal interview-about-instances she had scientifically categorised all the instances, except the marine instances:

> 'Yes [a horse is an animal] it's a living thing and it eats plants.' (322/1)
>
> 'Yeah, [a mosquito's an animal] yeah, because it's a living thing that eats plants and that. (And you yourself?) A scientist would but I wouldn't. I just don't think it should go in.' (322/1)
>
> 'Yes [a slug is an animal] it's a living thing that eats plants'.(322/1)

'Yes [a person's an animal] because they're living and they eat plants and meat'. (322/1)

'(And a shark?) Not sure if a shark is or isn't. I think they're animals. I'm not sure.' (322/1)

'(A dolphin?) Not sure if it's a mammal or animal. That's why I was getting mixed up. (What do you think a scientist would say?) He'd say a mammal. At the beginning (of the year) we had a study of dolphins. Thought they were called a mammal. Not sure though--- I'm not sure exactly what mammals are'. (322/1)

She then asked about the word 'mammal': (8)

'S. What's a mammal?
I. ---a mammal is a kind of animal---that suckles its young- gives its young milk and has live babies.
S. Yeah, so a dolphin would be---a mammal.
I. Would you call a dolphin an animal then?
S. No, if it's a mammal, it's not an animal.' (322/1)

Although she had read and discussed her construction of the Challenge Text, she had not constructed the author's intended meaning of the hierarchical classification of animals. The interviewer attempted to elaborate on her construction of the text for her:

'I. This diagram [no.2] here then, it's got a mammal as a group of animals. You've got a whole group of animals and you've got one particular group here, the mammals. What do you understand by that?
S. That the rest are those - lay eggs and that group, there has a live - they suckle.
I. ---if someone said to you is a person an animal, what would you say?
S. No, its not. It's a mammal because they have them [babies] alive and they suckle. Would that be right?' (322/1)

The interviewer then went on to explain, twice, about the set-subset relationship - that a person is a mammal and an animal, and that an insect is an animal. The interview continued:

'S. So if you say, if you have a question "Is a person an animal or a mammal?" how would you answer it?
I. Well, how would you answer it now?
S. Well, a mammal.
I. Right. It's a mammal because it suckles its young, but could you call it an animal as well?
S. Yes, because it eats meat and it's alive.

---

8. As the researcher took on the role of a teacher, the data collected in this last part of the interview were not included in the main data analysis of Phase II.

I. So, the answer a scientist would answer, well, it's both because a mammal is a kind of animal.
S. Oh, yeah---so if I put down a mammal or animal for a human, they'd still be right.
I. Yes, a human is an animal and a human is a mammal. It's both. Does that make sense to you?
S. Yes it does...that's probably where I was getting confused.' (322/1)

When she had accepted the set/subset relationship, her distinguishing features of living and eating still held valid.

When the researcher went to administer the final survey to her class two weeks later, she asked, while we were all waiting for the laboratory to be unlocked, if she was right in thinking that a whale and a person were both animals and mammals. This new piece of information was still fresh in her mind. In the final survey, she categorised all the instances as animals as would a scientist, and used the two reasons of 'living' and 'eating plants or animals'.

5.2.6 Phase II sample and the learning of the scientific concept

The results of the informal interview-about-instances at the end of the reading-to-learn interviews, and the final surveys, provided some indication of the learning of the scientific concept of animal that occurred during the interviews.

An analysis of the interview transcripts showed that, to learn through reading, the students had to construct and to accept the scientific meaning of the word 'animal'. However, further consideration of the transcripts suggests that learning the concept of animal does not involve making and accepting a single construction, but several, namely:

1. that living things can be divided into two groups: animals and plants;
2. the set and sub-set relationship between the group of animals and the different animal groups;
3. the rule of heterotrophic feeding, and what the different animals feed on; and
4. the different animal exemplars.

While some students in the sample did construct and accept the author's intended meaning for all four points, most did so for only some of them. Failure to learn the scientific concept may have occurred at either the construction or acceptance stage for some of the above four points.

As indicated by the responses in the final science survey, five students did not learn the scientific concept of animal (see Table 13); twelve had learnt the scientific concept to varying degrees; and three already had the scientific concept. (One student, 326, was not available to complete the final survey.) The responses in terms of categorising the instances as animals or not in the existing knowledge interview, the informal I.A.I, and final survey are given in Table 14.

It would appear that fewer students learnt and used the scientific distinguishing characteristics of 'animal' (see Table 15).

The reader is cautioned against concluding that the students who read either the Challenge or Dual Meaning Texts learnt the scientific concept better than those students who read the Typical Text, on two accounts:

1. Students who read the Typical Text, had not received any formal teaching on the hierarchical classification of living things, whereas the other students (316-329) had. While the teaching had not markedly changed the students' concept of 'animal' (as shown in the two sets of science survey responses) it may have helped the student to construct and more readily accept the author's intended meaning.
2. A sample of twenty-one is considered statistically too small a one from which to make generalisations of the findings.

The question as to which text if any, aided students the most in learning the scientific concept, was not attended to and therefore, not answered by Phase II. This question was addressed in Phase III.

TABLE 13: Phase II Students who learnt or did not learn the Scientific Concept of Animal with respect to Exemplars, as indicated by the Final Survey Results

	Challenge Text	Dual Meaning Text	Typical Text
Learnt	316, 318, 319, 320, 322	323, 324,327, 328, 329	308, 313
Did not learn	317	(326)*	307, 310, 311, 312
Initially had a scientific concept	321	325	309**

* Student 326 was not available for the final survey but she was categorised here on the basis of her reading-to-learn interview.

** Student 309 changed her survey answers in the knowledge interview.

TABLE 14: Phase II student categorisations of instances before and after reading a text

Existing knowledge interview

Student	cow	person	whale	spider	worm
307	Y	Y	N	N	N
308	Y	N	N	U	N
309	Y	Y	Y	Y	Y
310	Y	N	N	N	N
311	Y	N	N	N	N
312	Y	N	N	Y	N
313	Y	Y	Y	N	N
316	Y	N	N	N	Y
317	Y	Y	N	N	N
318	Y	N	N	Y	Y
319	Y	N	N	N	N
320	Y	Y	Y	N	N
321	Y	Y	Y	Y	Y
322	Y	Y	N	N	N
323	Y	N	N	N	N
324	Y	N	N	N	N
325	Y	Y	Y	Y	Y
326	Y	Y	Y	N	N
327	Y	N	N	N	N
328	Y	Y	N	N	N
329	Y	Y	Y	N	N

Reading-to-learn interview (the end)

Student	horse	sparrow	person	spider,weta	dolphin	fish	shark	worm	oyster	whale	cow	caterpillar	ostrich	mosquito	centipede	sponge	seastar	slug	barnacle	guinea pig
307	Y	Y	Y	Y	U	U	U	U												
308	Y		Y		Y			Y	U											
309								Y	Y											
310	Y		N	N			U	N		U										
311			Y	U				U		N	Y									
312		Y	N	Y	U						Y									
313								Y		Y										
316			Y								Y	Y								
317			Y	N							Y	N								
318			Y							Y	Y	Y		Y						
319			Y						Y		Y	Y								
320			Y			Y					Y	Y			Y					
321														Y		U	U			
322	Y		Y		Y		U							Y				Y		
323		Y			Y						Y			Y					Y	
324			Y	Y	Y		Y				Y									
325	Y		Y		Y			Y						U						Y
326	Y		Y	Y	U															
327	Y		Y		Y	Y								U				Y		
328	Y			Y										Y				Y		
329	Y				Y									Y						

Final Survey*

Student	horse	person	dolphin	butterfly	worm
307	Y	Y	N	N	N
308	Y	Y	Y	Y	Y
309	Y	Y	Y	Y	Y
310	Y	N	Y	N	N
311	Y	Y	Y	N	N
312	Y	N	N	N	Y
313	Y	Y	Y	Y	Y
316	Y	Y	Y	Y	Y
317	Y	Y	N	N	N
318	Y	Y	Y	Y	Y
319	Y	Y	Y	Y	Y
320	Y	Y	Y	Y	Y
321	Y	Y	Y	Y	Y
322	Y	Y	Y	Y	Y
323	Y	Y	Y	Y	Y
324	Y	Y	Y	Y	Y
325	Y	Y	Y	Y	Y
326		-**			
327	Y	Y	Y	Y	Y
328	Y	Y	Y	Y	Y
329	Y	Y	Y	Y	Y

*Changes from the existing knowledge interview are underlined
**Student 326 was unavailable for the final survey

Key
Y = Yes, it is an animal
N = No, it is not an animal
U = Unsure

TABLE 15: Students' use of Characteristics Before and After Reading a Text

Distinguishing characteristics	Existing knowledge interviews	I.A.I. at the End of the Reading-to Learn interview	Final survey
Only scientific		308, 309, 313, 316, 318, 319, 321, 324, 325, 326, 327, 329	316, 322
Mixture of scientific and everyday	313, 321, 323	307, 310, 311, 320, 322, 323, 328	318, 319, 321, 323, 324, 328, 329
Only everyday	307, 308, 309, 310, 311, 312. 316, 317, 318, 319, 320, 322, 324, 325, 326, 327, 328, 329.	312 317	312* 317
Not asked for reasons (see Table 9, page 137)			307, 308, 309 310, 311, 313
Survey not completed			320, 325, 327 (326)

* Student 312 gave reasons although not asked to.

5.3 REVIEW OF THE METHODOLOGY

The methodology used enabled the collection of indepth, qualitative data on:

1. the nature of the constructed meanings, and
2. the evaluation (both process and outcome) of the constructed meaning.

   Indirectly obtained were data on:

3. the process of generating links, and the nature of the links between text stimuli and existing knowledge;
4. the components of the constructed meaning - the text stimuli attended to and the existing knowledge used; and
5. the existing knowledge used to evaluate the constructed meaning.

Whilst the methodology would have allowed for it, little data were collected on the irrational (West and Pines, 1983) side of learning, that is, how the students _felt_ about changing their existing knowledge. This aspect of the process was not a central concern of this research.

The students, to varying degrees, were able to give self-reports on the processes and products of their comprehension and conceptual change.

The differences may have been due to:

1. their perceived ease and comfort with the interviewer and the interview situation. Student (324) admitted feeling uncomfortable and tense as he equated being taken out of class on his own, with remedial reading classes,which had not been a pleasant experience for him. Student (320) was very conscious of having to give 'the right' answer and nervously talked on about seemingly irrelevant things, despite the interviewer's attempts to make him feel at ease. One student, when asked for her consent to take part in the research and to have the interview tape recorded, declined on both accounts.

2. their language fluency and degree of talking. The researcher felt that some students seemed more readily able to express their thoughts in terms of having a wider vocabulary and better degree of articulation. The researcher felt that the amount of talking done by the students was greatly aided by their initially talking about their comprehension products i.e. the constructed meanings. It was through this discussion, that they also talked about the processes - the generating of the construction and evaluating it. The researcher also felt that the concurrent, thinking-out-aloud was connected with the student's learning as suggested by Barnes (1976). The interview situation (including the length of time, the concentration on detail and the active construction of meaning) enabled the student to reflect on her or his thoughts and thinking. The question unanswered by the data is whether what was verbalised in the interview occurs in a normal classroom reading situation. The researcher suspects not. Hence, the methodology was not entirely naturalistic with respect to the length of time spent reading the text, the concentration given to the reading and learning task, the lack of environmental distractions (peers, the laboratory), and a person to listen to one's spoken thoughts. However, it was naturalistic in terms of the task of reading-to-learn, the expository text (which would be acceptable to many teachers for use in a science lesson), and the post-reading survey questions.

5.4 SUMMARY AND CONCLUSIONS

The generative reading comprehension and learning models were a useful framework around which to construct an interpretation of the data. The data collected exemplified only certain aspects of the model, namely, the generation of links, the nature of the constructed meaning, and the evaluation of the construction. (An aspect not investigated was that of the role of existing knowledge in attention.)

The findings of Phase II can be summarised as:

1. The processes of comprehension and conceptual change appear to involve <u>both</u> the constructing and evaluating of a meaning for the print.
2. Existing knowledge (for example, the everyday concept of <u>animal</u>) was used both to construct and evaluate a meaning for the text. The extent of discussion on evaluation was unanticipated by the researcher. It is unknown if this degree of deliberation on the evaluation is a reflection of the methodology and if it occurs to the same extent in normal reading activities.
3. The text stimuli were used to construct a meaning. The extent to which the perceived text information was used in evaluation, varied, according to the student's view of the acceptability, authority or 'correctness' of the constructed text meaning. This was arrived at by comparing it with existing knowledge.
4. Most of the students interviewed were able to construct a meaning for the text (and for many, the author's intended meaning). This suggests that text characteristics such as writing style, vocabulary, sentence construction, use of pronouns and concept load did not present barriers to the students attempting to construct a meaning.
5. Students, who constructed alternative meanings to the author's intended one, were not always aware that they had not constructed the author's intended meaning. This was mainly due to the same existing knowledge being used to construct and to evaluate a meaning. No mismatch occurred.
6. Some of the students appeared to be unsure and expressed indecision in whether to accept or reject the author's intended meaning if they had constructed it. This appeared to be through a lack of relevant existing knowledge, for example, on feeding

habits, or because of emotional factors such as lack of confidence in their own existing knowledge, or in their construction.

7. Other students seemed to easily make a decision to accept or reject the author's intended meaning. Those who accepted it, did so for very different reasons:

a) They knew the information already. The constructed meaning was already a part of their existing knowledge.

b) The constructed meaning made more sense to them, and they were prepared to accept the construction and change their existing knowledge.

c) The authority of print, school knowledge, or scientific knowledge was perceived as high. Any construction based on these was accepted. It is unclear if the constructed meanings were integrated into existing knowledge or kept as separate for use only at times when the perceived authority was present.

Those, who readily rejected the author's intended meaning, appeared to be those students who:

a) were not <u>prepared</u> to consider changing their existing knowledge. There may be two possible reasons for this. Some may have seen no need to change their existing knowledge. The new construction may not have been seen as more useful or more plausible in terms of making sense of their world (Hewson, 1981a).

   Others may have been threatened by the prospect of changing their existing knowledge or by the prospect of change itself (Claxton, 1984).

b) and those who appeared not to see that the reading comprehension and learning task required them to change their existing knowledge. It could be said that these students had a passive view of learning (and reading). They may have thought that to decode the print was all that was required of them and not also the active engagement in the task of linking text stimuli and existing knowedge to construct a meaning.

8. Barriers to learning the scientific concept of animal appeared to be:

   i) with respect to constructing a meaning of the text:

      a) No construction was made. No sense was made of the text.

      b) The author's intended meaning was not constructed, and often the students seemed unaware of this.

   ii) and with respect to a decision on the status of the author's intended meaning (once constructed):

      a) The author's intended meaning was rejected.

      b) The student was uncertain whether to accept or reject her or his construction.

9. Conceptual change occurred only when the student both constructed and accepted the author's intended meaning. There, thus, appeared to be two important processes in the learning.

10. The decision to accept or reject a construction (and in particular the author's intended meaning) was not just a rational decision. Feelings and beliefs about oneself, knowledge, school, reading, and learning for example, appeared to be an integral part of this aspect of learning.

11. For many of the students interviewed, learning occurred when they actively engaged in the tasks of constructing and evaluating a meaning. This active engagement involved consideration of and reflection on text stimuli, existing knowledge and the constructed meanings. This activity required time, energy and some degree of commitment.

12. For some students, learning appeared to occur rapidly. For others it was a slow dawning or awakening.

A question not addressed in Phase II, but which was in Phase III, was 'Which of the three different texts, best helped students to construct and accept the scientific meaning of animal?'.

CHAPTER 6 : THE RESULTS OF PHASE III

6.1 INTRODUCTION

In this final and quantitative phase of the research, text characteristics rather than reader characteristics were investigated. More specifically the research investigated which of the different texts best helped students, with an everyday meaning of 'animal', to learn the scientific meaning, that is to both construct and accept the scientific meaning.
The results of Phase II suggested that most students were able to construct a meaning for the text they read. For many students their constructed meaning was also the author's intended meaning. It would appear that text characteristics such as writing style, vocabulary, sentence construction and use of pronouns did not present barriers to the construction of a meaning. Of interest in Phase III will be whether or not one of the three texts (Challenge, Dual Meaning or Typical Text) best helped students to accept the author's intended meaning once they had constructed it.

The Texts employed were adapted versions of the three texts used in Phases I and II. These are to be found in Appendix D and a record of their trialing in Appendix A. The details of the texts have been documented in section 3.4. In summary, the distinguishing features of the three main texts were the contexts in which the scientific concept of animal was embedded, namely:
the Challenge Text contained a paragraph, which aimed at helping the reader construct meanings that may conflict with the everyday meaning of

'animal';

the Dual Meaning Text contained sentences, which aimed at helping the reader construct a meaning of both the everyday and scientific meanings of 'animal'; and

the Typical Text, contained as do many published texts, sentences about the ecological role of animals, that is, about food chains, food webs, and about the movement of animals.

A fourth text (the Control Text) was also used in Phase III as a control for Text 3. It was similar in context to Text 3 but the scientific definitions and examples were not elaborated.

The sample consisted of 227 Form 3 students (approximately 13-years-old) in a city, coeducational secondary school. The students were in eight different classes and constituted all the third form students, except for the two classes of high and low ability students not included in the broad banding organisation. When the post-post survey was administered approximately one month later, 196 of the initial sample were present at school.

The methodology of Phase III has been described in section 3.3.3 and was essentially a conventional pre- and post- reading survey design. The surveys may be found in Appendix G, details of their construction in Section 3.5, and in Table 16 is given the composition of the surveys with respect to exemplars and non-exemplars of animals. As outlined in Section 3.5, the question instances were selected as they were known to discriminate between students using an everyday meaning and those using a scientific meaning (Stead, 1980). The prototypical exemplars are terrestrial mammals commonly known to students; the non-prototypical exemplars are commonly known, small, invertebrate animals; and in-between exemplars are commonly known as animals that are neither prototypical or non-prototypical, for example, the marine mammals, fishes, birds and reptiles.

TABLE 16: The Question Intances in the Pre-, Post-, and Post-Post Surveys used in Phase III

Category of question		Pre-survey	Post and Post-post-survey
Matched	Proto-typical animals	horse tiger dog guinea pig	cow lion cat rabbit
	In-between animals	person dolphin thrush duck	person whale sparrow chicken
	Non-proto-typical animals	earthworm spider sandfly slug	earthworm spider fly snail
	Plants	parsnip grass peach tree cabbage	carrot grass apple tree lettuce
	Non-living	candle stone truck stereo	fire rock car radio
Question Instances Unique to the Challenge Text		Proto-typical In-between Non-prototypical	opossum frog, snake grasshopper, oyster
Question Instances Unique to the Dual Meaning Text		Proto-typical In-between Non-prototypical	deer - butterfly, wasp
Question Instances Unique to the Typical and Control Texts		Proto-typical In-between Non-prototypical	- blackbird caterpillar
Question instances which did not appear in any text		Proto-typical In-between Non-prototypical	chimpanzee, elephant seagull, lizard, seal, flounder, octopus mosquito, cricket, bee

The procedure. All data collection was done in normal timetabled science lessons in school laboratories.

After initial introductions, the researcher explained to the class:

a. the field of interest of the research, i.e. reading in science;

b. that they were being asked to do 3 tasks to help in the research;

c. that instructions for each task would be given prior to the task being done;

d. and that the results would not contribute to their school records in any way.

The first task was the pre-reading survey (see Appendix G). Its purpose was to elicit information about the students' existing knowledge with respect to their concept of animal. The students completed the surveys working alone and in silence, in approximately 4-5 minutes. The surveys were then collected.

The second task was the 'reading-to-learn' one. Each student was asked to fill in a form indicating the code number of the text read, her or or his name and class. The students received the following instructions from the researcher:

> 'As I mentioned I'm interested in reading in science and in particular, what students like yourselves get out of a piece of reading. When you read this I'd like you to learn how a scientist would answer the question "What is an animal?". After you have read the pages, I'm going to ask you to answer some more questions so it would pay you to read the pages slowly and carefully.'

Hence, the purpose of the task was to attempt to learn the scientific meaning of 'animal' to use it in a post-reading survey. The texts were given out so that the different versions were distributed randomly. The students read in silence and on their own for approximately 5-10 minutes. Those who had finished reading earlier than the others, were encouraged to read it a second time. When all students had read through the pages at least once, the texts were collected.

The third task was the post-reading survey (see Appendix G). The instructions and procedures for completing this task were identical to those for the pre-reading survey. In all, the three tasks, plus administration, took approximately 30 minutes. All classes had completed these within an eight day time span. Particular care was taken to identify the text form used by each student, and to relate this to her or his survey results.

The 'Yes' or 'No' answers for all students' pre- and post- reading surveys, together with student code numbers and text code were entered into a computer file for analysis.

After approximately one month, the post-survey was again administered to those of the initial sample who were present at school on the day. All classes had completed this task within a 3-day span. The results of this 'post-post' survey were also entered into a computer file for analysis.

The whole sample was first divided into two - those who answered the pre-survey as would a scientist, and those who did not. The first sub-sample will be referred to as the scientist sample and the second the non-scientist sample. In the pre-survey, 65 of the 227 students chose only scientific answers. Thus 29% of the total sample could be said to have a scientific concept of animal before reading a text.

The three samples (total, scientists, non-scientists) were then further divided into four according to the text read. The numbers in each of the samples are given in Table 17.

TABLE 17: The Numbers of Students in Each of the Phase III Samples

	Pre-survey	Post-survey	Post-post-survey
Total sample	227	227	196
Text 1	61	61	51
Text 2	57	57	50
Text 3	55	55	47
Text 4	54	54	48
Scientists sample	65	65	56
Text 1	15	15	13
Text 2	14	14	10
Text 3	17	17	15
Text 4	19	19	18
Non-scientists sample	162	162	140
Text 1	46	46	38
Text 2	43	43	39
Text 3	38	38	32
Text 4	35	35	31

Key : Text 1 - Challenge Text
Text 2 - Dual Meaning Text
Text 3 - Typical Text
Text 4 - Control Text

6.2 THE RESULTS OF PHASE III

The analyses carried out on the data were:

i) Frequency (and percentages) of students, in each sample, choosing the correct scientific response for each question (Tables 18, 21, 25). An unanswered question was treated as a missing case and not included in the percentage calculations. All percentages were rounded off.

ii) Oneway analyses of variance on the total scores for students in the non-scientist sample (Tables 20, 24, 27). An individual student's score was computed by assigning each scientifically-correct answer a value of 1, incorrect or an unanswered question being assigned a value of 0.

6.2.1 The pre-survey results

a. Analysis of frequency (and percentage) of accepted scientific responses

The results of the pre-survey for the whole sample are documented in Table 18. The proportions of students selecting the correct scientific response were much as expected, and matched earlier results obtained by Bell (1981a) and Bell and Barker (1982). Most students in the total sample categorised the prototypical instances as animals [dog (99%), tiger(99%), horse (98%), guinea pig (96%)]. Fewer students categorised the two-legged and marine instances as animals [duck (86%), person (73%), thrush (68%), dolphin (67%)]. Even fewer students categorised the non-prototypical instances as animals [earthworm (52%), slug (49%), spider (44%), sandfly (39%)]. Most students categorised the non-living instances (candle, stone, truck, stereo) and the plants (peach tree, cabbage, parsnip, grass) as non-animals as would a scientist.

b. Oneway analyses of variance

The results (Table 19) for the whole sample indicate that there was no significant difference at the 0.05 level between students of the total sample, in the different text samples. In other words, the students were randomly assigned to the four text samples, with respect to their responses on the pre-survey.

In addition, the results on the pre-survey for the non-scientists (Table 20) indicate that at the 0.05 level, there was no significant difference between the pre-survey scores of the non-scientists students in each of the four text sub-samples, with respect to their existing knowledge as measured by the survey.

TABLE 18: Numbers (and Percentages) choosing the Accepted Scientific Answer: Whole Sample (N=227), Pre-survey

Question instance	Total Sample N=227	Text 1 Sample N=61	Text 2 Sample N=57	Text 3 Sample N=55	Text 4 Sample N=54
horse	223 (98)	61 (100)	55 (96)	55 (100)	52 (96)
guinea pig	219 (96)	59 (97)	53 (93)	54 (98)	53 (98)
dolphin	152* (67)	40 (66)	40 (71)	37 (67)	35 (65)
earth-worm	117* (52)	29 (48)	28 (49)	29 (53)	31 (57)
candle	226 (99)	61 (100)	56 (98)	55 (100)	54 (100)
peach tree	225 (99)	59 (97)	57 (100)	55(100)	54 (100)
thrush	154* (68)	44 (72)	36 (64)	37 (67)	37 (68)
sandfly	89* (39)	23 (38)	19 (34)	22 (40)	25 (46)
cabbage	223**(99)	60 (98)	55 (98)	55 (100)	53 (100)
tiger	224 (99)	61 (100)	55 (96)	54 (98)	54 (100)
stone	227 (100)	61 (100)	57 (100)	55 (100)	54 (100)
person	164**(73) **	38 (62)	41 (73)	42 (78)	43 (83)
parsnip	223* (99)	58 (97)	57 (100)	54 (98)	54 (100)
duck	195* (86)	54 (88)	46 (81)	48 (89)	47 (87)
truck	224* (99)	60 (98)	57 (100)	54 (98)	53 (98)
slug	110**(49)	27 (44)	25 (45)	28 (51)	30 (57)
dog	225* (99)	61 (100)	55 (98)	55 (100)	54 (100)
grass	224 (99)	60 (98)	56 (98)	55 (100)	53 (98)
stereo	226 (99)	60 (98)	57 (100)	55 (100)	54 (100)
spider	99 (44)	23 (38)	23 (40)	27 (49)	26 (48)

Key * represents the number of students giving no response.

TABLE 19: The Analysis of Variance of the Total Scores of the Whole Sample by Text : Pre-survey (N=227)

Survey	Source	d.f.	Sum of squares	Mean square	F ratio
Pre	Between groups	3	13.5	4.5	0.6
	Within groups	223	1699.7	7.6	
		226	1713.2		

TABLE 20: The Analysis of Variance of the Total Scores by Text for the Pre-survey, Phase III, for the Non-scientist sample (N=162)

Source	degrees of freedom	Sum of squares	Mean squares	F ratio
Between groups	3	2.7	0.9	0.2
Within groups	158	745.2	4.7	
Total	161	747.9		

6.2.2. The post-survey results

a. Analysis of frequency (and percentage) of accepted scientific responses

The results for the post-survey of the non-scientists are given in Table 21. An initial visual inspection suggests an increase in the proportions of students choosing the correct response, from those in the pre-survey. More of the non-scientist students answered the questions as would a scientist after reading a text.

The 32 animal instances were correctly categorised by the non-scientist sample,(N=162),in descending order: lion, cat (100%); deer, rabbit (99%); blackbird, chicken, sparrow (98%); elephant, opossum, person, chimpanzee (97%); seal, seagull (96%); lizard, frog (96%); snake, earthworm (95%); spider (94%); grasshopper (94%); whale, caterpillar (93%); fly (93%); octopus, snail (91%); flounder (90%); wasp (89%); bee, cricket (88%); butterfly (88%); mosquito (85%) and oyster (58%). Generally, the non-prototypical instances were categorised by fewer students as animals, than were the prototypical animals. This is not an unexpected result.

The result for the 'oyster' question requires further attention. The 'oyster' was mentioned only in Text 1. A chi-square test on the results across the four text samples (see Table 22) gives a X^2 value of 33.4 which is significant at the 0.001 level. The results of the Text 2 sample contribute most (18.2) to the value of 33.4. There was a significant difference in the way the non- scientists who read Text 2 answered the oyster question compared to the non-scientists who read Texts 1, 3 or 4. The Text 2 sample were less likely to categorise the oyster as an animal than the other 3 text samples.

The mean percent increase in correct responses over all questions in the post-survey is given in Table 23. The average percent increases of correct responses from the pre- to the post survey, particularly for the non-scientist sample, suggest that more correct responses were given by students who had read Texts 1 and 3 than those who had read Texts 2 and 4.

TABLE 21: Numbers (and Percentages) Choosing the Accepted Scientific Answer, Non-scientists Sample (N=162) : Post-Survey

Question	Total Sample N=162	Text 1 Sample N=46	Text 2 Sample N=43	Text 3 Sample N=38	Text 4 Sample N=35
lion	162 (100)	46 (100)	43 (100)	38 (100)	35 (100)
cat	162 (100)	46 (100)	43 (100)	38 (100)	35 (100)
lettuce	159* (99)	46 (100)	42 (98)	38 (100)	33 (97)
snail	148 (91)	44 (96)	36 (84)	35 (92)	33 (94)
carrot	159* (99)	46 (100)	42 (98)	38 (100)	33 (97)
car	162 (100)	46 (100)	43 (100)	38 (100)	35 (100)
earthworm	154 (96)	45 (98)	39 (91)	38 (100)	32 (91)
person	157 (97)	46 (100)	42 (98)	36 (95)	33 (94)
spider	153 (94)	45 (98)	38 (88)	37 (97)	33 (94)
butterfly	142 (88)	42 (91)	35 (81)	33 (87)	32 (91)
grass	159**(99)	45 (100)	41 (98)	38 (100)	35 (100)
cow	161 (99)	46 (100)	43 (100)	38 (100)	34 (97)
rock	160**(100)	46 (100)	42 (100)	38 (100)	34 (100)
fly	150 (93)	45 (98)	39 (91)	34 (89)	32 (91)
sparrow	159 (98)	46 (100)	41 (95)	38 (100)	34 (97)
lizard	155 (96)	45 (98)	40 (93)	37 (97)	33 (94)
whale	151 (93)	45 (98)	40 (93)	34 (89)	32 (91)
rabbit	160 (99)	46 (100)	43 (100)	38 (100)	33 (94)
chicken	159 (98)	46 (100)	42 (98)	38 (100)	33 (94)
fire	160**(100)	46 (100)	42 (100)	38 (100)	34 (100)
opossum	156* (97)	44 (96)	42 (100)	37 (97)	33 (94)
frog	155 (96)	44 (96)	41 (95)	37 (97)	33 (94)
grasshopper	152 (94)	43 (93)	40 (93)	36 (95)	33 (94)
snake	154 (95)	45 (98)	39 (91)	37 (97)	33 (94)
oyster	92**(57)	33 (71)	15 (36)	23 (60)	21 (62)
radio	161*(100)	45 (100)	43 (100)	38 (100)	35 (100)
deer	160 (99)	46 (100)	43 (100)	38 (100)	33 (94)
wasp	145 (89)	41 (89)	37 (86)	35 (92)	32 (91)
caterpillar	151 (93)	43 (93)	39 (91)	36 (95)	33 (94)
blackbird	159 (98)	46 (100)	41 (95)	38 (100)	34 (97)
chimpanzee	157 (97)	44 (96)	42 (98)	38 (100)	33 (94)
seagull	156 (96)	46 (100)	40 (93)	38 (100)	32 (91)
mosquito	137* (85)	38 (83)	34 (81)	34 (89)	31 (89)
apple tree	159* (99)	46 (100)	41 (98)	37 (97)	35 (100)
seal	156 (96)	45 (98)	42 (98)	37 (97)	32 (91)
cricket	143 (88)	41 (89)	36 (84)	34 (89)	32 (91)
flounder	145* (90)	42 (91)	38 (88)	35 (92)	30 (88)
octopus	148 (91)	43 (93)	37 (86)	37 (97)	31 (89)
elephant	157 (97)	45 (98)	41 (95)	38 (100)	33 (94)
bee	143 (88)	40 (87)	37 (86)	35 (92)	31 (89)

Key = * represents the number of no responses.

TABLE 22: X^2 values for Numbers of Non-scientists choosing the Accepted Scientific Responses on Selected Questions in the Post and Post-post surveys in Phase III

Question instance	X^2 value		Significant at .05 level with 3 d.f.
	Post-survey	Post-post-survey	
Non-prototypical			
mosquito	4.2	4.6	no
cricket	2.4	3.6	no
bee	0.6	2.9	no
grasshopper	0.6	2.9	no
oyster	33.4	23.2	Yes (sig.also at .001 level)
butterfly	2.8	3.5	no
wasp	1.9	3.3	no
caterpillar	1.9	3.3	no
In-between			
seal	0.3	0.2	no
flounder	1.9	3.5	no
octopus	1.5	2.4	no
frog	0.3	1.5	no
snake	0.5	1.9	no
blackbird	0.1	0.7	no

TABLE 23: Mean Percent Accepted Responses for the Different Samples in the Pre- and Post-surveys

	Pre-survey	Post-survey	Mean % increase
Total sample	83	96	13
Text 1 (Challenge)	82	97	15
Text 2 (Dual)	82	94	12
Text 3 (Typical)	84	97	13
Text 4 (Control)	85	96	11
Scientists sample	100	99	
Text 1	100	100	
Text 2	100	99	
Text 3	100	99	
Text 4	100	100	
Non-scientists sample	76	95	19
Text 1	76	96	20
Text 2	75	92	17
Text 3	77	96	19
Text 4	77	94	17

N.B. Percentages are rounded off

In the post-survey, the students in the scientist sample correctly categorised all the instances except in the questions about the oyster and cricket. Only 50 of the 65 students categorised the oyster as an animal (87% of the Text 1 Scientist sample; 85% of the Text 2 sample; 59% of the Text 3; and 85% of the Text 4 sample). The oyster may not have been familiar to many students. Two students of the 65 scientist sample did not categorise a cricket as an animal. One student was in the Text 2 sample, the other in the Text 3 sample. 'Cricket' may have been interpreted as the sport, not as the insect.

b. Oneway analyses of variance

The ANOVA results of total scores for the non-scientist sample in the post-survey are given in Table 24. Results for all seven categories of questions, indicate that there was no significant difference between the four text samples, with respect to their answers on the post-survey questions.

Firstly, the F ratio of the total scores over all 40 questions in the post-survey was 1.0. There was no significant difference between the four text samples with respect to their answers on the post-survey. Students, who read any one of the four texts, did not significantly answer the post-survey question more like a scientist, than students who read another text.

The ANOVA results for the scores on the questions about all the non-prototypical, in-between, matched, animal instances not in any text, non-prototypical instances not in any text and in-between instances not in any text are also given in Table 24. (Details of question categories may be found in Table 16.) All six sets of results indicate that there was no significant difference between the four text samples on their answers to the different question groups in the post-survey.

TABLE 24: Analyses of Variance of Total Scores by Text in the Post-Survey, Phase III, for the Non-scientist Sample for the difference Question Categories

Question Type*	Source	Degrees of Freedom	Sum of Squares	Mean Squares	F ratio	Significant at the 0.05 level?
All questions (N=40)	Between groups	3	55.2	18.4	1.0	
	Within groups	158	2853.6	18.1		
	Total	161	2908.8			No
Matched Animal Instances (N=12)	Between groups	3	7.0	2.3	1.5	
	Within groups	158	244.5	1.5		
	Total	161	251.5			No
Matched Non-Prototypical Instances (N=4)	Between groups	3	26.9	9.0	1.2	
	Within groups	158	1159.1	7.3		
	Total	161	1186.0			No
Matched In-between Instances (N=4)	Between groups	3	9.9	3.3	1.3	
	Within groups	158	414.1	2.6		
	Total	161	424.0			No
Animal Instances Not in any Text (N=10)	Between groups	3	7.4	2.5	0.8	
	Within groups	158	482.2	3.1		
	Total	161	489.6			No
Non-Prototypical Instances Not in any Text (N=3)	Between groups	3	1.2	0.4	0.6	No
	Within groups	158	117.3	0.7		
	Total	161	118.5			
In-between Instances Not in any Text (N=5)	Between groups	3	3.1	1.0		
	Within groups	158	125.5	0.8	1.3	No
	Total	161	128.6			

*Details of question types may be found in Table 16.

c. Summary

More students answered the post-survey questions as would a scientist than in the pre-survey, for all text samples. Reading a text appears to have helped students construct the scientific concept of animal with respect to exemplars. However, no one text appeared to help the non-scientist students learn the scientific concept of animal, more than the other three texts.

6.2.3 The post-post survey results

a. The analysis of frequency (and percentage) correct scientific responses

These results for the non-scientist sample can be found in Table 25. The animal instances were categorised correctly by the non-scientist sample, in the descending order: cat (100%); lion, cow, rabbit, deer, chimpanzee, elephant (99%); seal (98%); opossum (97%); lizard, chicken, seagull (96%); sparrow, blackbird (95%); whale, frog (93%); person, octopus (92%); snake (91%); earthworm (90%); flounder, caterpillar, wasp, spider, fly, grasshopper (88%); snail, cricket (87%); butterfly, bee, mosquito (86%), and oyster (61%). These results reflect a trend of more students categorising as animals, the prototypical instances than in-between and non-prototypical instances.

Visual inspection of the results of the whole sample indicates that there has been a small drop (0-5%) in the percentage correct response for most questions from the post-survey. This is not unexpected as there was a month between the post and post-post surveys. The spider question had the largest decrease (5%) between the two surveys. The results show that for no question, did the post-post survey answers match or approximate to the pre-survey answers. The majority of students appeared to have constructed and retained the scientific concept of animal with respect to exemplars to use in the post-post survey.

Several students in the scientist sample appeared to have used an everyday meaning of 'animal' to answer some, but not all, the questions. A further analysis indicates that 64% of the scientist sample categorised the oyster as an animal (61% of the Text 1 sample; 70% of Text 2; 67% of Text 3 and 61% of Text 4). Three students did not categorise the cricket as an animal (1 from the Text 2 sample, and 2 of the Text 4 sample). Three students did not categorise the flounder as an animal (1 from each of the Text 1, 3, 4 samples). These incorrect answers appeared to be isolated ones except in the case of students 144 and 218, who had both read Text 4.

TABLE 25: Numbers (and Percentages) choosing the Accepted Scientific Answer, Non-scientist Sample (N=140) : Post-post Survey

Question	Total Sample N=140	Text 1 Sample N=38	Text 2 Sample N=39	Text 3 Sample N=32	Text 4 Sample N=31
lion	139 (99)	38 (100)	38 (97)	32 (100)	31 (100)
cat	140 (100)	38 (100)	39 (100)	32 (100)	31 (100)
lettuce	134* (96)	34 (92)	38 (97)	31 (97)	31 (100)
snail	121* (87)	33 (89)	31 (79)	30 (94)	27 (87)
carrot	133**(96)	33 (92)	38 (97)	31 (97)	31 (100)
car	137* (99)	36 (97)	39 (100)	31 (97)	31 (100)
earthworm	125* (90)	35 (95)	32 (82)	30 (94)	28 (90)
person	128* (92)	35 (92)	33 (87)	31 (97)	29 (93)
spider	122* (88)	34 (89)	29 (76)	32 (100)	27 (87)
butterfly	119* (86)	33 (89)	30 (77)	29 (91)	27 (87)
grass	131* (94)	34 (92)	37 (95)	31 (97)	29 (93)
cow	138 (99)	38 (100)	37 (95)	32 (100)	31 (100)
rock	137**(99)	37 (100)	38 (97)	32 (100)	40 (100)
fly	122* (88)	33 (89)	31 (80)	31 (97)	27 (87)
sparrow	132* (95)	37 (97)	35 (92)	32 (100)	28 (90)
lizard	134 (96)	38 (100)	34 (87)	32 (100)	30 (97)
whale	129* (93)	36 (97)	32 (82)	32 (100)	29 (93)
rabbit	139 (99)	38 (100)	39 (100)	32 (100)	30 (97)
chicken	135 (96)	37 (97)	38 (97)	32 (100)	28 (90)
fire	136* (98)	37 (100)	38 (97)	30 (94)	31 (100)
opossum	135* (97)	37 (97)	36 (95)	31 (97)	31 (100)
frog	128**(93)	35 (95)	33 (87)	32 (100)	28 (90)
grasshopper	122**(88)	34 (92)	31 (82)	31 (97)	26 (84)
snake	127* (91)	36 (95)	32 (84)	32 (100)	27 (87)
oyster	84**(61)	24 (65)	19 (50)	20 (62)	21 (68)
radio	137**(99)	37 (100)	38 (100)	31 (97)	31 (100)
deer	137* (99)	38 (100)	37 (97)	32 (100)	30 (97)
wasp	121**(88)	33 (89)	30 (77)	31 (97)	27 (87)
caterpillar	122**(88)	33 (89)	31 (82)	31 (97)	27 (87)
blackbird	132* (95)	37 (97)	35 (92)	32 (100)	28 (90)
chimpanzee	137* (99)	37 (97)	37 (97)	32 (100)	31 (100)
seagull	133* (96)	38 (100)	35 (92)	32 (100)	28 (90)
mosquito	118***(86)	32 (86)	28 (76)	31 (97)	27 (87)
apple tree	130**(94)	34 (92)	37 (97)	31 (97)	28 (90)
seal	136* (98)	38 (100)	37 (97)	32 (100)	29 (93)
cricket	120**(87)	32 (86)	30 (79)	31 (97)	27 (87)
flounder	122**(88)	36 (97)	29 (76)	31 (97)	26 (84)
octopus	127**(92)	37 (100)	30 (79)	32 (100)	28 (90)
elephant	137* (99)	38 (100)	37 (97)	32 (100)	30 (97)
bee	119**(86)	32 (86)	30 (79)	31 (97)	26 (84)

Key = * represents the number of no responses

On the pre-survey, student 144 initially categorised the whale, earthworm, thrush, sandfly, person, slug and spider as non-animals but had then changed these to animals on the answer sheet. The post-survey was answered as would a scientist. On the post-post survey the whale, oyster, wasp, mosquito, cricket, flounder, octopus and bee were called non-animals and again, the crossings out suggest he had changed his mind on many answers.

Student 218 had answered the pre- and post-surveys as would a scientist. However, on the post-post survey, he categorised the spider, fly grasshopper, wasp, mosquito, cricket and bee as non-animals. When interviewed about his answers, he was unable to say what had lead to the change in thinking.

The oyster question elicited the most incorrect responses from the non-scientist sample, as in the post-survey results also. A chi-square test of significance indicates that at the .001 level there is a significant difference between the results for the four different text sub-samples of the scientist sample on this question's responses (see Table 22). The results of the Text 2 sample contribute most (10.3) to the chi-square value of 23.2. Like the post-survey results for the oyster question, the Text 2 sample were less likely to categorise the oyster as an animal than the other three text samples.

The instance of oyster was only mentioned in the Challenge Text (Text 1).

The mean percent correct responses and the mean percent increases from the pre-to the post-post survey are given in Table 26. It would appear that the post-post survey questions were better answered by the students who read Texts 1 and 3 (the Challenge and Typical Texts) than those who read Texts 2 and 4 (the Dual Meaning and Control Texts).

TABLE 26: Mean Percent Accepted Responses for the Different Samples in the Pre- and Post-post Surveys

	Pre-survey	Post-survey	Mean % increase
Total sample	83	94	11
Text 1	82	95	13
Text 2	82	91	9
Text 3	84	98	14
Text 4	85	94	9
Scientists sample	100	98	
Text 1	100	99	
Text 2	100	99	
Text 3	100	99	
Text 4	100	97	
Non-scientists sample	76	93	17
Text 1	76	94	18
Text 2	76	88	12
Text 3	77	97	20
Text 4	77	92	15

N.B. Percentages are rounded off

b. The analyses of variance of total scores of the non-scientist sample in the post-post survey

These results are given in Table 27 (Parts 1 and 2).

The ANOVA on the non-scientists' total scores on all forty questions in the post-post survey is given in Part 1. The F ratio of 3.1 and the Duncan and Scheffe tests indicate that there is a significant difference between the mean scores of students in the 4 text samples at the 0.05 level. On the Duncan test, there is a significant difference at the 0.05 level between the Text 2 sample and Text 1 and 3 samples. On the Scheffe test, there is a significant difference at the 0.05 level between the Text 2 and Text 3 samples - the mean score of the Text 2 sample was significantly lower than the mean score of the Text 3 sample.

The ANOVA results on the total sample of non-scientist scores for all the matched animal instances in the post-post survey are given in Table 27, Part 1. This analysis gave an F ratio of 2.8. The Duncan test at the 0.05 level indicated that the mean scores of the Text 2 sample were significantly different from those of the Text 3 sample. However, on the Scheffe test no two groups mean scores were significantly different at the 0.05 level.

The ANOVA results on the non-scientist total scores on the matched in-between instances (in all texts) in the post-post surveys are given in Table 27, Part 1. The ANOVA indicates a significant difference at the 0.05 level between the mean scores on the post-post survey for the in-between instances (F ratio is 4.2). The Duncan test indicates that the mean scores of the students in Text 2 samples were significantly different from those of the students in the Text 1 and 3 samples.

The Scheffe test indicates that the mean score of the Text 2 sample was significantly lower than those of the Text 3 sample at the 0.05 level. But these results need to be interpreted with caution as there were only 4 questions in this category.

TABLE 27 (Part 1): The Analyses of Variance of Total Scores by Text in the Post-Post Survey, Phase III, for the Non-scientist Sample.

Question Type	Source	Degrees of Freedom	Sum of Squares	Mean Squares	F ratio	Duncan Procedure at 0.05 level	Scheffe Procedure at 0.05 level
All questions (N=40)	Between groups Within groups Total	3 136 139	323.2 4653.7 4976.9	107.7 34.2	3.1	Subset 1 group 2 4 mean 27.2 29.2 Subset 2 group 4 1 3 mean 29.2 30.1 31.3	groups 2 and 3 are significantly different
All Matched Animal Instances (N=12)	Between groups Within groups Total	3 136 139	26.4 435.1 461.6	8.8 3.2	2.8	Subset 1 group 2 4 1 mean 10.6 11.2 11.4 Subset 2 group 4 1 3 mean 11.2 11.4 11.8	no two groups are significantly different
Matched In-between Instances (N=4)	Between groups Within groups Total	3 136 139	54.7 588.5 643.2	18.2 4.3	4.2	Subset 1 group 2 4 mean 10.3 10.9 Subset 2 group 4 1 3 mean 10.9 11.6 11.9	groups 2 and 3 are significantly different

TABLE 27 (Part 2): The Analyses of Variance of Total Scores by Text in the Post-Post Survey, in Phase III, by the Non-scientist Sample

Question Type	Source	Degrees of Freedom	Sum of Squares	Mean Squares	F ratio	Duncan Procedure at 0.05 level	Scheffe Procedure at 0.05 level
Matched Non-Prototypical Instances (N=4)	Between groups	3	83.8	27.9	2.0	Subset 1 group 2 1 4 mean 9.0 10.2 10.2 Subset 2 group 1 4 3 mean 10.2 10.2 11.2	No two groups are significantly different
	Within groups	136	1877.6	13.8			
	Total	139	1961.4				
Animal Instances Not in any Text (N=10)	Between groups	3	42.5	14.2	3.9	Subset 1 group 2 4 mean 8.4 9.1 Subset 2 group 4 1 3 mean 9.1 9.4 9.9	Groups 2 and 3 are significantly different
	Within groups	136	498.7	3.7			
	Total	139	541.2				
Non-Prototypical Instances not in any Text (N=3)	Between groups	3	7.5	2.5	2.4	Subset 1 group 2 1 4 mean 2.3 2.5 2.6 Subset 2 group 1 4 3 mean 2.5 2.6 2.9	No two groups are significantly different
	Within groups	136	143.2	1.1			
	Total	139	150.7				
In-between Instances not in any Text (N=5)	Between groups	3	13.2	4.4	5.0	Subset 1 group 2 4 mean 4.2 4.5 Subset 2 group 4 1 3 mean 4.5 4.9 5.0	groups 1 and 2 and groups 2 and 3 are significantly different
	Within groups	136	120.3	0.9			
	Total	139	133.5				

The results of ANOVA analysis of total non-scientist scores for the matched non-prototypical questions (in all texts) are given in Table 27, Part 2.

The ANOVA analysis on this group of questions yields an F ratio of 2.0. On the Duncan but not the Scheffe test, the mean score of the Text 2 sample was significantly lower than those of the Text 3 sample at the 0.05 level. This result is reflected in an ANOVA on the non-prototypical instances which are not mentioned in any text (see Part 2). The former result needs to be interpreted with caution as only 4 questions were in this category.

The ANOVA results on the total non-scientist scores for the animal instances not in any text in the post-post survey are given in Part 2 of Table 27. This analysis gave an F ratio of 3.9. The Duncan test indicated that the mean score of the Text 2 sample was significantly lower than those of the Text 1 and 3 samples, at the 0.05 level. The Scheffe test indicated that the mean score of the Text 2 sample was significantly lower than those of the Text 3 sample at the 0.05 level.

The ANOVA results tablulated in the last two sections of Part 2 suggest that the mean scores on the 'in-between instances, not in any text' contributed more to the difference than the scores on the 'non-prototypical instances, not in any text'.

A summary of the ANOVA of the scores on the 'in-between' and 'not in any text' questions is given in Part 2. As only 5 questions fell into this question category, the results need to be interpreted cautiously. However, the trend shown in other ANOVA results for the post-post survey is evident. That is, that the mean score for the Text 2 sample was significantly lower than those of the Text 1 and 3 samples.

c. Summary

Two main results were obtained from the post-post survey analysis. Firstly, the post-post results of the whole sample matched the post-survey results more than the results of the pre-survey. Secondly, the analysis of variance indicated that the mean score of the Text 2 sample was significantly lower than that of the Text 3 sample and sometimes that of the Text 1 sample.

6.2.4 Other results

a. Some instances in the post (and post-post) survey were mentioned in only one of the four texts (see Table 16). As the number of unique instances for each text and each sub-section (prototypical, in-between and non-prototypical) was small, it was decided to analyse the results for these questions using a chi-square test and not a oneway analysis of variance. The frequencies of correct scientific responses for these questions were given in Tables 21 and 25. A goodness-of-fit chi-square test was carried out and the resulting values documented in Table 22
The chi-square test was also carried out on the results for some of the questions that were not in any of the four texts.
The oyster was only mentioned in Text 1, and only for the oyster question was there any significant difference between the frequency of correct responses for the non-scientists in each text sample in both the post and post-post surveys. The Text 2 sample contributed most (18.2 and 10.3) to the chi-square values of 33.4 (post-survey) and 23.2 (post-post survey). That a text sample of students had or had not read a text with an animal exemplar explicitly mentioned appeared to make no significant difference in a following post or post-post survey question as to whether that instance was considered an animal or not, except for the oyster question, and this appeared to be related to the instance itself and not whether a student had read of it in the text.

b. <u>The answers to question 41 - the final and qualitative question</u>

In the post and post-post surveys, question 41 required a short written answer about the distinguishing characteristics of animals. The ideas in each student's answer were categorised into groups - 9 groups being formed from the data (see Table 28). As a student could write several ideas in a response, each idea was recorded, and not just the 'whole' answer.

In the post-survey, which was done immediately after the reading, the main category or answer for all 4 text samples was that 'an animal is something that eats other living things for food'. This characteristic was the one stressed in each text. Of the Text 1 sample, 66% mentioned this characteristic; of the Text 2 sample 56%; of the Text 3 sample, 80%; and of the Text 4 sample, 76%. A chi-square goodness of fit on the frequency counts resulted in a chi-square value of 23.5, which for 3 d.f., is significant at the 0.001 level. This may be interpreted as the Text 1 and 2 samples having used significantly less the characteristic of 'eating other living things', although the Text 1 sample did appear to list 'It is a consumer' more often. The next main category of answer, for all four text samples,was that 'an animal is not a plant'. Another main category of answer for all text samples was that 'animals can be herbivores, carnivores or omnivores'. While this is not a distinguishing feature of animals, it was mentioned in all texts as it relates to the notion of consumer feeding and it was familiar to many students. A main category for the Text 2 sample was the everyday meaning characteristics of legs, size or fur. Text 2 was the Dual Meaning text and it would appear that the students did not distinguish between the everyday meaning and the scientific meaning as requested in question 41. It would appear that the Text 1 sample recalled the characteristics of 'It is a consumer' more than the Text 2, 3 and 4 samples. The Text 1 and 2 samples appeared to name more exemplars than the Text 3 and 4 samples, in answering question 41.

TABLE 28: The Results (Frequencies and Percentages) of Question 41 in the Post and Post-post Surveys by the Whole Sample

Post-Survey	Text	Sample Size	Frequency of Occurrence of Ideas in Answers to Question 41								
			Eats other living things	Consumer	It is not a plant	Herbivore, canivore, etc.	MRS. GREN.	Sub-groups of animal	Named exemplars	Partially scientifically correct answer	Everyday meaning characteristics
(Challenge text)	1	61	40 (66%)	12	14	12	8	2	11	6	4
(Dual meaning text)	2	57	32 (56%)	6	15	10	2	5	10	6	12
(Typical text)	3	55	44 (80%)	9	12	10	1	4	5	6	2
(Control text)	4	54	41 (76%)	5	15	12	5	2	6	4	0
Post-post Survey	1	51	8	0	7	5	29	1	2	2	10
	2	50	9	1	12	5	25	0	0	1	9
	3	47	14	0	17	3	23	1	2	1	1
	4	48	12	1	11	9	23	1	0	1	3

In the post-post survey, the main category of answer was the characteristics of living things, for example, movement, breathing, for all text samples. It may be that the consumer feeding characteristic of animals had been recalled as feeding, which is characteristic of all living things. The category of 'It is not a plant' was still widely recalled as was the categories of 'eats other living things' and 'herbivores, carnivores and omnivores'. These latter two relate to animal nutrition. An interesting trend to note is the greater use of everyday characteristics by the students who read Texts 1 and 2 in the post-post survey. Text 2 was the Dual Meaning Text, and the characteristics of legs, fur, for example, were mentioned in the Challenge Text (Text 1) although they were not explicitly mentioned as being part of the everyday meaning.

In summary the text characteristic of 'animals eat other living things' was recalled more often by students in all 4 text samples, than any other characteristic in the post-survey question 41. In the post-post survey the main type of answer for all 4 text samples was that of the characteristics of living things, not just of animals. The characteristic of 'an animal is not a plant' was more widely recalled by all 4 text samples in both the post and post-post surveys than the characteristic of 'an animal is a consumer'. Therefore, the rule of 'an animal is a living thing that is not a plant' may be the least confusing and the more easily remembered rule for the students to use to distinguish between animals and non-animals.

6.3 DISCUSSION OF THE RESULTS OF PHASE III

The quantitative study was not intended, and therefore not designed, to elicit information as to the thinking of the students while they were answering the surveys. A small scale study was undertaken to investigate the thinking of nine other 13-year-old students who had completed a reading-to-learn task as well as the pre- and post-surveys in an interview setting. It was envisaged that the results of this small scale study would help explain the findings of the quantitative survey to some degree.

6.3.1 The small scale study

As the main sample was to be retested after one month, a separate sample was used to elicit the additional information. These students, like the main sample, were third formers, who had not done class work on 'animal'. They had all (except Student 356) scored average results (Level scores 7, 8) on the P.A.T. comprehension test, which had previously been administered by school personnel for school use. On a pre-survey, administered by the researcher to the whole class, they had all used a non-scientific meaning of the word 'animal', with respect to exemplars and characteristics. All nine students were members of the one science class. Further details are in given Appendix H.

Each student was interviewed on a one-to-one basis in a small book room, during a timetabled science lesson. First, the student was encouraged to recall the pre-survey done by the whole class. Then, the researcher discussed briefly her or his answers on the pre-survey, in that, the meaning of the word 'animal' used by the students was slightly different to the meaning used by scientists. The student was then asked to read the text to learn how a scientist would answer the question 'What is an animal?'.

Each student was alerted to the follow-up questions (the post survey), and then given as long as she or he wanted to read the pages. Most of the nine students took approximately the five minutes to read the text and did so only the once. Each student was required to read only one version of the texts (either Text 1, 2 or 3). Text 4 was not used as it was similar to Text 3 in that it was a control. As the quantitative Phase III study indicated less learning occurred with Text 2, more students were asked to read this one to ascertain why some students found this text less helpful for their learning. On completion of the task, they were asked to complete the post-survey. They were then interviewed on their choice of answer in the post-survey; on their understanding of the key sentences; on whether the text information made sense to them (i.e. a status probe); and on which parts of the text were most helpful in learning the scientific meaning of 'animal'. Details of the survey results are given in Appendix H. The reading-to-learn task was similar to that done by students in the larger sample in that the task was uninterrupted and accompanied by immediate pre- and post-survey measures. Each interview and task took approximately thirty minutes. The interviews were audiotaped with the consent of each student and transcribed for analysis.

Transcript quotations from this small study will be used here to expand and illustrate the discussion of results of the main quantitative study.

6.3.2 The main findings of the quantitative study were:

1. Most students, after reading one of the four texts, learnt the scientific concept of animal, as indicated by the post and post-post surveys. That most students gave more correct responses on the post-survey than on the post-post survey may be explained in terms of the relative time spans between the reading of a text and the two surveys. The post-survey was completed immediately after the reading and, the post-post

survey a month later. However, the differences between the post and post-post surveys were minor when compared to the changes between the pre- and post-surveys. The students in the small study were asked to explain what, in the text that they read,helped them to learn the scientific meaning of 'animal'.

Most of the students identified the author's key sentences as helpful in their learning:

a. 'All living things are either animals or plants':

9

> '(What helped you learn what an animal is?) ---
> So there's only two groups. One's plants and one's animal. So there's no separate other groups like insect or mammal. (Was that new to you?) Oh, yes. Sort of but insect. I thought that was a separate group altogether.' (356/1)

10

> '--that makes human beings animals, a snail and fish an animal, and trees and lettuces are plants.' (350/1)

b. 'Something is an animal if it is living and if it eats other animals, plants or their remains for food':

> '---Well, if anything eats food, well, I know now it is an animal, and that's why I know a tree isn't an animal because it doesn't eat food.' (356/1)

In the interview, it appeared that this student was using the word 'eat' in terms of consuming food.

c. the paragraph about the set and sub-sets of animal:

> '---because I just sort of thought a weta and a moth were just insects, creepy crawlies. (You didn't realise they were animals as well?) Just classify them as a simple insect.' (352/1)

d. and the named exemplars:

> '---Um, really I looked at the words - the animals and that. I read mainly to find out whether they were animals or something. (When they actually named one?) Yes, they named some of them.' (354/3).

---

9. () Inclusive of interviewer comments
   [] Researcher inserted works in the transcript
   --- a break in the transcript
   ... a pause in student talk

10. 356 student code number
    1 indicates text read 1 - Challenge Text
    2 - Dual Meaning Text
    3 - Typical Text
    4 - Control Text

These four perceived helpful text segments were in all four texts. That there was no significant difference between the mean scores in the post-survey of the non-scientists in each of the four text samples may be interpreted as the students being able to identify the key sentences and to construct the author's intended meaning, independent of the type of text they read. This interpretation suggests that the four texts were written in such a way (with respect to content and style) to successfully help most students construct the author's intended meaning about the scientific concept of animal.

Another trend is that in the post and post-post surveys results, there were more correct responses being given in response to the prototypical and in-between instances, than to the non-prototypical instances of 'animal'. As a group, the students had more difficulty learning that the non-prototypical animals, for example, the bee, were animals to a scientist. This is not an unexpected result.

2. Some students in the main study (and in the small study) did not learn the scientific concepts. This may be because they had not constructed or not accepted the author's intended meaning. This is illustrated by the following quotation:

> '(What do you understand by that "all living things are either animals or plants.There is no other group?") Didn't really tell me much at all.---sort of told you that things - living things were sort of animals and things that grew on the ground, like some plants.---there's no other group apart from those two. (Does that make sense to you?) No---because I think there is more - other groups than just there (like what?) the set of animals - non-animals. Things that don't eat or something like that.---like if you had---a fire, could say be living but it doesn't---isn't an animal or a plant or anything like that. (Is a fire living to you?) Yes, when it gets going, yeah.' (354/3)

His concept of living differed from the scientific concept and hence his construction was not that intended by the author.

3. The results of the post-survey suggested that the students in the main study not only constructed the author's intended meaning, but used it to answer the post-survey. This was supported by the findings of the small study, when the students were asked to explain their choice of answers in the post-survey.

The following 'rules' were used:

a. 'All living things are either animals or plants':

> '[A whale is mammal and an animal]---because you've got back there that tigers are animals, mice are, and then everything's animal. There's only two groups - animals and plants.' (351/2)

b. 'Something is an animal if it is living and if it eats other animals, plants or their remains for food':

> '[Yes, a spider's an animal] that's an animal because, even though it does have 8 legs I used to think that was an insect or something because it didn't live on four legs, but because it eats other things, living things.' (350/1)

c. Set and subsets of animal:

> 'Yes, a whale is an animal. A whale I know is a mammal. Eats plankton or something, and it breathes air, and I know it's a mammal so it is also an animal.'(356/1)

d. Named exemplars:

> '[Yes, an oyster is an animal]. Well, I think it eats plankton, or something from the sea. And they had it in the book too.' (356/1)

The reasons given verbally by the small study students matched the reasons written by them in question 41 in the post-survey, as well as the reasons listed in question 41 by the large sample. As well as the scientifically acceptable reasons described above, other students in the small study sample used:

e. Everyday distinguishing characteristics:

> '[Yes, an opossum is an animal]. Well, I just know it's an animal.---it's just furry and has a long tail.' (353/2)

f. Herbivores, carnivores, omnivores:

> '---Down there says that nearly everything's an animal.---that one there carnivores.'
>
> (357/2)

This student did not learn the scientific concept of animal and equated animals with carnivores, the meat-eaters.

3. There was a small decrease in the proportions of students giving the correct scientific response from the post to the post-post survey in the main study. One explanation may be that the scientific meaning constructed during the text reading and used to answer the post-survey was not integrated with existing knowledge. It may have been a compartmentalised piece of knowledge used to answer the post-survey, and then 'forgotten' to varying degrees. This interpretation was supported by the findings of the small study in that many students, while they had answered the post-survey as a scientist, had not necessarily accepted the scientific meaning. This is exemplified in statements made about the exemplars:

> '[Yes, a person is an animal] - is an animal as it eats, both meat and vegetables. A person does that. (Does that make sense to you - a person is an animal?) If you call people animals they'd take to you. (A scientist would call a person an animal. You've ticked "Yes" there. Do you think you'd think like a scientist now and call them an animal?) Not really---you'd get your head thrashed in for one. You just don't think of people as animals.'
>
> (351/2)

This student had not accepted the scientific meaning over the everyday one, nor was he conscious of the two meanings, despite having read Text 2. However, that he used the scientific concept of animal to answer the survey, but did not wish to use it outside the classroom context, indicates that to some extent he was using the two meanings in different contexts. Another quotation also illustrates this point:

> '[Yes, an octopus is an animal] Well, an octopus eats other, um, flesh, but I don't know if it eats plants or anything. I just know it eats flesh because I was once watching a programme and it ate a fish - I mean a human - a giant octopus. (Does that make sense to you calling an octopus an animal?) Not really because you'd think an octopus is another fish. (And you wouldn't call normally fish, animals?) Not really. I just put them in a part of their own.' (352/1)

The next quotation may reflect a preference for using the subset name (human) rather than the set name of animal. This preference is acceptable if the student is also aware of the set/subset relationship.

> '[Yes, a person is an animal] A person's an animal because it eats plants as well as flesh or meat. (Would you have called a person an animal before?) No, I'd just call it a human. (Does that make sense to you calling a person an animal?) Not really, because people think that an animal's got four legs and they eat grass or things like...other meat. (So do you think you'd call a person an animal from now on?) Um, it all depends really---if I was just talking about a human and---they'd just say it's a human, nothing else.' (352/1)

Another quotation hints at the difficulty students have in accepting what is perceived as conflicting information:

> '(What was confusing you?) The whole bit I reckon, because the earthworm and aphids---because I just can't get into my brain that they are animals---(Thinking about it now, are earthworms animals or not, to you?) Not really. (What do you think a scientist would call them?) Animals.' (357/2)

As this next student commented, the everyday meaning may be used in preference to a new and conflicting meaning:

> '(Which of the two meanings do you think you use the most?) The everyday meaning. (Which one would you use with Mr.---- in the science lesson?) The everyday meaning--- it's easier to remember. (Which one do you think Mr.---- uses?) The scientific one. (Do you think there are any problems in that?) Yep, because what he's saying we don't really understand.' (357/2)

Overall, the discussions on whether to accept or reject the scientific meaning, mirrored those in the Phase II interviews. What is of interest here, is that in a normal classroom task and testing situation, the students accepted the authority of the 'correct' scientific meaning to answer the survey. A 'Yes' response, however, may not be made with complete confidence in or acceptance of the scientific meaning. The students did appear to be aware of what was required of them to complete the school task as requested.

4. The post-post survey responses indicated that the Text 2 sample (who read the Dual Meaning Text) had a significantly lower mean score than students who read the other texts. This trend was suggested in the mean percent correct responses in the post-survey (Table 23), but was not supported by the oneway analysis of variance. The ANOVA did, however, support the trend in the post-post survey results (see Table 27). A chi-square test (Table 22) showed there was no significant difference between text samples on the instances 'unique to any text' other than for the oyster question. For this one, the results of the Text 2 sample contributed most to the significant difference.

These results also suggest that there was no significant difference between the results of the Text 1, 3 and 4 samples. In other words, the students who read the Challenge, Typical or Control Text appeared to learn equally well the scientific concept, as measured by the survey. The distinguishing characteristics of animals, written in all four texts; 'animals are not plants', and 'consumer feeding' - would appear to have been constructed and used by the students, especially those in samples 1, 3 and 4. The context in which the scientific concept was embedded appears to have had no benefit over any other. However, the context of the Dual Meaning Text appears to have had a negative influence, especially after a month. Several explanations may be given:

a. Students may be inexperienced in learning about and using two meanings for a common word. It could be that they got the two labels and the two meanings confused.

b. Students may have been confused about when to use either of the two meanings. Whilst the context cues of the science laboratory, the science lesson and the instructions to answer the survey as would a scientist, seem explicit to the researcher, they may not have been perceived as such by the students.

c. For students who have only an everyday meaning of the word 'animal', reading the Dual Meaning Text may have increased the status and acceptance of the everyday meaning more than that of the scientific meaning. In other words, the students' constructed meanings for the Dual Meaning Text may have resulted in their receiving confirmation as to the correctness and acceptability of their own existing knowledge.
The 'hidden' message of the constructed meaning of Text 2 may be that the everyday meaning is the one most people use and for the students to keep on using it, even in a scientific context.
Whatever reason is used to explain the results, the findings suggest that when the scientific and only the scientific concept is read, will it be most successfully learnt.
One question unanswered by this research is whether the students had difficulty in learning and using the two meanings of animal or whether they simply had difficulty learning them through reading a text.

5. The 'oyster' question in both the post and post-post surveys was answered correctly the least often by all four text samples. The exemplar of oyster was mentioned only in Text 1. There was no significant difference between the total responses to this question by the

Text 1, 3 and 4 samples. The responses of the Text 2 samples were significantly different. Two issues are of interest here. The results suggest that whether or not a student had read about the oyster (as a sessile animal) did not appear to influence whether they considered it to be an animal. The instance itself, and not the text in which it was mentioned, appears to be a factor. In the small study, many students spoke of lack of knowledge of the oyster in terms of structure and feeding habits:

> '[No, an oyster is not an animal.] All that is, is water really. It doesn't kind of eat anything really, or not that I know of. So it's just a sea - another fish.' (351/2)
>
> •
>
> 'Well, I wasn't sure about that so I put "No".---because it's a sea fish sort of thing so it's a fish but it's in a shell. And I don't know whether it eats.' (353/2)

Others, not knowing of the feeding, used another rule instead:

> '[Yes, an oyster is animal] Didn't know for that one. (But you've put "Yes" down?) Yes, because it's not a plant.---(What do you think it might eat?) I don't know.' (350/1)

Lack of knowledge of feeding habits was not restricted to the oyster:

> '[A wasp is not an animal] I thought it doesn't eat. I thought they just sting people and after that they used to die. (You don't know if they feed or not?) No.' (354/3)
>
> '[An opossum is not an animal] I don't know much about opossums. I don't know if they eat plants. They might eat other animals. I don't know.' (355/3)

Therefore, in interpreting the incorrect categorisations of students in the main study, one cannot assume they were using an everyday meaning of animal. It may be that they knew of the scientific meaning (they had constructed it by reading the text) but were unable to use it, or used it incorrectly because of a lack of knowledge about feeding habits. This would appear to be a feasible interpretation of the 'oyster' responses as many of the students choosing 'No' for the oyster, gave scientifically correct responses for most of the other instances.

6. The influence of the different texts read was evidenced in the students' responses to Question 41 (which investigated the distinguishing characteristics used by the students). The results mentioned already in Points 1-5 are concerned mainly with perceived exemplars and non-exemplars of animals.

Overall, the students found it more difficult to learn the scientific distinguishing characteristics than the scientific exemplars. There is a discrepancy here, in that, to a scientist, the distinguishing characteristics are used to decide if something is an animal or not. It could be suggested that the decision on exemplars and the documenting of a reason, were two different tasks for the students. This is similar to previous findings (Stead, 1980, p.144).

It would appear that while many of the students constructed and accepted the characteristic of feeding, many did not construct and learn the nature of animal feeding. Students appear to have alternative meanings for the common words of 'eat', 'feed', 'consume', and 'living' as suggested by the Phase II results and the results of the small Phase III study. These alternative meanings add a source of possible confusion for some students learning the scientific concept. It would appear that the characteristic of 'An animal is a living thing that is not a plant' leads to the least confusion. However, it should also be appreciated that students often have alternative meanings for 'living' and 'plant' (Stead, 1980), but these three basic categorical concepts can be taught together. The concepts of plant and animal nutrition may be more difficult to teach in the light of students' existing knowledge (Barker, personal communication).

7. The last main finding, is the relative ease with which the students learnt the scientific concept of animal when compared to other

studies of student learning of force for example, Osborne and Schollum (1981). The categorical nature of the scientific concept of animal may may be a factor here. Categories are arbitary and may not reflect a fundamental belief system about natural phemomena as do students' alternative concepts of force, gravity, air. Hence, it may be easier for students to change their existing knowledge about 'animal' than for other concepts, despite the moral connotations, for example, of calling a person an animal.

6.4 REVIEW OF THE METHODOLOGY

The advantages and disadvantages of this Phase III methodology are those of most quantitative methodologies. The advantages include:

1. the ability to efficiently survey a large, statistically representative sample, from the point of view of both collecting and analysing the data;
2. the ability to generalise from the findings, for example, to indicate which text is least likely to promote conceptual change; and
3. the methodology more closely resembled a naturalistic reading and classroom task than the methodologies of Phases I and II.

The disadvantages centre around the interpretation of the results. For example, the interpretation of the findings involved a heavy component of researcher inference. This was made considerably easier and perhaps more valid by the supportive qualitative data of the small study and by the findings of Phase I and II. In this sense, this quantitative research was not in the same vein as other quantitative educational research. It was, in fact, a combination of both qualitative and quantitative. Whilst the qualitative findings of Phase I and II supported and helped in the interpretation of the Phase III findings, the reverse was not so true.

To some extent, the question asked in Phase III did not address the main issue arising out of Phase II, that of the decision to accept or reject the author's intended meaning. It would be of value to carry out further quantitative work on how widespread the problem of not accepting the scientific meaning is.

Of interest, was the extent of uncertainty about the construction and evaluation of meanings by the students in the Phase II sample. While the Phase III sample may have had the same kinds of doubts and uncertainties, they were able to choose the correct answers. It would appear that the amount of discussion on the construction and evaluation of meanings by the Phase II sample, reflected the methodology, which enabled them to do so. The Phase III methodology required them to make a choice between a 'Yes' and a 'No', and in this context, the students were able to do as would a scientist.

The Phase III methodology, while similar to usual classroon activities, was also atypical in that the students only dealt with the concept of animal on the one brief occasion. Usually, students would also be given the opportunity to learn the concept on several occasions, and through several learning modes, for example, class discussion, group discussion, activity sheets, and homework.

6.5 SUMMARY AND CONCLUSIONS

1. Most students after reading one of the four texts, learnt the scientific concept of animal, particularly with respect to exemplars.

2. The total correct responses for each text sample indicated that more students considered the prototypical instances (for example, a cow)

to be an animal than the in-between instances (for example, a bird) and non-prototypical instances (for example, a snail) in the pre, post and post-post surveys.

3. Each of the four text samples gave more correct responses in the post than in the post-post survey. The post-post survey results did not return to those of the pre-survey. This suggests that to varying degrees the students had not made permanent changes to their existing knowledge. Whilst they had constructed the scientific meaning during reading, and had used it to answer the post-survey, some may not have accepted it to the extent of altering their existing knowledge, which was subsequently used to answer the post-post survey.

4. As a group, the Text 2 sample's results on the post-post survey differed significantly from the results of the Texts 1 and 3 samples. Text 2 sample's results indicated that they had changed their existing knowledge the least. A factor may be the context of Text 2, that is, the discussion of the two meanings of the word 'animal'.

5. There was evidence to suggest that a lack of knowledge of feeding habits may have prevented some students from correctly using the distinguishing characteristic of animal (heterotrophic) feeding.

6. The different meanings for 'feed' and 'eat' used by students in connection with the scientific distinguishing characteristics, suggests that, for teaching purposes, the characteristic of 'An animal is a living thing that it not a plant' may be a more useful one to use than the characteristics of 'consumer feeding' or 'eats other living things'.

CHAPTER 7 : SUMMARY, CONCLUSIONS AND IMPLICATIONS

7.1 SUMMARY OF RESULTS

Summaries of the findings of each of the three phases of the research were documented in Sections 4.4, 5.4, and 6.5, and are repeated here:

7.1.1 Summary of the Phase I results

1. Students did use their existing knowledge to generate a construction, along with text stimuli, and to evaluate that construction.

2. The existing knowledge used was often the everyday meaning of 'animal' as elicited in the science survey and existing knowledge interviews, as well as other aspects of existing knowledge, such as past experiences with and general knowledge of animals.

3. Students, who had only the everyday meaning of 'animal', tended not to construct the author's intended meaning, given the methodology and task of Phase I. The students were able to make sense of the text by constructing an alternative meaning. Only rarely was no construction made of a sentence.

4. Some students, who had only the everyday meaning of 'animal', did construct the author's intended meaning, but did not necessarily accept it. In other words, the construction appeared not to match their existing knowledge. It should be noted that the methodology, whilst not influencing the existence of a mismatch, may have influenced the decision as to whether it was to be accepted or rejected.

5. Points 1-4 apply to the findings from all three text samples.

6. In the Typical Text, there were few examples and elaborations given by the author. The students, who read this text, used their

existing knowledge of the everyday meaning to construct an elaborated meaning. Often this construction was restricted when compared to the author's intended one. The students tended to accept this construction as the same existing knowledge was used to evaluate it as was used to construct it. The students were often unaware that their construction was not the author's intended meaning.

7.1.2 Summary of the Phase II results

1. The processes of comprehension and conceptual change appear to involve both the constructing and evaluating of a meaning for the print.

2. Existing knowledge (for example, the everyday concept of animal) was used both to construct and evaluate a meaning for the text. The extent of discussion on evaluation was unanticipated by the researcher. It is unknown if this degree of deliberation on the evaluation is a reflection of the methodology and if it occurs to the same extent in normal reading activities.

3. The text stimuli were used to construct a meaning. The extent to which the perceived text information was used in evaluation, varied according to the student's view of the acceptability, authority or 'correctness' of the constructed text meaning. This was arrived at by comparing it with existing knowledge.

4. Most of the students interviewed were able to construct a meaning for the text (and for many, the author's intended meaning). This suggests that text characteristics such as writing style, vocabulary, sentence construction, use of pronouns and concept load did not present barriers to the students attempting to construct a meaning.

5. Students, who constructed alternative meanings to the author's intended one, were not always aware that they had not constructed the

author's intended meaning. This was mainly due to the same existing knowledge being used to construct and to evaluate a meaning. No mismatch occurred.

6. Some of the students appeared to be unsure and expressed indecision in whether to accept or reject the author's intended meaning if they had constructed it. This appeared to be through a lack of relevant existing knowledge, for example, on feeding habits, or because of emotional factors such as lack of confidence in their own existing knowledge, or in their constructions.

7. Other students seemed to easily make a decision to accept or reject the author's intended meaning. Those,who accepted it, did so for very different reasons:

a. They knew the information already. The constructed meaning was already a part of their existing knowledge.

b. The constructed meaning made more sense to them, and they were prepared to accept the new construction and change their existing knowledge.

c. The authority of print, school knowledge, or scientific knowledge was perceived as high. Any construction based on this was likely to be accepted. It is unclear if the constructed meanings were integrated into existing knowledge or kept as separate for use only at times when the perceived authority was present.

Those, who readily rejected the author's intended meaning, appeared to be those students who:

a. were not prepared to consider changing their existing knowledge. There may be two possible reasons for this:

i) Some may have seen no need to change their existing knowledge. The new construction may not have been seen as more useful or more plausible in terms of making sense of their world (Hewson, 1981a).

ii) Others may have been threatened by the prospect of changing their existing knowledge or by the prospect of change itself (Claxton, 1984).

b. and those who appeared not to see that the reading and learning task required them to change their existing knowledge. It could be said that these students had a passive view of learning (and reading). They may have thought that to decode the print was all that was required of them and not also the active engagement in the task of linking text stimuli and existing knowledge to construct a meaning.

8. Barriers to learning the scientific concept of <u>animal</u> appeared to be:

with respect to <u>constructing</u> a meaning of the text:

a) No construction was made. No sense was made of the text.

b) The author's intended meaning was not constructed, and often the students seemed unaware of this.

and with respect to a decision on the <u>status</u> of the author's intended meaning (once constructed):

a) The author's intended meaning was rejected.

b) The student was uncertain whether to accept or reject her or his construction.

9. Conceptual change occurred only when the student <u>both</u> constructed <u>and</u> accepted the author's intended meaning. There thus appeared to be <u>two</u> important processes in conceptual change.

10. The decision to accept or reject a construction (and in particular the author's intended meaning) was not just a rational decision. Feelings and beliefs about oneself, knowledge, school, reading, and learning, for example, appeared to be an integral part of this aspect of learning.

11. For many of the students interviewed, conceptual change occurred when they actively engaged in the tasks of constructing and evaluating a meaning. This active engagement involved consideration of and reflection on text stimuli, existing knowledge and the constructed meaning. This activity required time, energy and some degree of commitment.

12. For some students conceptual change appeared to occur rapidly. For others it was a slow dawning or awakening.

7.1.3 Summary of Phase III Results

1. Most students, after reading one of the four texts, learnt the scientific concept of animal, particularly with respect to exemplars.

2. The total correct responses for each text sample indicated that more students considered the prototypical instances, (for example, a cow) to be an animal than the in-between instances (for example, a bird) and non-prototypical instances (for example, a snail) in the pre-, post- and post-post surveys.

3. Each of the four text samples gave more correct responses in the post than the post-post survey. The post-post survey results did not return to those of the pre-survey. This suggests that to varying degrees, the students had not made permanent changes to their existing knowledge. Whilst they had constructed the scientific meaning during reading, and had used it to answer the post-survey, they may not have accepted it to the extent of altering their existing knowledge, which was subsequently used to answer the post-post survey.

4. As a group, the Text 2 sample's results on the post-post survey differed significantly from the results of the Texts 1 and 3 samples. Text 2 sample's results indicated that they had changed their existing knowledge the least. A factor may be the context of Text 2, that is, the discussion of the two meanings of the word 'animal'.

5. There was evidence to suggest that a lack of knowledge of feeding habits may have prevented some students from correctly using the distinguishing characteristic of animal (heterotrophic) feeding.

6. The different meanings for 'feed' and 'eat' used by students in connection with the scientific distinguising characteristics of animal suggest that, for teaching purposes, the characteristic of 'An animal is a living thing that is not a plant' may be a more useful one to use.

The findings on conceptual change in this whole investigation are summarised further in Table 29.

TABLE 29: Some Differences between Conceptual Change and No Conceptual Change

Aspects of Conceptual Change	Aspects of No Conceptual Change
Construction of the scientific conception.	No construction made, or an alternative construction is made.
Acceptance of the scientific conception, if it is constructed.	Non-acceptance or indecision as to accept or reject the scientific conception.
Learner is actively engaged in constructing and evaluating the scientific conception.	The learner is passive and not active in the learning process.
The learner is committed and willing to change her/his knowledge.	The learner is not committed and not willing to change.

7.2 DISCUSSION AND CONCLUSIONS

The main finding of this investigation is that comprehension and conceptual change involve a two-step process - the construction of a meaning and then the evaluation of the construction in terms of whether to accept or reject the construction. This second step - the evaluation and acceptance - would appear to be a major and crucial part of learning and yet it is underplayed in learning theories.

The other key finding was the influential role of existing knowledge in comprehension and conceptual change, highlighting the strong interactionist and the constructivist nature of these processes.

The following discussion of these findings and their implications is centred around the issue of the use of existing knowledge in comprehension and conceptual change.

7.2.1 The use of existing knowledge in the construction of a meaning

The findings support the idea of comprehension and conceptual change being interactive and constructivist processes. They are constructive in that they require the reader/learner to actively generate links between the text stimuli and existing knowledge, to creatively construct a meaning, to evaluate the constructed meaning, and to change their existing knowledge. The reader/learner may not always be aware of her or his active involvement.

The two processes are interactive in that both text stimuli and existing knowledge are used in the construction of a meaning. The constructed meaning has components of the author's intended meaning and of the reader's existing knowledge. As one would expect, the relative importance of each in the construction varies, with respect to context (e.g. whether the content of the text is familiar or not) and to reader (e.g. some readers rely more on text stimuli than their own existing knowledge [Spiro, 1980b]). As Wittrock (1981b) suggests, the reader is guided by and constrained by the print towards generating the author's intended meaning. But as the reader must also use existing knowledge in the construction of meaning, the construction will to varying degrees not be identical to the author's intended one.

The data analysis, of Phase II in particular, illustrated the use of existing knowledge in the construction of meaning. The readers/learners generated links between their existing knowledge and the text stimuli. The author had deliberately designed the text stimuli to enhance the generation of certain links by the learner. However, the existing knowledge of the student and author may differ, or the existing knowledge linked by the student may not have been that intended by the author. In both cases, the constructed meaning would differ from the author's intended one and hence, from the scientifically acceptable one.

There was evidence to illustrate the notion in schema theory of instantiation of variables using values from the text or from existing knowledge (that is, default values). This was especially so for animal exemplars. Students, who read the Challenge Text, tended to recall the exemplars mentioned in the text. Others, who had read the Typical Text, had to use their existing knowledge to instantiate their animal schema. The exemplars they mentioned tended to be prototypical ones only.

There is also evidence to support a strong interactionist view, in that existing knowledge not only contributed to the construction of meaning but it also influenced what meaning will be constructed.

7.2.2 The evaluation of a constructed meaning

Existing knowledge was also used in the evaluation of the constructed meaning. Schema theorists discuss evaluation somewhat superficially in terms of hypothesis testing and problem solving. This notion is more fully discussed in the progressive refinement theory, again in terms of problem solving and the strategies involved in the evaluation. Osborne and Wittrock (1983) also list a variety of ways in which a tentative construction may be evaluated:

a) for the plausibility of the assumptions on which the reader has based the construction,

b) in terms of consistency between the constructed meaning and existing knowledge and sensed experiences, and

c) in terms of predictions that follow from the constructed meaning.

However, the findings of Phase II suggest a much more important role for evaluation than the schema, progressive refinement or generative theories would indicate. It would appear that comprehension and conceptual change involve a two step process - the construction of a meaning and then the evaluation of the construction in terms of whether to accept or reject the construction. The second stage is of great importance in learning as the construction is new and it must be accepted before it is likely to be successfully incorporated into the existing knowledge and subsequently used. The decision as to whether to accept or reject a new construction involves an evaluation - a 'weighing-up'. Accepting a scientific construction may be a long-term issue. Of equal value is the short-term outcome of constructing the intended meaning, and understanding it as another point of view, even though one does not entirely accept it.

The generative learning model (Osborne and Wittrock, 1983) does embody these two main steps in learning. The model essentially outlines five activities involved in learning:

a. active, selective attention of sensory input;

b. generation of links between existing knowledge and sensory input;

c. active construction of meanings;

d. the evaluation of the constructions; and

e. the subsumption of constructions.

Steps (a,b,c) are concerned with the construction of meaning, step (d) with the evaluation and the decision to accept or reject the construction, and (e) the integration of the new conception with existing knowledge.

The findings of this investigation illustrate the importance of (d) in comprehension and conceptual change, and that it is of no lesser importance than the construction of meaning and the subsumption of constructed meanings. Hence, the consideration of the evaluation and the acceptance (or rejection) of a construction needs to be a key part of a theory of learning. Schema theory and progressive refinement theory do not give prominence to the evaluation and acceptance of constructed meanings, nor emphasise it as an essential part of learning. The generative learning model,as described in Osborne and Wittrock (1983), whilst acknowledging this aspect, does not fully explore its importance in the learning process. However, as illustrated, the model is able to incorporate this aspect.

Other researchers promoting a conceptual change view of learning, do include lengthy discussions on the evaluation and acceptance (or rejection) of new conceptions. Strike and Posner (1984) develop further the ideas of Posner et al (1982) and Hewson (1981a, b; 1982) and outline the conditions necessary for accommodation - the more radical restructuring and conceptual change - for scientists and students:

'(1) There must be dissatisfaction with existing conceptions. Scientists and students are unlikely to make major conceptual changes until they believe that less radical change will not work.

(2) A new conception must be minimally understood. The individual must be able to grasp how experience can be structured by a new conception sufficiently to explore the possibilities inherent in it.

(3) A new conception must appear initially plausible. Any new conception adopted must at least appear to have the capacity to solve the problems generated by its predecessors, and to fit with other knowledge, experience and help. Otherwise it will not appear a plausible choice.

(4) A new conception should suggest the possibility of a fruitful program. It should have the potential to be extended, to open up new areas of inquiry and to have technological and/or explanatory power.' (Posner and Strike, 1984)

The minimal understanding of the new conception is akin to the construction of meaning in the generative learning model, and the dissatisfaction, plausibility and fruitfulness to the evaluation and the decision to accept or reject the new construction.

The distinction is also made between understanding and commitment. Understanding a new idea does not imply accommodation or agreement and acceptance. It is possible to understand an idea with which one disagrees. Strike and Posner (1984) suggest three possible kinds of understanding:

(1) Minimal understanding:

'It is having enough sense of the idea to begin to explore its possibilities and to see some of its implications. An appreciation of the full range of implications of the conception will be lacking at this level.'

(2) Fuller understanding:

'Here the individual has a level of understanding of the conception that resembles that of an expert. The person sees a wide range of the implications of the conception and is able to apply it to complex and novel situations.'

(3) Accommodation:

'Accommodation involves not only understanding, but a degree of acceptance. In order to claim that a person has accommodated a new conception, a person must have at least a minimal grasp of the meaning of it.'

This last category contains explicitly the ideas of construction and acceptance of the new conception, as outlined in this investigation. However, Strike and Posner (1984) give no supporting empirical data, nor do they discuss the process of constructing meanings as do Osborne and Wittrock (1983) in their account of the generative learning model. The conceptual change theory of learning, as described by Strike and Posner, is thus an incomplete account when compared to the generative learning model.

The analysis of the data of this investigation suggests that the evaluation is essentially of two kinds. There may be a rational checking of plausibility and consistency, that is, does it logically make sense? Does it match the given environmental stimuli and the store of existing knowledge? There is also the affective aspect of the decision, in terms of whether to accept the construction as part of one's own knowledge.

Does the new construction lie easily with the reader's existing knowledge in an intuitive way? Can the reader believe in it? This investigation (in particular, the two case studies reported in Section 5.2.4) generates a hypothesis, worthy of further research, that those students, who did learn the scientific concept, did so as they appeared to accept the logical evaluation of the new construction in terms of the exemplars and distinguishing characteristics given in the text.

The new constructions often appeared to offer an acceptable solution to a problem, for example, of whether people are animals or not. In other words, a solution to a problem owned by the student was suggested. The student was looking for and was prepared to accept a plausible answer. On the other hand, those who did not learn appeared to evaluate the new construction more from the affective and from the intuitive aspects. They often made comments of the kind 'You can't go around calling people animals'. Even a logical presentation of rules was not perceived as a rationale for accepting a new construction. The capacity to accept or reject the new construction lies within the student and not in the presentation of a consensus and arbitrary scientific interpretation.

The carefully designed texts used in this research were only partially successful in obtaining <u>acceptance</u>, although many students appeared to construct the author's intended meaning. If conceptual change is to be promoted, we need not only to look at ways to logically challenge alternative ideas but to also consider this affective side of the decision to accept or reject a new construction.

7.2.3 Ways of promoting conceptual change

To promote conceptual change, then, we not only need to help students construct the scientific concept, but we have to help them accept it as part of their own belief system. Each of these issues will be discussed in turn.

In terms of helping students construct the author's intended meaning while reading, previous research has been concerned with the text factors of, for example, sentence construction and length, vocabulary, and density of concept words. Such research (reviewed in Section 2.1.2) has provided a valuable source of information as to the writing of material from which students find it easy to construct the author's intended meaning. Such ideas were incorporated in the texts employed in this investigation. The texts also incorporated the ideas of the generative learning model in terms of ways to help students actively construct a meaning (Linden and Wittrock, 1981), and students' alternative ideas about 'animal' (Bell, 1981a). The findings of this investigation indicate that most students, after reading a text, were able to construct to varying degrees, the author's intended meaning.

Other research into learning in science, has not specifically investigated whether or not students can construct the scientific conceptions. Much of the work has been related to finding out if students intuitively construct the scientific conception (and results suggest they do not), or whether they change their alternative conceptions towards the scientific one. Embodied in that change are the two stages of constructing and of accepting or rejecting the scientific conception. For the concept of animal, most students in this investigation were able to construct the scientific meaning, to some extent. But is this the case for other concepts, for example, force or conservation of energy? Once having constructed the scientific concept, do they accept it? This investigation indicated that even for the relatively basic concept of animal this may be difficult. Further research is needed, in other concept areas, to investigate if student difficulty in developing a scientific concept is in terms of constructing or accepting the scientific concept, or both.

Several issues are worthy of further debate and research with respect to the notion of accepting or rejecting the scientific concept:

a Two meanings for a word

The results of Phase III suggest that the students, who read the Dual Meaning Text, did not as a group accept the scientific meaning of 'animal' as much as the students who read the other texts. They appeared to have constructed and used the scientific concept in the post-survey but they did not appear to use it to the same extent in the post-post survey as the other text samples.

Several points for discussion arise:

i) It may be that the students' constructions of the explicit writing on the everyday and scientific meanings, may have been perceived as support for only the everyday concept;

ii) There may have been insufficient emphasis in the texts on when to use the scientific meaning to enable the students to construct an understanding;

iii) The students may have been confused in learning which concept went with which label, and in which context to use either meaning;

iv) Students may be inexperienced in coping with the notion of two meanings for one word; and

v) The cognitive development of students at that age may be such that they can only successfully operate on one meaning at a time. There may be a case for teaching the notion of two meanings only after they have successfully learnt the scientific concept.

For whatever reason, it seems students may have difficulty constructing and accepting the scientific concept, when learnt in conjunction with an elaboration on the everyday meaning.

This is an important finding as many of the words associated with basic science concepts, for example, force, energy, living, dissolving, have two meanings - a precise scientific meaning and an alternative one. Many researchers advocate students learning both meanings for such reasons as:

i) helping students link the scientific concept with their existing knowledge of the word;

ii) neither meaning is 'correct' - both meanings are useful in different contexts; and

iii) the threatening aspect of conceptual change may be reduced if their intuitive and alternative meanings are given acceptability in a certain context.

However, reading a text is but one learning activity. Further research is needed to investigate whether the construction, acceptance and use of the two meanings is promoted more by other teaching and learning modes, for example, class discussions, didatic teaching, small group discussions, activity sheets or computer activities. It may be that learning of the two meanings may be better done in another way to reading a text, particularly in an interactive situation where students' constructions can be immediately supported, acknowledged, elaborated or queried. To a very limited extent, this interaction can be incorporated into a text, based on our knowledge of possible areas of confusion. To this end, another text could be written in the light of the Phase III findings. The positive and negative aspects of each of the three main texts are given in Table 30. The revised text could incorporate all the positive aspects, and would resemble the Challenge Text with the first paragraph altered to reduce explicit mention of the everyday characteristics. The second paragraph could be expanded to include more exemplars and information on feeding habits.

TABLE 30: The Characteristics of the Three Main Texts and Conceptual Change

Text	Promotion of conceptual change	
	Positive Aspects	Negative Aspects
All texts	Rules An animal is not a plant. An animal is a consumer. Animals carry out heterotropic feeding. Exemplars of animals Elaboration sentences, e.g. 'A worm is an animal as it eats decaying leaves for food.' Set/subset diagrams Aids to generative learning, e.g. inserted questions, underlining. Writing style, e.g. few passive sentences.	Too few examples of what the different animals feed on.
Challenge Text	Additional exemplars.	Explicit mention of the everyday characteristics of fur, size, legs.
Dual Meaning Text		Explicit comparison of the two meanings.
Typical Text		Additional information on herbivorous and carnivorous feeding.

b. <u>The challenging of existing ideas</u>

Current research in science education is exploring ways to logically challenge students' alternative conceptions to increase dissatisfaction with them and hopefully encourage the <u>acceptance</u> of a new conception. Earlier studies were reviewed in Section 2.4.3, and a recent one is reviewed here. Strike and Posner (1984) theorise that dissatisfaction with a current (and maybe alternative conception) results from the individual experiencing one or more of the following conditions:

' 1. A conception is incapable of interpreting experiences presumed to be interpretative (resulting in an anomaly).

2. A conception is seen to be no longer necessary in the interpretation of experiences previously considered significant. This may be a consequence of another conception's greater success in interpreting the experiences or another conception reducing the significance of the experiences.

3. A conception is incapable of solving some problems that it presumably should be able to solve.

4. A conception violates an epistemological or metaphysical standard.

5. The implications of a conception are unacceptable.

6. The conception becomes inconsistent with knowledge in other areas.' (Strike and Posner, 1984)

Several studies, for example, Stavy and Berkovitz (1980) and the present one, have challenged ideas through the use of counter examples or anomalies. Strike and Posner (1984) question the effectiveness of this technique as when faced with an anomaly, the individual has several alternatives. They state:

> 'One may come to the conclusion that one's existing conceptions require some fundamental revision (i.e. an accommodation) in order

to eliminate the conflict. But this is most difficult and, therefore, the most unlikely approach especially when there are other possibilities:

(1) rejection of the observational theory;

(2) a lack of concern with experimental findings on the grounds that they are irrelevant to one's current conceptions;

(3) a compartmentalization of knowledge to prevent the new information from conflicting with existing belief ("Science doesn't have anything to do with the 'real' world"); and

(4) an attempt to assimilate the new information into existing conceptions (e.g. "Newtonizing" relativistic phenomena).'

These four possibilities have been previously discussed by Gilbert, Osborne and Fensham (1982) and Osborne, Bell and Gilbert (1983) in the context of what normally happens in science classrooms when students' alternative ideas are not addressed directly. It would appear that similar reactions may also occur when these alternative ideas <u>are</u> challenged. Strike and Posner (1984) suggest that the presentation of anomalies will produce dissatisfaction with an existing conception only if:

'1. Students understand why the experimental finding represents an anomaly;

2. Students believe that it is necessary to reconcile the findings with their existing conceptions;

3. Students are committed to the reduction of inconsistences among the beliefs they hold; and

4. Attempts to assimilate the findings into students' existing conceptions are seen not to work.'

Given such a list of conditions, it is not surprising that students do not readily change their existing ideas. It would appear that the challenging of students' alternative ideas and the presentation of the current scientific vews is alone not enough to promote conceptual change.

c. The affective aspect of conceptual change

The affective aspect of conceptual change appears to be an important factor in a student accepting or rejecting the scientific concept, once it has been constructed, for instance, the emotional repugnance of thinking of humans as animals. A student may reject the scientific concept if she or he feels threatened by change and by knowing that a previous way of making sense of the world is deemed unacceptable (Claxton, 1984). The scientific concept may also be rejected if the student lacks a willingness to change. There may be no perceived reason for changing or their concerns may be simply elsewhere. They may not be committed to spending the time and actively engaging in the creative construction and integration of the new concept. In their review of science education research over the decade of the seventies, White and Tischer (in press) comment that most of the research on attitudes was in terms of attitudes as outcomes of learning. Few studies looked at the role of attitudes as determinants of learning. The generative learning model does incorporate some motivational factors. But little is proposed in current research, except in the position papers of Head and Sutton (n.d.), Claxton (1984) and West and Pines (1983), and no research has been done on the role of feelings of students towards conceptual change. This is, however, currently being researched by the Children's Learning in Science Project (Bell and Driver, 1984), in Phase II. The research is based on an assumption that an awareness of the feelings students have towards changing their conceptions, will enable the affective components to be better taken into account in the promotion of conceptual change. However,Claxton (personal communication) also advocates that as insecure feelings are an integral part of any learning situation, we may need to help students develop a greater tolerance for insecurity, to accept that feeling unsure and anxious is an acceptable and expected part of being in a learning situation. This once again suggests the need for a supportive classroom atmosphere, in which different views are valued and given attention, and in which it is acceptable to express doubts and hesitations. The view of scientific knowledge, often reinforced in science classrooms, is one of 'absolute truth' and not one of a tentative nature, and many students (and teachers) perceive a major outome of science lessons to be getting the 'right answer' or 'correct result or instrument reading'. This view militates against an open discussion of different conceptions and feelings in the process of learning. Likewise, the present external examinations and internal assessment do not promote the kind of supportive atmosphere described. Lastly, few science teachers have in their training at University or Teachers' College, the opportunity to specifically develop skills of promoting small group discussion, and interpersonal communications. The Secondary Science Curriculum Review (1983) in Britain has undertaken to address this last point with the appointment of a Health Education Officer (Bentley, 1984), one aspect of whose role is to help science teachers working in the Review to develop these skills of promoting emotionally supportive atmospheres in which learning can occur. Curriculum work in other areas, for example Barnes (1976), is a source of information as are the intuitive ideas and personal qualities of individual teachers and researchers. To date, science education has few guidelines to offer teachers or researchers, and it is an area requiring detailed research.

d. Responsibility for learning

Another factor in promoting conceptual change, and in particular, the acceptance of a new construction, is the importance of the learner accepting responsibility for her or his own learning. Conceptual change tends to be enhanced if learners are aware of the necessity for them to be active in attending to sensory data, generating and evaluating constructions, and accepting and subsuming accepted scientific ideas (Baird, 1984). This requires the use of the skills of reflective and critical questioning. Baird (1984) argues that learners need to be helped to develop and use these skills to monitor what they do and do not know, what they are learning and why. These kinds of student behaviours are not typically encouraged in current science lessons.

The issues of dual meanings, challenging existing ideas, the affective aspect of conceptual change and responsibility for learning all suggest implications for teaching and learning, particularly the implementation of a constructivist view of learning in science classrooms, and these are discussed in the following section.

7.3 IMPLICATIONS FOR TEACHING AND LEARNING

Recent research in learning in science and this current investigation promote a constructivist and interactionist view of comprehension and conceptual change. Yet most science teachers, curriculum developers and school administrators hold a transmission view of teaching and learning (Watts and Bell, 1984). All people have implicit, if not explicit, theories about how people learn (Fox, 1983). Such personal theories guide one's views of the learner, the teacher, and classroom activities. In addition, they shape views on the nature of scientific knowledge.

A commonly held view in science education is one that sees teaching as the transmission of knowledge, and learning as the passive reception of this knowledge. The scientific knowledge is seen as analogous to building blocks (Fox, 1983) and therefore the task of teaching is to give, in small, sequenced portions, building blocks to learners, who add them to the store of knowledge or 'brick wall'. The central ethic is one of teacher authority and control, not learners' control of and responsibility for their own learning. Teaching and learning are often seen as reciprocal processes. If the teacher has told the class about 'energy', then the class must have learnt it if the message was well formulated and clearly spoken, and the students were attending. Transmission is seen as automatically followed by the reception of that knowledge.

This research has illustrated that the learning process cannot be described using a transmission model. Rather, students actively construct their own meanings and these may or may not be the intended ones. In addition, students may or may not accept a construction, for example, a scientific conception. Learning is characterised by active, constructive and interactive processes. In addition, knowledge is the personal construction of an individual and does not exist externally to be transmitted.

If effective conceptual change is to be promoted, then it follows that views of teaching, the role of the teacher and the curriculum must also reflect this constructivist view of learning. What does it mean to teach in a constructivist way? The following points are listed as possible ways to help students construct and accept scientific conceptions, if implemented in the classroom:

a. Giving importance to students' existing ideas, whether they be alternative or currently scientifically accepted ones. This includes allocating time for students to discuss ideas with the teacher and other students; provision of activites, which require the sharing of ideas; and providing feedback to the students (both verbal and non-verbal) that their ideas are worth communicating to, and are worthy of consideration by, others.

b. Accepting that knowledge and understanding is created by each person and cannot be transmitted directly. Students themselves, make sense of their world - teachers cannot do it for them. Implementing this in the classroom means providing the time and the opportunities for students to construct their own meanings, to reflect on them, to challenge and test them out in practical situations or in conversations with others, and to use new constructions in familiar and novel situations. In doing this, the teacher adopts the role of enabler and facilitator of the construction and acceptance of the scientific ideas, not the transmitter of knowledge. Hence, the skill of the teacher is not in being the 'expert of knowledge' but in being a diagnostician and resource. In addition, teachers may have to help students develop their skills of generating, evaluating and subsuming the scientific ideas. The possibility of unintended meanings being constructed needs to be recognised and seen as a normal and expected part of learning.

c. Helping students to accept that they are responsible in the end for their own learning and that it is through their own active engagement in constructing, evaluating and accepting new ideas, aided and supported by the teacher, that they will learn.

If we are to promote conceptual change in students, then science teachers, pre-service tutors, and curriculum developers must also change their views of teaching and learning, and especially the teacher's role (Smith and Anderson, 1983; Appleton et al, 1984). This is an important point as currently there is a mismatch between the view of teaching and learning held by many in science education and the process of learning done by students, and between classroom activities and the learning processes. A way to proceed would be to implement a constructivist approach to teaching and learning in the classroom and to evaluate its effectiveness in promoting conceptual change - both the construction and acceptance of new ideas. Such research is being undertaken by the Children's Learning in Science Project (Bell and Driver, 1984).

A resulting issue is that of helping science teachers to change their views of teaching and learning. There is a parallel between the conceptual change of teachers' conceptions of teaching and learning, and the conceptual change of students' alternative conceptions. Presently, many pre- and in-service courses for science teachers operate on a transmission view of learning. Courses run on a constructivist model would allow for:

a. clarification of personal conceptions of teaching and learning;
b. time for discussion in which ideas are shared and challenged;
c. time for the construction and acceptance of new ideas;
d. teachers to be responsible for their own learning;
e. the development of a supportive atmosphere, in which the threatening aspects of change are minimised; and
f. the continuing opportunities and resource backup to allow new teaching ideas to be used, with confidence, in familiar and unfamiliar situations.

The conceptual change and the resulting change in classroom behaviours suggested of teachers, would probably need to be extensive. As with other learners, it might be expected that teachers would experience difficulty or reluctance in constructing, accepting or using with confidence a constructivist view of learning. The challenge would be to illustrate the plausibility and fruitfulness of this different view!

A major resource being suggested to promote conceptual change for students and science teachers is that of time - time which is not presently available, given for example, current constraints of the curriculum. The implications of implementing a constructivist view of teaching and learning for the curriculum are discussed in the next section.

7.4 IMPLICATIONS FOR THE CURRICULUM

Conceptual change is typically a slow process. Strike and Posner (1984) assert the radical conceptual change of the kind required to learn many basic concepts is:

> 'a gradual and piecemeal affair' with 'much fumbling about and many false starts and mistakes'.

Time, and maybe much more than initially presumed, is required if we genuinely wish to give students the opportunity to construct, evaluate, accept and use scientific conceptions. Increasing the amount of time spent on one conceptual area, for example, animal, has ramifications for both the content of the curriculum, classroom activities, and assessment.

7.4.1 Curriculum content

Many curriculum writers assume all children (over the age of 5) know the scientific meaning of animal. They neither include 'animal' in the curriculum nor periodically review the concept in units on insects, arachnids, mammals, consumers, etc. However, previous research has documented that many 15-year-old students have and use only the everyday meaning of animal (Bell, 1981a). This investigation, like earlier ones (Bell and Barker, 1982; Boe, Cox and Bell, 1981) indicates that if teaching specifically focuses on this basic concept, then students can learn the scientific concept of animal and others, for example, consumer (Bell and Barker, 1982). It would appear that this scientific concept is not inherently difficult for students to learn. Its exclusion from the curriculum is not warranted in terms of difficulty, nor relevancy as it is a basic and underlying biological concept. If more time is allocated to learning basic scientific concepts, for example, animal, living, force, particulate nature of matter, then the number of concepts included may need to be decreased. The decision to include one conceptual area and not another is influenced not only by psychological factors but also by epistomological, social and political ones. While current science education research, such as the present study, suggests the need for the specific inclusion of basic concepts, social pressures often support the inclusion of more abstract ones, for example, in the area of biotechnology, that are seen to be more relevant to a technological world and to vocational futures. The Secondary Science Curriculum Review (1983), in consultation with industrialists, science teachers, science education researchers and others, has suggested an initial list, to stimulate debate, of the following content areas: energy; evolution; particulate nature of matter; ecology; competition, balance and dynamic equilibrium; community; nature of materials; chance and probability; change, rate of change, order and disorder; communications; systems; feedback and control; space; time; interaction and forces; growth, reproduction and replication; health. The concept of animal would be included in sections on energy relationships in the living world in the areas of energy, ecology or community studies.

The present study also highlights that the process of conceptualising (generating a construction and evaluating, accepting and using it) involves the use of conceptual skills, for example, predicting and hypothesising, and attitudes, for example, open-mindness and suspended judgement. The three facets are not separate but interrelated. However, the Draft New Zealand F1-4 Science Syllbus (1978) separates the science curriculum into the three domains of content (knowledge and concept development), process skills and attitudes and interests. While three separate lists are useful to itemise the components of the curriculum, it may not reflect, in a useful way, the nature of the learning required of science students.

7.4.2 Classroom activities

If more time is allocated to the learning of a particular conception, and if a constructivist approach to teaching and learning is to be implemented in classrooms, then more and a wider variety of learning activities for any one topic may have to be used. Initial suggestions as to what these different and varied activities may be, have been made by Boe, Cox and Bell (1981), Cosgrove, Osborne and Tasker (n.d.), Biddulph and Osborne (1984), Stavy and Berkovitz (1980) and Nussbaum and Novick (1981) for example. These activities range from discussions to task sheets to practical activities but are all characterised by the students being required to actively engage in constructing and accepting the scientific ideas rather than the more conceptually passive activities of, for example, following instructions in a 'recipe-book' fashion to complete a practical assignment. The development and evaluation of these classroom activities is an area requiring more attention.

7.4.3 Assessment

If it is accepted that conceptual change is slow for many students, then the way in which conceptual change is evaluated needs further attention. Current assessment procedures emphasise and give credit for accepted scientific ideas only. The reaching of the end of the learning 'journey' only is accorded value. But what of the student, who has changed her or his conceptions towards the scientific one. While much effort, activity and engagement in process of conceptual change has occurred, no credit is given as the intended outcome has not been reached. Other assessment measures are necessary if we are to distinguish between those who have not changed their conceptions at all and those who have begun to modify their existing knowledge.

7.5 IMPLICATIONS FOR READING IN SCIENCE CLASSROOMS

The emphasis on practical investigations and the development of process skills in science curricula in the 1970's, often resulted in the reading of expository texts being down-played or even positively discouraged. Yet reading-for-learning may be seen as a valued learning skill to be used not only in science classrooms, but in other curricular areas and everyday life. Developmental reading courses in secondary schools often focus on this skill as one of the many study skills.

The present investigation supports the use of textbooks in two ways:

(i) If students have, as part of their existing knowledge, the central concept(s) (e.g. animal) of a text, then it is highly likely they can be independent readers; that is, they can probably construct the author's intended meaning by themselves. This being the case, the text could well be used when the teacher is absent from the classroom or not wanting to be interactive with the students. The text would then act as a resource for the extension and reinforcement of earlier learning. The use of another source of information (other than the teacher) may help to promote the role of the teacher as an enabler of learning, rather than as the transmitter of knowledge.

(ii) If students do not have, as part of their existing knowledge, the central concept(s) of the text, it is likely that they may have difficulty constructing the author's intended meaning and accepting it. They may have difficulty in comprehending the text and/or changing their existing knowledge, and may not be able to read and learn independently of the teacher, for example. In this case, reading the textbook could well come after an oral teaching sequence, and act as a catalyst for discussion between teacher and students, or student and student, to clarify, elaborate, compare and contrast constructed meanings. The textbook is, therefore, used in an interactive situation, in which the skill of generative reading comprehension (Wittrock 1981b) can be explicitly demonstrated to the students for them to copy as suggested in Table 1.

However, it needs to be emphasised that reading is but one learning activity and is probably most useful when used in conjunction with others, and in an interactive situation with the teacher.

7.6 IMPLICATIONS FOR TEXT-BOOK AUTHORS

The main implications suggested by this study are:

a. Authors should be encouraged to make more use of the ways (documented in Dilena, 1978; Wittrock, 1981b; Bell and McGrath, 1983) to write so as to best help readers construct the intended meaning.

b. Research in science education has described the alternative concepts to the accepted scientific ones, held by many students. Rather than ignore these findings, authors should be encouraged to address these basic concepts in the text, for example, including a page on the accepted scientific meaning of 'animal'.

c. There are specific ways textbooks can be effectively used in classrooms (see previous section) and authors could usefully set out for teachers, in associated teachers' guide booklets, the ways they consider the various sections of their books could best be used.

7.7 FURTHER RESEARCH

Areas of further research have already been mentioned. In summary, they are:

a. The two stage model of conceptual change needs to be examined in relation to other concept areas in science. Are the difficulties and issues currently documented in other research studies, connected with the construction and/or the acceptance of a scientific concept?

b. The role of feelings and affective factors in learning, especially in terms of accepting or rejecting the scientific concept.

c. The learning of a scientific concept in the context of the two meanings (the scientific and alternative ones) for a common word. Is such learning promoted by learning of one meaning, then the other or concurrently using a different teaching/ learning mode? What are the difficulties that students perceive in learning and using the two meanings?

d. The role of existing knowledge in the attention aspect of the generative learning model. This may add to the debate by reading researchers as to whether the interactionist position is a strong or a weak one (Gough, 1983).

e. The development and evaluation of in-service courses to help science teachers learn and implement a constructivist view of teaching and learning.

f. The documentation of successes and difficulties experienced by teachers learning of and implementing a constructivist view of teaching and learning.

g. The development and evaluation of classroom activities to help students construct and accept scientific conceptions.

APPENDIX A : THE INITIAL TRIALING AND CHANGES MADE TO THE TEXTS

The texts used in the research were revised throughout the research, as a result of:

a. the limitations and desirable changes perceived in the initial trialing,

b. further limitations highlighted by the texts used in Phases I and II, and

c. the differing purposes of each phase of the research.

a. The initial trialing was undertaken to eliminate any sources of irrelevant difficulties students may have in constructing a meaning of the text - irrelevant difficulties being those not related to the student having an everyday meaning of animal. The method of trialing the texts was one-to-one interviews, carried out in a laboratory prep. room in normal timetabled lessons, with students from four different third form classes in one coeducational high school. The students were selected by the teacher on the basis that they were of average ability.

The introduction to the interviews was:

> 'I am interested in the textbooks used in science lessons in secondary schools. In particular, I am interested in finding ways to make the textbooks easy to read and understand. At the moment, I am trialing part of a textbook to find out if there is anything that could be changed before the book is published, so that it is easier to read. I have been talking to other students, like yourself, to find out what they think could be changed to make it easier to read.'

Consent to tape record the interview was then requested. The specific instructions were:

> 'I'd like you to read the two pages, taking as long as you wish, so that you understand the reading. While you are reading, I would like you to read to learn the author's answer to the heading "What

is an Animal?", and if there is anything unusual, difficult, or incorrect, I'd like you to put a small pencil mark at the end of of the line, so that we can come back to it and discuss it later on.'

The specific changes are detailed in Bell (1982a). The seven changes made to the Challenge Text could be categorised as either being:

a. stylistic, for example, the very short sentences in paragraph one were combined to make the language appear less stilted and 'juvenile';

b. rewording, for example in paragraphs 2 and 3 the word 'zebra' replaced the word 'antelope' as the latter tended to be less well known to students; or

c. diagram changes, for example, more exemplars were added.

The changes made to the Dual Meaning Text were mainly in relation to the dual meaning sentences. For example, an introductory sentence was added to further explain that some words can have two meanings; the explanation of the everyday meaning was expanded to include the subgroups of animals in the everyday sense; and the diagrams in the summary were changed to highlight the restricted nature of the everyday meaning.

Few changes were made to the Typical Text, the main one being the addition of a summary.

The diagrams in the texts were trailed in the following way. The original texts had tree-branching diagrams but the initial trials suggested that some students found these confusing. In other trails, no diagrams were drawn in the text, but blank spaces were left, and each student was asked to draw a diagram that showed the relationships written about in the text. After the students had discussed their own diagrams, they were shown Venn diagrams and asked to say what these diagrams meant to them. Most students drew pictures of animals rather than diagrams of relationships. While they tended not to produce Venn diagrams, they recognised their constructions of the author's ones as Venn diagrams and most could interpret them in a scientifically acceptable way. It was, therefore, decided to use Venn, not branching diagrams,in the texts for the reasons already mentioned, and because the diagrams themselves acted as a catalyst for students to discuss their constructed meanings for the text-print and diagrams.

The modified version of the original texts, used in Phase I are in Appendix B. Concurrent with the initial trials, the texts were validated by biologists and by biology teachers. Their comments suggested no further changes.

b. The second reason for changing the texts was in response to other limitations being highlighted in the use of the texts in a phase of the research. The additional changes were mainly those that would further help students to construct the author's intended meaning and to learn. At the end of Phase I, the following changes were made:

i) in all 3 texts the sentence about 'consumer' was rewritten to read:

 'Animals are also called consumers. Consumers are living things that must eat or consume other living things for food.'

ii) in the Typical Text, the summary was reworded and the question 'What is an animal?' underlined.

iii) in the Challenge Text, the answer to the question 'How do we know if something is an animal?' was rewritten to be 'Something is an animal if it is living and if it eats other animals, plants or their remains for food'; the sentence about mice as omnivores was rewritten to avoid possible ambiguity of construction; a summary was added; and the Universal set was removed from a Venn diagram.

iv) in the Dual Meaning Text, a change was made to the opening paragraph. The two meanings of the word 'animal' were compared to the two meanings of the word 'table', not 'jam' as it was considered a better analogy. Other changes made were that an additional sentence to help the reader construct the line of thought, was inserted before a discussion on the scientific meaning; the sentence about mice as omnivores was changed as in the Challenge Text; the contrast between the scientific and everyday meanings was made more explicit by the addition of such phrases as 'rather than the everyday meaning'; the diagram at the end was explicitly described as a set-subset diagram; the last paragraph was shortened and included a discussion of the last diagram. The texts used in Phase II are in Appendix C.

The changes made to the texts at the end of Phase II were due mainly to the design and methodology of Phase III and are therefore discussed in the third category of reasons for change to texts. The texts of Phase III are in Appendix D.

c. The third category of reasons for changing the texts, was the differing purposes and methodologies of the 3 research phases. The spot-the-mistake methodology of Phase I required that small, deliberate errors be included in the texts. These were (the underlining was not present in the text):

i) in Text 1 : 'A carrot is an animal'
'Lions eat stones'

ii) in Text 2 : 'Usually when we use the word "animal", we think of a cat, dog, lion, or a car'
'Lions eat stones'

iii) in Text 3 : 'Horses, rabbits, tigers and aphids are herbivores'.

One error was placed at the beginning of the texts and with Texts 1 and 2 the second error was placed approximately half way into the reading. Only one error was included in the Typical Text, as the abstract nature of the text made it difficult to compose simple errors. These errors were corrected in the Phase II texts.

The reading-to-learn interviews of Phase II required no special alterations to the texts. The changes made already by the use of the texts in Phase I, were changes that promoted the students' constructing and learning of the author's intended meaning.

The quantitative methodology of Phase III required major changes to the three texts and the writing of a fourth text, as the methodology required a stricter control of variations between texts than the other two phases. The three main texts were rewritten so that the only variation between the texts was the context in which the similar sections of print were embedded. Therefore, the three texts, not just Texts 1 and 2, had paragraphs on:

i. the two groups of living things. However, only Texts 1 and 2 had the second sentence 'There is no other group'. This sentence was placed at the beginning so that the key ideas of living, animal and plant were high in the text structure (Clements, 1976) and therefore more likely to be recalled (Meyer, 1975);

ii. the scientific definition of animal, consumer, herbivore, carnivore, omnivore;

iii. the subgroups of animal; and

iv. a summary.

Essentially, these four sections were identical except for minor variations to allow for cohesion with other unique paragraphs. Each of the three texts, contained a unique paragraph(s), which gave the particular context to each text. These unique paragraphs ensured that the special character of each of the texts used in Phases I and II was retained. The sequence of the various paragraphs and the numbers of words, is given in Table 31.

A fourth text (the Control text) was written to control for elaboration in the Typical Text. Usually published science texts do not elaborate on key statements. The 'Typical' Text in Phase III did, for example, 'A lion is an animal as it eats other animals like zebras for food'. This and other elaborations were included in the Phase III text, to keep it similar to the Challenge and Dual Meaning Texts. The Control Text mentioned the same exemplars and non-exemplars as the Typical Text but there was no elaboration of the sentences. Consequently the Control Text was shorter than the Typical Text. To lengthen it to be comparable to the other three texts, two paragraphs on the kinds of food eaten by herbivores and carnivores, and on the interdependency of living things were added. The Typical and Control Texts may be considered atypical when compared to published texts as a large number of exemplars was given. Research findings suggest that this promotes learning and so the atypically large number of exemplars was retained.

The exemplars mentioned in each text were specifically chosen. All four texts in Phase III contained a common core of animal exemplars (see Tables 32, 33). These included prototypical, in-between, and non-prototypical exemplars. Twelve of these 22 core exemplars were in the post and post-post survey used in Phase III and had parallel exemplars in the pre-survey (see Table 16). In other words, all students in the Phase III sample could answer questions based on these exemplars on recall if need be, rather than on the use of a rule. Also, each of the Texts 1, 2 and 3, 4 contained exemplars unique to that text (see Table 32). Some of the exemplars unique to each text were in the post and post-post survey (see Table 16). Therefore, only the students, who read that text, could use recall of the text construction to answer the survey question. In addition, the post and post-post Phase III survey contained questions based on exemplars not found in any text. The analysis of the exemplars

TABLE 31: Number of Words in each Paragraph and the Order of paragraphs for each Text used in Phase III

	Challenge Text - 1	Dual Meaning Text - 2	Typical Text - 3	Control Text - 4
No.of words in Paragraphs	1 - 13 A - 256 2 - 181 3 - 168 4 - 84 5 - 72	1 - 13 B1 - 183 2 - 180 3 - 168 4 - 84 B2 - 67 5 - 76	1 - 13 2 - 181 3 - 168 C - 261 4 - 84 5 - 72	1 - 8 2 - 148 3 - 107 D - 402 4 - 45 5 - 72
Total	774	768	779	782
in Common Paragraphs	518	521	518	380
in Unique Paragraphs	256	274	261	402

Key : Paragraphs in Common

1 : the two groups of living things
2 : the scientific definiton of animals
3 : herbivores, carnivores and omnivores
4 : groups of animals
5 : summary

Unique Paragraphs

A : specific exemplars and distinguishing characeristics of the scientific concept of animal to challenge the everyday concept of animal.
B : the two meanings of the word 'animal' are explicitly discussed.
C : food chains and food webs.
D : food chains, food webs and herbivores, etc.

TABLE 32: The Animal Exemplars in the four Phase III texts and the Frequency of Occurrence

Animal Exemplars	Common Paragraphs				Unique Paragraphs			
	Text 1	Text 2	Text 3	Text 4	Text 1	Text 2	Text 3	Text 4
aphid	3	3	3	2	–	1	2	2
cat	3	3	3	2	1	3	5	5
chicken	1	1	1	1	–	–	–	–
cow	3	3	3	2	3	4	–	–
earthworm	4	3	4	2	1	4	–	–
fly	2	2	2	1	1	–	–	–
hawk	1	1	1	1	–	–	–	–
lion	4	4	4	3	–	1	–	–
moth	1	1	1	1	1	–	–	–
mouse	3	3	3	2	–	3	2	2
person	4	4	4	2	4	2	–	–
rabbit	3	3	3	2	1	3	–	–
shark	3	3	3	2	2	–	–	–
sheep	1	1	1	1	–	2	–	–
snail	1	1	1	1	–	1	–	–
snapper	1	1	1	1	–	1	–	–
sparrow	5	5	5	2	2	–	–	–
spider	4	4	4	3	3	4	2	2
tui	1	1	1	1	–	–	–	–
weta	1	1	1	1	1	–	–	–
whale	1	1	1	1	3	–	–	–
zebra	2	2	2	1	–	–	–	–
goat					1	–	–	–
opossum					1	–	–	–
grasshopper					1	–	–	–
bat					1	–	–	–
oyster					1	–	–	–
barnacle					1	–	–	–
snake					1	–	–	–
frog					1	–	–	–
beetle					1	–	–	–
deer					–	2	–	–
leopard					–	1	–	–
butterfly					–	3	–	–
wasp					–	1	–	–
blackbird					–	–	6	6
caterpillar					–	–	3	3

TABLE 33: Frequency Occurrence of Animal Groups, Plant and Inanimate Exemplars in the four Phase III texts

	Common Paragraphs				Unique Paragraphs			
Animals Groups	Text 1	Text 2	Text 3	Text 4	Text 1	Text 2	Text 3	Text 4
birds	4	4	5	3	-	-	1	1
fish	2	2	2	2	-	-	-	-
insects	4	4	5	3	-	-	1	1
mammals	5	5	5	3	-	-	-	-
reptiles	2	2	2	2	-	-	-	-
spiders	1	1	1	1	-	-	-	-
worms	2	2	2	2	-	-	-	-
Inanimate								
car	1	1	1	1	-	1	-	-
Plants								
leaves	2	2	2	-	-	-	-	-
fruit	1	1	1	-	-	-	-	-
grass	1	1	1	-	-	-	-	-
lettuce	2	2	2	-	-	-	-	-
plant juices	1	1	1	-	-	-	-	-
seeds	3	3	3	-	-	-	2	2
tree	2	2	2	2	-	1	1	1
cabbage	-	-	-	-	-	-	3	3

in the Phase III surveys was given in Table 16.

Hence, the exemplars mentioned in each of the Phase III texts, were specifically related to the survey instances and, therefore, differed slightly from those in the Phase I and II texts.

APPENDIX B : THE PHASE I TEXTS

(Print size reduced by half)

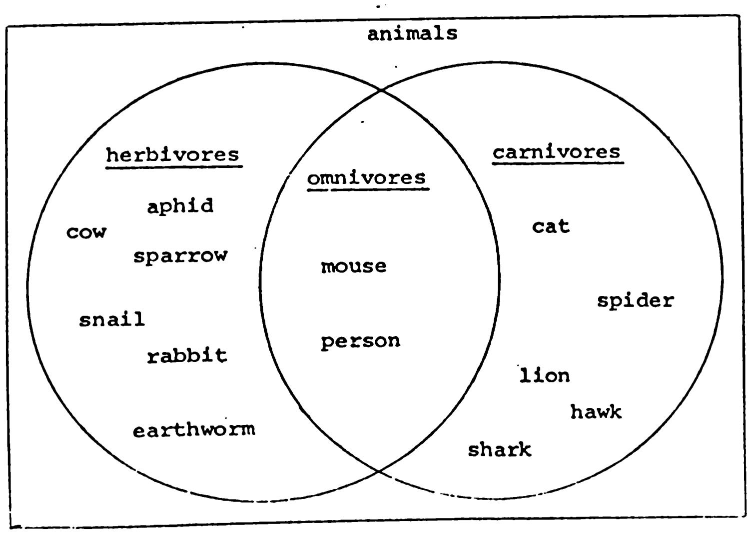
WHAT IS AN ANIMAL? (Challenge text)

All living things are either animals or plants. There are no other groups. What is an animal? A cow is an animal. A carrot is an animal. Sparrows, goats, spiders, earthworms, and sharks are also animals. What does an animal look like? An animal can be as big as a ship or as small as a pin. A whale is a big animal and a fly is a small animal. Where are animals found? Onimals can be found in a house, in a tree, in the sea, or in a crack. A person is an animal that may be found in a house. An opossum is an animal that may be found in a tree. A dolphin is an animal found in the sea. A spider is an animal that may be found in a crack. How do animals move? Some animals, such as people and cows, walk. Rabbits and grasshoppers are two animals that hop. Some animals like sharks and whales, swim. Butterflies and bats are both animals that fly. Some animals, like oysters and barnacles, stay in one spot and never move away. Some animals have many legs and some have no legs. Spiders are animals with eight legs. A weta is an animal with six legs. A cow is an animal with four legs. A person is an animal with two legs. A snake is an animal with no legs. What do animals feel like to touch? Some animals like a cat are furry to touch. A frog is an animal that is slimy to touch. Some animals like a beetle are hard.

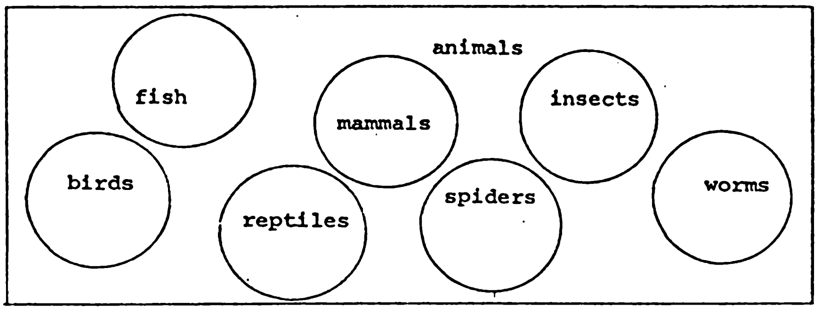
What is an animal? To a scientist, animals are living things that eat other animals or plants for food. A lion is an animal as it eats other animals, like zebras, for food. A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? If something is a living thing that eats other animals, plants, or their remains for food, then it is an animal. Animals are also called consumers as they must eat or consume other living things for food. Another name for an animal is a consumer.

Do all animals eat the same food? No. Some animals eat only plants or parts of plants. Animals that eat only plants are called herbivores. Cows, aphids, earthworms, sparrows, and rabbits are animals and herbivores. Cows eat grass, aphids suck plant juices, earthworms eat decaying leaves in the soil, sparrows eat the fruit and seeds from plants, and rabbits eat lettuces. Some animals eat only other animals, or their remains, and are called carnivores. Cats, spiders, lions, and sharks are all carnivores. Cats eat birds, spiders eat flies, lions eat stones, and sharks eat fish. Some animals eat both plants and animals. Animals that eat both plants and animals are called omnivores. People and mice are omnivores. People eat plants like lettuce and other animals like chickens and sheep. Mice eat seeds from plants or dead animals.

We have just read how animals can be divided into three groups - herbivores, carnivores and omnivores. We can draw a diagram to show how these three groups are related:



Another way to put animals into groups is to put all the animals of the same kind together. Birds are one group of animals. A tui is a bird and it is also an animal. Mammals are another group of animals. A person is a mammal and an animal. A whale is a mammal and an animal. Insects are another group of animals. A weta and a moth are insects and they are also animals. We can draw a diagram to show these groups:



WHAT IS AN ANIMAL?

Introduction (Dual Meaning text)

Some words have two meanings. The word 'jam' has two meanings. 'Jam' can mean something sweet as plum jam. Jam can also mean things crowded together, as in traffic jam. The word 'animal' also has two meanings. These two meanings we will call the everyday meaning and the scientific meaning.

The Everyday Meaning

What is the everyday meaning of animal? Usually when we use the word animal, we think of a cat, dog, lion, or a car. They are large, furry, four-legged creatures that live on land. We may not call worms, spiders and butterflies, animals as they are small. We are using the word animal in an everyday sense when we say cows and dogs are animals, and worms and spiders are not animals.

When we use the everyday meaning, we often put animals into groups according to where they are found. Some animals are found on a farm. Other groups of animals are zoo animals, wild animals, sea animals and pets.

An example of when we use the word animal in the everyday sense is when we go shopping. Many food shops show the sign "No animals allowed". We take the sign to mean that we cannot take cats, dogs or horses into the shop. In the everyday sense of the word, people are not animals so we can go in to buy food.

The Scientific Meaning

What is the scientific meaning of animal? To a scientist, living things can be either animals or plants. There is no other group. An animal is a living thing that eats plants or other animals for food. A lion is an animal as it eats other animals, like zebras, for food. A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? If something is a living thing that eats other animals, plants, or their remains for food then it is an animal. Animals are also called <u>consumers</u> as they must eat or consume other living things for food. Another name for an animal is a consumer.

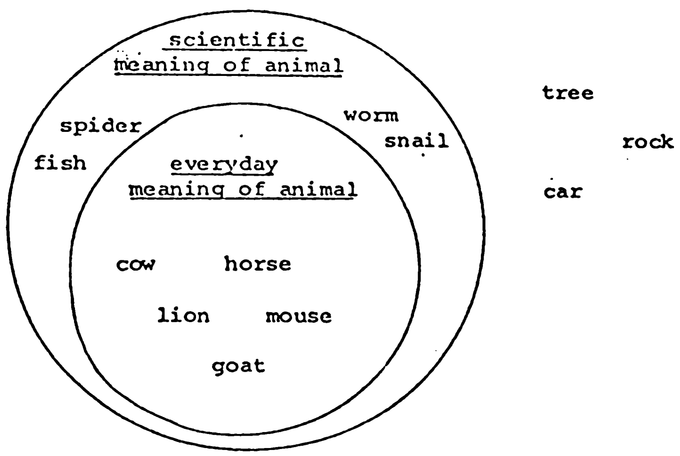
Scientists put animals into groups according to what the animals feed on. Some animals eat only plants or parts of plants. Animals that eat only plants are called <u>herbivores</u>. Cows, aphids, earthworms, sparrows, and rabbits are animals and herbivores. Cows eat grass, aphids suck plant juices, earthworms eat decaying leaves in the soil, sparrows eat the fruit and seeds from plants, and rabbits eat lettuces. Some animals eat only other animals or their remains and are called <u>carnivores</u>. Cats, spiders, lions, and sharks are all carnivores. Cats eat birds, spiders eat flies, lions eat stones, and sharks eat fish. Some animals eat both plants and animals. Animals that eat both plants and animals are called <u>omnivores</u>. People eat plants like lettuces and other animals like chickens and sheep. Mice eat seeds from plants or dead animals.

Another way scientists put animals into groups, is to put all the animals of the same kind together. Birds are one group of animals. Other groups of animals are the fish, mammals, ~~insects, worms, and spiders.~~

In the science classroom, the scientific meaning of the word animal is the better one to use. A science teacher may ask you to collect several different animals and bring them to the classroom. The teacher is using the word animal in a scientific sense and is thinking of the small animals like spiders, beetles, worms and butterflies.

<u>Summary</u>

The everyday and the scientific meanings are two meanings of the word animal. We can show the difference between the two meanings in this diagram:



We can use both meanings of the word animal. We often use the everyday meaning in our everyday lives, like when we do the shopping. We use the scientific meaning in the science laboratory. Both meanings are acceptable, but we use each meaning at a different time.

(Typical text)

WHAT IS AN ANIMAL?

The world of living things can be divided into two main groups : animals and plants. Why do we call some living things animals? Some living things are put into the group of animals because of the way they feed. Plants can make their own food using the sun's energy but animals are unable to make their own food. Animals must eat other living things for food. An animal is a living thing that eats other animals, plants, or their remains for food. Animals are also called consumers as they must eat or consume other living things for food. Another name for an animal is a consumer. Do all animals eat the same food? No. Animals which eat plants or parts of plants are called herbivores. Horses, rabbits, tigers, and aphids are herbivores. Animals which eat other animals or their remains are called carnivores. Snakes, owls, and lions are carnivores. Animals which eat both plants and animals are called omnivores. People are omnivores.

There are two main types of plant food available to herbivores. Some herbivores eat the solid food of the roots, stems and leaves. Other herbivores eat the liquid food that is found in plant stems. Herbivores that eat solid parts of the plant often have mouth-parts capable of biting and chewing. All caterpillars found in your garden are herbivores and all have mouth-parts for biting and chewing plants. Many animals actually burrow their way into the leaves, stems, and roots of plants by eating the material as they go. Leaf miners feed on sow thistles in this way and have mouth-parts for biting and chewing. Cows are herbivores and have teeth for crushing and grinding plants. Herbivores that eat liquid food have mouth-parts like a tube for sucking up the sap or juices of a plant. Aphids are herbivores that suck the sap of plants.

Carnivores also differ in the way they feed. Some carnivores actively seek out the animals they are going to eat, and kill their prey quickly. The thrush seeks out snails and eats the soft meat of the snail. A tiger has sharp teeth to kill its prey and tear the flesh. Other carnivores live inside the body of other animals and feed on the juices. These carnivores are also called parasites. A tapeworm is a parasite.

As a result of animals not being able to make their own food, they must be able to move to get their food. Also animals often need to move over a large area to get enough food for their needs. Unlike plants, most animals have to move from place to place to get enough food.

Most of the food required by animals is provided by plants. If there were no plants, there would be no food for the plant-eating animals, and therefore, there would be no food for the animal-eating animals. You can see that there is a simple pattern of eating and being eaten. Green plants use the sun's energy, water and carbon dioxide to make food. Plants are eaten by herbivores. Herbivores are eaten by carnivores. We call this simple pattern a food chain. A food chain is a way of showing the simple pattern of eating and being eaten. A food chain also shows that living things are dependent on each other for food.

An example of a simple food chain is:

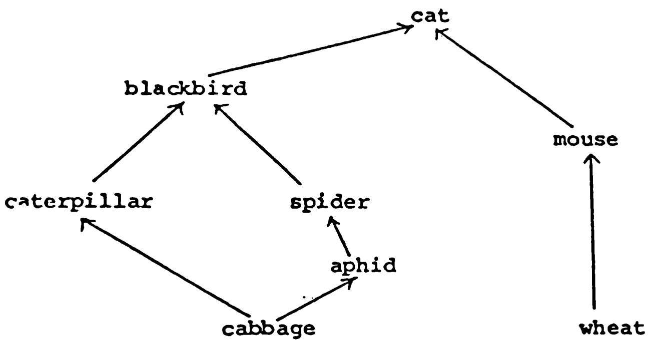
cabbage ⟶ caterpillar ⟶ blackbird ⟶ cat

Other food chains may be more complicated. Blackbirds do not feed on only earthworms. Cats do not feed only on blackbirds. A blackbird or a cat may be mentioned in several different food chains. Examples may be:

seeds ⟶ mouse ⟶ cat

cabbage ⟶ aphid ⟶ spider ⟶ blackbird

From these food chains a single diagram can be made in which each animal is mentioned only once but some may have more than one arrow going to or from it. This kind of diagram is called a food web diagram. An example of a food web diagram would be



By studying food chains and food webs, scientists study the way that living things are dependant on each other for food. A piece of native bush is not just a collection of trees, birds, and insects that live together in the same place. The living things do not live together just because they can put up with each other. The animals and plants are dependant on each other. Most plants and animals could not live without each other.

The main ideas, we have read about, answer the question what is an animal? An animal is a living thing that eats other animals or plants for food. Another name for an animal is a consumer. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. A food chain is a way of showing that animals and plants depend on each other for food.

APPENDIX C : THE PHASE II TEXTS

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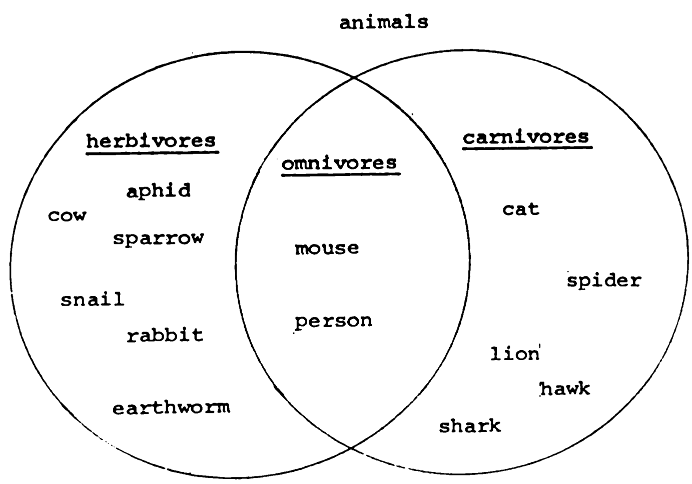
WHAT IS AN ANIMAL? (Challenge text)

All living things are either animals or plants. There are no other groups. What is an animal? A cow is an animal. A person is an animal. Sparrows, goats, spiders, earthworms, and sharks are also animals. What does an animal look like? An animal can be as big as a ship or as small as a pin. A whale is a big animal and a fly is a small animal. Where are animals found? Onimals can be found in a house, in a tree, in the sea, or in a crack. A person is an animal that may be found in a house. An opossum is an animal that may be found in a tree. A dolphin is an animal found in the sea. A spider is an animal that may be found in a crack. How do animals move? Some animals, such as people and cows, walk. Rabbits and grasshoppers are two animals that hop. Some animals like sharks and whales, swim. Butterflies and bats are both animals that fly. Some animals, like oysters and barnacles, stay in one spot and never move away. Some animals have many legs and some have no legs. Spiders are animals with eight legs. A weta is an animal with six legs. A cow is an animal with four legs. A person is an animal with two legs. A snake is an animal with no legs. What do animals feel like to touch? Some animals like a cat are furry to touch. A frog is an animal that is slimy to touch. Some animals like a beetle are hard.

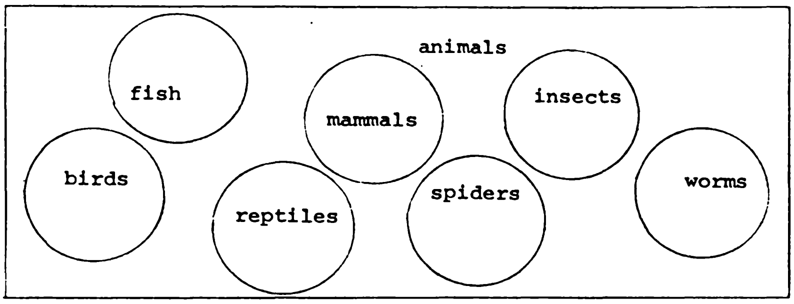
What is an animal? To a scientist, animals are those living things that are not plants. Scientists also say that animals are living things that eat other animals or plants for food. A lion is an animal as it eats other animals, like zebras for food. A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? Something is an animal if it is living and if it eats other animals, plants or their remains for food. Animals are also called consumers. Consumers are living things that must eat or consume other living things for food. All animals are consumers.

Do all animals eat the same food? No. Some animals eat only plants or parts of plants. Animals that eat only plants are called herbivores. Cows, aphids, earthworms, sparrows, and rabbits are animals and herbivores. Cows eat grass, aphids suck plant juices, earthworms eat decaying leaves in the soil, sparrows eat the fruit and seeds from plants, and rabbits eat lettuces. Some animals eat only other animals, or their remains, and are called carnivores. Cats, spiders, lions, and sharks are all carnivores. Cats eat birds, spiders eat flies, lions eat zebras, and sharks eat fish. Some animals eat both plants and animals. Animals that eat both plants and animals are called omnivores. People and mice are omnivores. People eat plants like lettuce and other animals like chickens and sheep. Mice eat seeds from plants and they eat dead animals.

We have just read how animals can be divided into three groups - herbivores, carnivores and omnivores. We can draw a diagram to show how these three groups are related:



Another way to put animals into groups is to put all the animals of the same kind together. Birds are one group of animals. A tui is a bird and it is also an animal. Mammals are another group of animals. A person is a mammal and an animal. A whale is a mammal and an animal. Insects are another group of animals. A weta and a moth are insects and they are also animals. We can draw a diagram to show these groups:



<u>Summary</u>

The main ideas we have read about, answer the question <u>what is an animal</u>? An animal is a living thing that eats other animals or plants for food. All animals are consumers. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. Some groups of animals are the fish, birds, mammals, insects, reptiles, and worms.

WHAT IS AN ANIMAL?

Introduction

(Dual meaning text)

Some words, like the word table, can have two meanings. 'Table' can often mean the piece of furniture at which we eat a meal. 'Table' can also refer to any flat surface with legs. The word 'animal' also has two meanings - a narrow meaning and a wider meaning. These two meanings of the word 'animal' we will call the everyday meaning and the scientific meaning.

The Everyday Meaning

What is the everyday meaning of animal? Usually when we use the word animal, we think of a cat, dog, lion, or a cow. They are large, furry, four-legged creatures that live on land. We may not call worms, spiders and butterflies, animals as they are small. We are using the word animal in an everyday sense when we say cows and dogs are animals, and worms and spiders are not animals.

When we use the everyday meaning, we often put animals into groups according to where they are found. Some animals are found on a farm. Other groups of animals are zoo animals, wild animals, sea animals and pets.

An example of when we use the word animal in the everyday sense is when we go shopping. Many food shops show the sign "No animals allowed". We take the sign to mean that we cannot take cats, dogs or horses into the shop. In the everyday sense of the word, people are not animals so we can go in to buy food.

The Scientific Meaning

We have just read about the everyday meaning of the word animal. The other meaning is the scientific meaning of animal. What is the scientific meaning? To a scientist, living things can be either animals or plants. There is no other group. Animals are those living things that are not plants. A scientist also says that an animal is a living thing that eats plants or other animals for food. A lion is an animal as it eats other animals, like zebras, for food.

A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? Something is an animal if it is a living thing and if it eats other animals, plants or their remains for food. Animals are also called consumers. Consumers are living things that must eat or consume other living things for food. All animals are consumers.

Scientists put animals into groups according to what the animals feed on. Some animals eat only plants or parts of plants. Animals that eat only plants are called herbivores. Cows, aphids, earthworms, sparrows, and rabbits are animals and herbivores. Cows eat grass, aphids suck plant juices, earthworms eat decaying leaves in the soil, sparrows eat the fruit and seeds from plants, and rabbits eat lettuces. Some animals eat only other animals or their remains and are called carnivores. Cats, spiders, lions, and sharks are all carnivores. Cats eat birds, spiders eat flies, lions eat zebras, and sharks eat fish. Some animals eat both plants and animals. Animals that eat both plants and animals are called omnivores. People eat plants like lettuces and other animals like chickens and sheep. Mice eat seeds from plants and they eat dead animals.

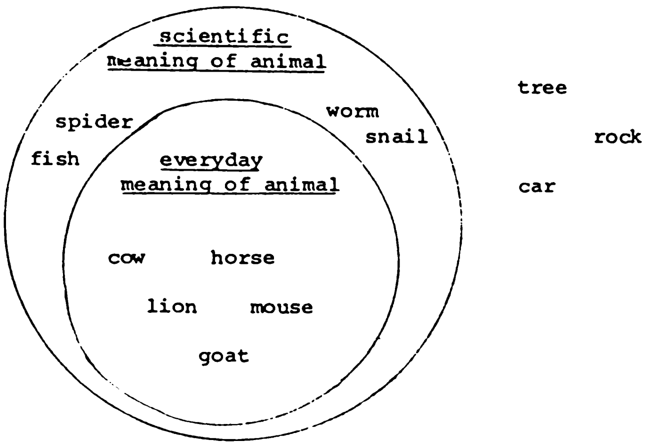
Another way scientists put animals into groups, is to put all the animals of the same kind together. Birds are one group of animals. Other groups of animals are the fish, mammals, insects, worms, and spiders.

In the science classroom, the scientific meaning of the word animal is the better one to use, rather than the everyday meaning. A science teacher may ask you to collect several different animals and bring them into the classroom. The teacher is using the word animal in the scientific sense and is thinking of the small animals like spiders, worms and butterflies, rather than cats and mice.

Summary

The everyday and the scientific meanings are two meanings of the word animal.

We can show the difference between the two meanings in this set and subset diagram:



The everyday meaning is a subset of the scientific meaning. The everyday meaning refers to only a small number of animals such as the cow and mouse. The scientific meaning includes the cow and the mouse, and it also includes all the other animals such as a spider and a worm.

We can use both meanings of the word animal, but we use each meaning at a different time.

(Typical text)

WHAT IS AN ANIMAL?

The world of living things can be divided into two main groups : animals and plants. Why do we call some living things animals? Some living things are put into the group of animals because of the way they feed. Plants can make their own food using the sun's energy but animals are unable to make their own food. Animals must eat other living things for food. An animal is a living thing that eats other animals or plants for food. Animals are also called consumers. Consumers are living things that must eat or consume other living things for food. All animals are consumers. Do all animals eat the same food? No. Animals which eat plants or parts of plants are called herbivores. Horses, rabbits, sheep, and aphids are herbivores. Animals which eat other animals or their remains are called carnivores. Snakes, owls, and lions are carnivores. Animals which eat both plants and animals are called omnivores. People are omnivores.

There are two main types of plant food available to herbivores. Some herbivores eat the solid food of the roots, stems and leaves. Other herbivores eat the liquid food that is found in plant stems. Herbivores that eat solid parts of the plant often have mouth-parts capable of biting and chewing. All caterpillars found in your garden are herbivores and all have mouth-parts for biting and chewing plants. Many animals actually burrow their way into the leaves, stems, and roots of plants by eating the material as they go. Leaf miners feed on sow thistles in this way and have mouth-parts for biting and chewing. Cows are herbivores and have teeth for crushing and grinding plants. Herbivores that eat liquid food have mouth-parts like a tube for sucking up the sap or juices of a plant. Aphids are herbivores that suck the sap of plants.

Carnivores also differ in the way they feed. Some carnivores actively seek out the animals they are going to eat, and kill their prey quickly. The thrush seeks out snails and eats the soft meat of the snail. A tiger has sharp teeth to kill its prey and tear the flesh. Other carnivores live inside the body of other animals and feed on the juices. These carnivores are also called parasites. A tapeworm is a parasite.

As a result of animals not being able to make their own food, they must be able to move to get their food. Also animals often need to move over a large area to get enough food for their needs. Unlike plants, most animals have to move from place to place to get enough food.

Most of the food required by animals is provided by plants. If there were no plants, there would be no food for the plant-eating animals, and therefore, there would be no food for the animal-eating animals. You can see that there is a simple pattern of eating and being eaten. Green plants use the sun's energy, water and carbon dioxide to make food. Plants are eaten by herbivores. Herbivores are eaten by carnivores. We call this simple pattern a food chain. A food chain is a way of showing the simple pattern of eating and being eaten. A food chain also shows that living things are dependent on each other for food.

An example of a simple food chain is:

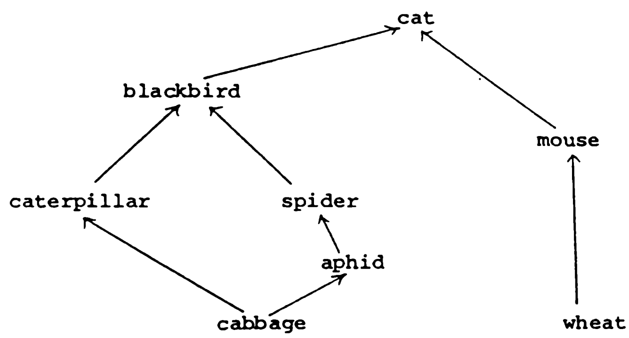
cabbage ⟶ caterpillar ⟶ blackbird ⟶ cat

Other food chains may be more complicated. Blackbirds do not feed on only earthworms. Cats do not feed only on blackbirds. A blackbird or a cat may be mentioned in several different food chains. Examples may be:

seeds ⟶ mouse ⟶ cat

cabbage ⟶ aphid ⟶ spider ⟶ blackbird

From these food chains a single diagram can be made in which each animal is mentioned only once but some may have more than one arrow going to or from it. This kind of diagram is called a food web diagram. An example of a food web diagram would be



By studying food chains and food webs, scientists study the way that living things are dependant on each other for food. A piece of native bush is not just a collection of trees, birds, and insects that live together in the same place. The living things do not live together just because they can put up with each other. The animals and plants are dependant on each other. Most plants and animals could not live without each other.

The main ideas, we have read about, answer the question <u>what is an animal</u>? An animal is a living thing that eats other animals or plants for food. All animals are consumers. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. A food chain is a way of showing that animals and plants depend on each other for food.

APPENDIX D : THE PHASE III TEXTS

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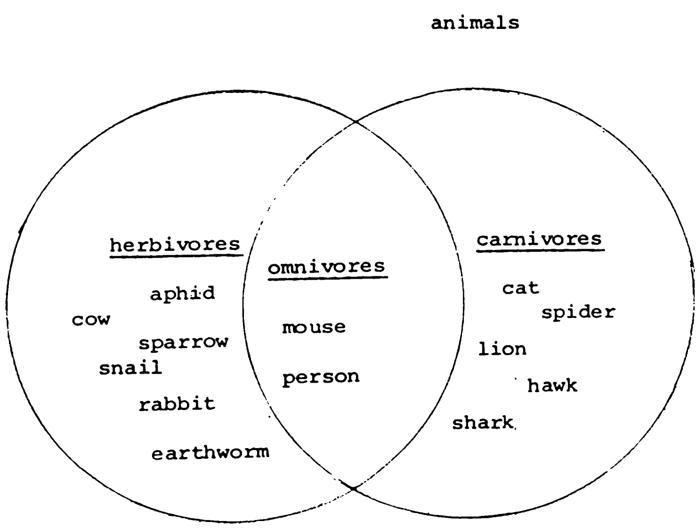
WHAT IS AN ANIMAL? (Challenge text)

All living things are either animals or plants. There is no other group. What is an animal? A cow is an animal. A person is an animal. Sparrows, goats, spiders, earthworms, and sharks are also animals. What does an animal look like? An animal can be as big as a ship or as small as a pin. A whale is a big animal and a fly is a small animal. Where are animals found? Animals can be found in a house, in a tree, in the sea, or in a crack. A person is an animal that may be found in a house. An opossum is an animal that may be found in a tree. A whale is an animal found in the sea. A spider is an animal that may be found in a crack. How do animals move? Some animals, such as people and cows, walk. Rabbits and grasshoppers are two animals that hop. Some animals like sharks and whales swim. Moths and bats are both animals that fly. Some animals, like oysters and barnacles, stay in one spot and never move away. Some animals have many legs and some have no legs. Spiders are animals with eight legs. A weta is an animal with six legs. A cow is an animal with four legs. A person and a sparrow are both animals with two legs. A snake is an animal with no legs. What do animals feel like to touch? Some animals like a cat are furry to touch. A frog is an animal that is slimy to touch. Some animals like a beetle are hard.

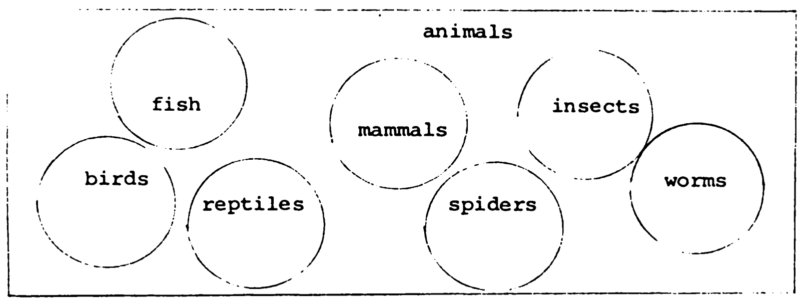
What is an animal? To scientists, animals are those living things that are not plants. Scientists also say that animals are living things that eat other animals or plants for food. A lion is an animal as it eats other animals, like zebras for food. A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? Something is an animal if it is living and if it eats other animals, plants or their remains for food. Animals are also called consumers. To a biologist, consumers are living things that must eat or consume other living things for food. All animals are consumers of food.

Do all animals eat the same food? No. Some animals eat only plants or parts of plants. Animals that eat only plants are called herbivores. Cows, aphids, earthworms, sparrows, and rabbits are animals and herbivores. Cows eat grass, aphids suck plant juices, earthworms eat decaying leaves in the soil, sparrows eat the fruit and seeds from plants, and rabbits eat lettuces. Some animals eat only other animals, or their remains, and are called carnivores. Cats, spiders, lions, and sharks are all carnivores. Cats eat sparrows, spiders eat flies, lions eat zebras, and sharks eat snapper. Some animals eat both plants and animals. Animals that eat both plants and animals are called omnivores. People and mice are omnivores. People eat plants like lettuce and other animals like chickens and sheep. Mice eat seeds from plants and they eat dead animals.

We have just read how animals can be divided into three groups - herbivores, carnivores, and omnivores. We can draw a diagram to show how these three groups are related:



Another way to put animals into groups is to put all the animals of the same kind together. Birds are one group of animals. A tui is a bird and it is also an animal. Mammals are a group of animals. A person is a mammal and an animal. A whale is a mammal and an animal. Insects are another group of animals. A weta and a moth are insects and they are also animals. We can draw a diagram to show these groups:



Summary

The main ideas we have read about, answer the question what is an animal? An animal is a living thing that eats other animals or plants for food. All animals are consumers. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. Some groups of animals are the fish, birds, mammals, insects, reptiles, and worms.

WHAT IS AN ANIMAL? (Dual meaning text)

Introduction

All living things are either animals or plants. There are no other groups. What is an animal? The word 'animal' has two meanings. These two meanings we will call the everyday meaning and the scientific meaning.

The everyday meaning

What is the everyday meaning of animal? Usually when we use the word animal we think of a cat, rabbit, lion, sheep, or a deer. They are large, furry, four-legged creatures that live on land. We may not call earthworms, aphids, spiders and butterflies animals as they are small. We are using the word animal in an everyday sense when we say cows, sheep, and cats are animals and earthworms, spiders and butterflies are not animals. An example of when we use the word animal in the everyday sense is when we read the sign outside food shops "No animals allowed". We take the sign to mean that we cannot take cats, rabbits, or deer into the shop, although we can go in. In the everyday meaning of the word animal, people are not animals so we can go in to buy food. But scientists call people animals. What is the scientific meaning of animal?

The scientific meaning

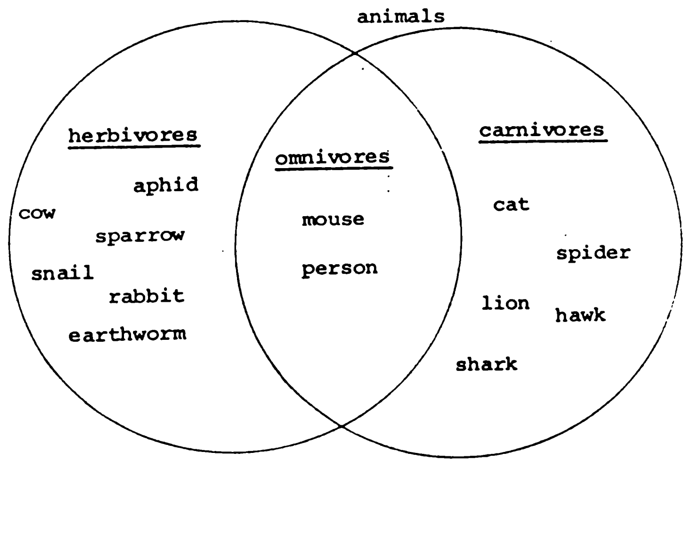
To scientists, animals are those living things that are not plants. Scientists also say that animals are living things that eat other animals or plants for food. A lion is an animal as it eats other animals, like zebras, for food. A spider is an animal as it eats flies for food. An earthworm is an animal as it eats decaying leaves in the soil. A sparrow is an animal as it eats seeds from plants. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? Something is an animal if it is living and if it eats other animals, plants, or their remains for food.

.2.

Animals are also called consumers. To a biologist, consumers are living things that must eat or consume other living things for food. All animals are consumers of food.

Do all animals eat the same food? No. Some animals eat only plants or parts of plants. Animals that eat only plants are called herbivores. Cows, aphids, earthworms, sparrows and rabbits are animals and herbivores. Cows eat grass, aphids suck plant juices, earthworms eat decaying leaves in the soil, sparrows eat the fruit and seeds from plants, and rabbits eat lettuces. Some animals eat only other animals or their remains and are called carnivores. Cats, spiders, lions, and sharks are all carnivores. Cats eat sparrows, spiders eat flies, lions eat zebras, and sharks eat snapper. Some animals eat both plants and animals. Animals that eat both plants and animals are called omnivores. People and mice are omnivores. People eat plants like lettuces and other animals like chickens and sheep. Mice eat seeds from plants and they eat dead animals.

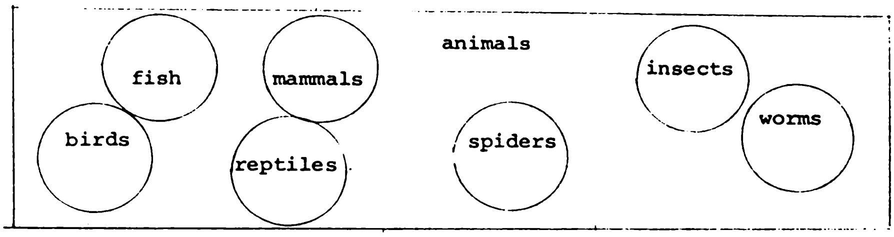
We have just read how animals can be divided into three groups - herbivores, carnivores and omnivores. We can draw a diagram to show how these three groups are related:



.3.

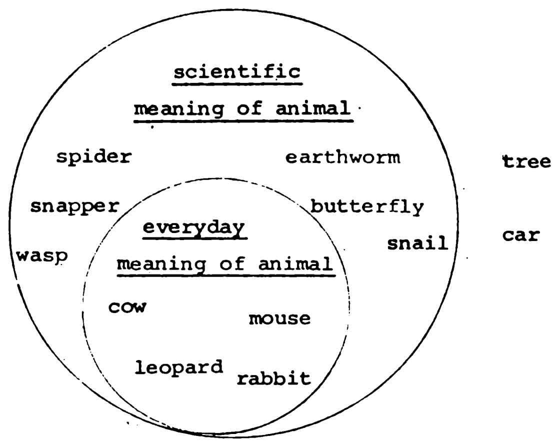
Another way to put animals into groups is to put all the animals of the same kind together. Birds are one group of animals. A tui is a bird and it is also an animal. Mammals are a group of animals. A person is a mammal and an animal. A whale is a mammal and an animal. Insects are another group of animals. A weta and a moth are insects and they are also animals.

We can draw a diagram to show these groups:



Summary

The main ideas we have read about answer the question what is an animal? The word animal has two meanings and we can show the differences between the two meanings in a set and subset diagram:



The everyday meaning refers to only a small number of animals such as a cow and a mouse. The scientific meaning includes the cow and the mouse, and it also includes all the other animals such as a spider and an earthworm. The scientific meaning of an animal is a living thing that eats other animals or plants for food. All animals are consumers. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. Some groups of animals are the fish, birds, mammals, insects, reptiles, and worms.

(Typical text)

WHAT IS AN ANIMAL?

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.2.

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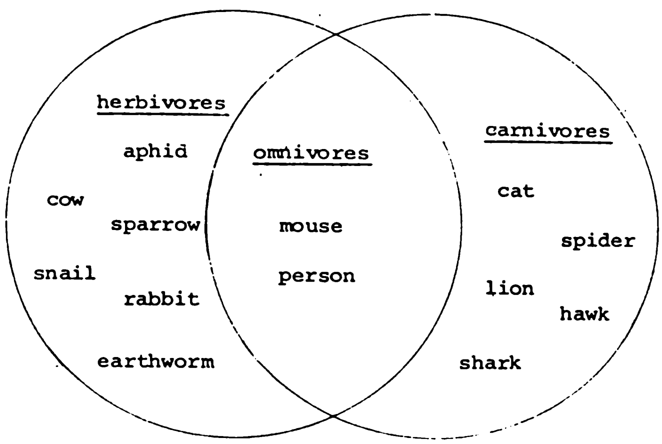


Most of the food required by animals is provided by plants. If there were no plants, there would be no food for the plant-eating animals, and therefore, there would be no food for the animal-eating animals. You can see that there is a simple pattern of eating and being eaten. Green plants use the sun's energy, water, carbon dioxide to make food. Plants are eaten by herbivores. Herbivores are eaten by carnivores. We call this simple pattern a food chain. A food chain is a way of showing the simple pattern of eating and being eaten.
A food chain also shows that living things are dependant on each other for food.
An example of a simple food chain is:

cabbage ⟶ caterpillar ⟶ blackbird ⟶ cat

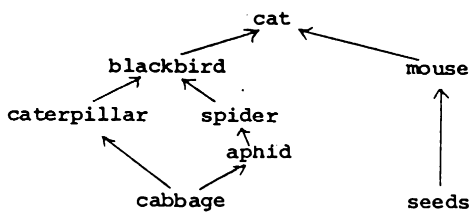
Other food chains may be more complicated. Blackbirds do not feed on only caterpillars. Cats do not feed on only blackbirds. A blackbird or a cat may be mentioned in several different food chains. Examples may be:

seeds ⟶ mouse ⟶ cat

cabbage ⟶ aphid ⟶ spider ⟶ blackbird

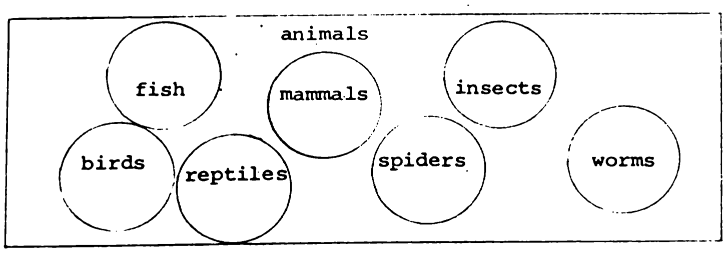
3.

From these food chains a single diagram can be made in which each animal is mentioned only once but some may have more than one arrow going to or from it. This kind of diagram is called a food web diagram. An example of a food web diagram would be:



By studying food chains and food webs, scientists study the way that living things are dependant on each other for food. A piece of native bush is not just a collection of trees, birds, and insects that live together in the same place. Most plants and animals could not live without each other.

Another way to put animals into groups is to put all the animals of the same kind together. Birds are one group of animals. A tui is a bird and it is also an animal. Mammals are a group of animals. A person is a mammal and an animal. A whale is a mammal and an animal. Insects are another group of animals. A weta and a moth are insects and they are also animals. We can draw a diagram to show these groups:



<u>Summary</u>

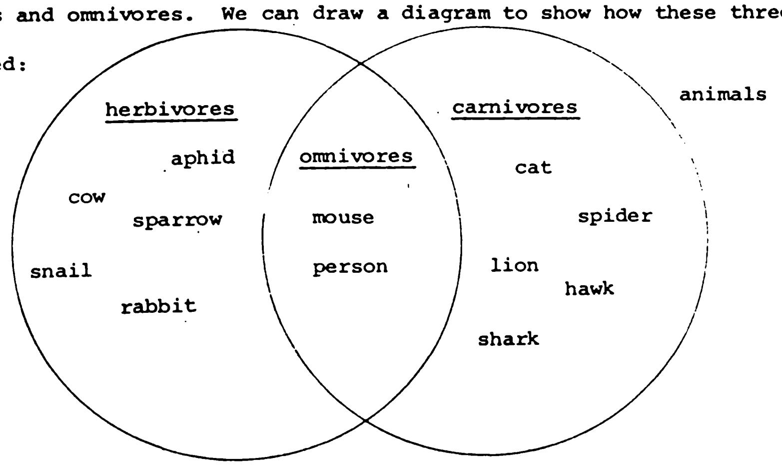
The main ideas we have read about, answer the question <u>what is an animal</u>? An animal is a living thing that eats other animals or plants for food. All animals are consumers. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. Some groups of animals are the fish, birds, mammals, insects, reptiles, and worms.

WHAT IS AN ANIMAL? (Control text)

All living things are either animals or plants. What is an animal? To scientists,animals are those living things that are not plants. Scientists also say that animals are living things that eat other animals or plants for food. A lion, zebra, spider, fly, weta, earthworm, tui, snapper, whale, moth, chicken and sheep are animals. A tree is not an animal as it does not eat other living things. A tree can make its own food using the sun's energy. A car is not an animal as it is not living and it does not eat plants or animals. How do we know if something is an animal? Something is an animal if it is living and if it eats other animals, plants, or their remains for food. Animals are also called consumers. To a biologist, consumers are living things that must eat or consume other living things for food. All animals are consumers of food.

Do all animals eat the same food? No. Some animals eat only plants or parts of plants. Animals that eat only plants are called herbivores. Cows, aphids, earthworms, sparrows, and rabbits are animals and herbivores. Some animals eat only other animals, or their remains, and are called carnivores. Cats, spiders, lions, and sharks are all carnivores. Some animals eat both plants and animals. Animals that eat both plants and animals are called omnivores. People and mice are omnivores.

We have just read how animals can be divided into three groups - herbivores, carnivores and omnivores. We can draw a diagram to show how these three groups are related:



Herbivores may eat two different kinds of plant food. Some herbivores eat the solid food of roots, stems, and leaves. Other herbivores eat the liquid food that is found in plant stems. Herbivores that eat solid parts of the plant often have mouth-parts capable of biting and chewing. Herbivores that eat liquid food have mouth-parts like a tube for sucking up the sap or juices of a plant.

Carnivores also differ in the way they feed. Some carnivores actively seek out the animals they are going to eat, and kill their prey quickly. Other carnivores live inside the body of other animals and feed on the juices. These carnivores are also called parasites.

Most of the food required by animals is provided by plants. If there were no plants, there would be no food for the plant-eating animals, and therefore, there would be no food for the animal eating animals. You can see that there is a simple pattern of eating and being eaten. Green plants use the sun's energy, water and carbon dioxide to make food. Plants are eaten by herbivores. Herbivores are eaten by carnivores. We call this simple pattern a food chain. A food chain is a way of showing the simple pattern of eating and being eaten. A food chain also shows that living things are dependent on each other for food. An example of a simple food chain is:

Cabbage ⟶ caterpillar ⟶ blackbird ⟶ cat

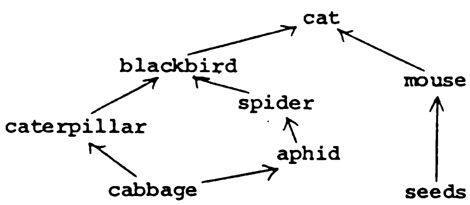
Other food chains may be more complicated. Blackbirds do not feed on only caterpillars. Cats do not feed on only blackbirds. A blackbird or a cat may be mentioned in several different food chains. Examples may be:

seeds ⟶ mouse ⟶ cat

cabbage ⟶ aphid ⟶ spider ⟶ blackbird

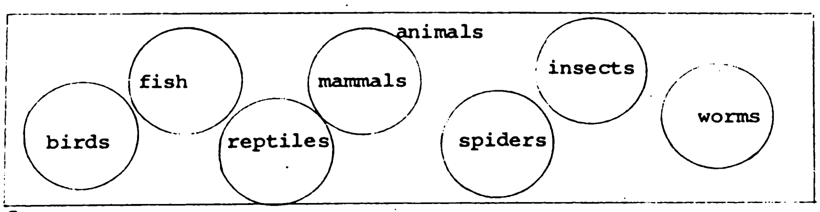
.3.

From these food chains a single diagram can be made in which each animal is mentioned only once but some may have more than one arrow going to or from it. This kind of diagram is called a food web diagram. An example of a food web diagram would be:



By studying food chains and food webs, scientists study the way that living things are dependant on each other for food. A piece of native bush is not just a collection of trees, birds, and insects that live together in the same place. The living things do not live together just because they can put up with each other. The animals and plants are dependant on each other. Most plants and animals could not live without each other.

Another way to put animals into groups is to put all the animals of the same kind together. Birds are one group of animals. Mammals are a group of animals. Insects are another group of animals. We can draw a diagram to show these groups.



<u>Summary</u>

The main ideas we have read about, answer the question <u>what is an animal</u>? An animal is a living thing that eats other animals or plants for food. All animals are consumers. Animals that eat plants are called herbivores, animals that eat other animals are called carnivores, and animals that eat both plants and animals are called omnivores. Some groups of animals are the fish, birds, mammals, insects, reptiles, and worms.

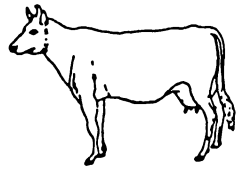
APPENDIX E : THE PRE-SURVEY FOR PHASES I AND II

(Print size reduced by half)

LEARNING IN SCIENCE PROJECT

A Survey of Some Ideas

The following questions are about the word animal.

1. 

Is a cow an animal?

(a) Yes

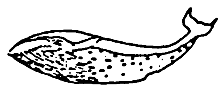
(b) No

2. 

Is a person an animal?

(a) Yes

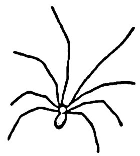
(b) No

3. 

Is a whale an animal?

(a) Yes

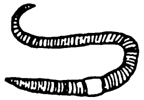
(b) No

4. 

Is a spider an animal?

(a) Yes

(b) No

5. 

Is a worm an animal?

(a) Yes

(b) No

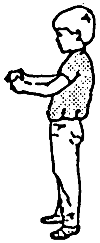
The following questions are about the word <u>living</u>.

5. 

Is a fire living?

(a) Yes

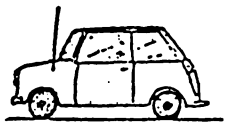
(b) No

7. 

Is a person living?

(a) Yes

(b) No

8. 

Is a moving car living?

(a) Yes

(b) No

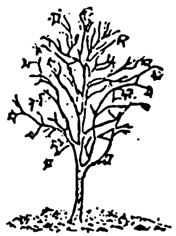
The following questions are about the word <u>plant</u>.

9. 

Is a carrot a plant?

(a) Yes

(b) No

10. 

Is a tree a plant?

(a) Yes

(b) No

APPENDIX F : THE PHASE II POST-SURVEY

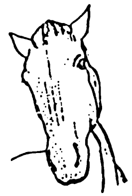
(Print size reduced by half)

LEARNING IN SCIENCE PROJECT

A Survey of Some Ideas

The following questions are about the word animal.

1.

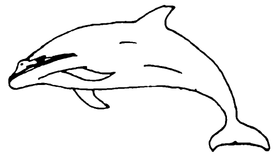


Is a horse an animal?

(a) Yes

(b) No

2.

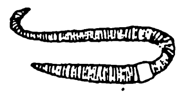


Is a dolphin an animal?

(a) Yes

(b) No

3.



Is a worm an animal?

(a) Yes

(b) No

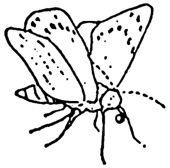
4.

Is a person an animal?

(a) Yes

(b) No

5.



Is a butterfly an animal?

(a) Yes

(b) No

The following questions are about the word <u>living</u>.

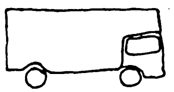
7.

Is a candle flame living?

(a) Yes

(b) No

8.



Is a truck living?

(a) Yes

(b) No

9.

Is a person living?

(a) Yes

(b) No

The following questions are about the word <u>plant</u>.

9.

Is a pine tree a plant?

(a) Yes

(b) No

10.

Is a parsnip a plant?

(a) Yes

(b) No

APPENDIX G : THE PHASE III SURVEYS

(Print size reduced by half)

(Pre-survey)

NAME _ _ _ _ _ _ _ _ _ _ _ _ _

CLASS _ _ _ _ _ _ _ _ _ _ _ _

Which of these would a scientist call an animal?

Put a circle around the Yes or the No to show your answer.

Is it an animal?

1.	horse	Yes	No
2.	guinea pig	Yes	No
3.	dolphin	Yes	No
4.	earthworm	Yes	No
5.	candle	Yes	No
6.	peach tree	Yes	No
7.	thrush	Yes	No
8.	sandfly	Yes	No
9.	cabbage	Yes	No
10.	tiger	Yes	No
11.	stone	Yes	No
12.	person	Yes	No
13.	parsnip	Yes	No
14.	duck	Yes	No
15.	truck	Yes	No
16.	slug	Yes	No
17.	dog	Yes	No
18.	grass	Yes	No
19.	stereo	Yes	No
20.	spider	Yes	No

NAME _____________

(Post and post-post surveys) CLASS _____________

Put a circle around the Yes or the No to show your answer.

Is it an animal?

1.	lion	Yes	No
2.	cat	Yes	No
3.	lettuce	Yes	No
4.	snail	Yes	No
5.	carrot	Yes	No
6.	car	Yes	No
7.	earthworm	Yes	No
8.	person	Yes	No
9.	spider	Yes	No
10.	butterfly	Yes	No
11.	grass	Yes	No
12.	cow	Yes	No
13.	rock	Yes	No
14.	fly	Yes	No
15.	sparrow	Yes	No
16.	lizard	Yes	No
17.	whale	Yes	No
18.	rabbit	Yes	No
19.	chicken	Yes	No
20.	fire	Yes	No

Please turn over to the next page......

<u>Is it an animal?</u>

21.	opossum	Yes	No
22.	frog	Yes	No
23.	grasshopper	Yes	No
24.	snake	Yes	No
25.	oyster	Yes	No
26.	radio	Yes	No
27.	deer	Yes	No
28.	wasp	Yes	No
29.	caterpillar	Yes	No
30.	blackbird	Yes	No
31.	chimpanzee	Yes	No
32.	seagull	Yes	No
33.	mosquito	Yes	No
34.	apple tree	Yes	No
35.	seal	Yes	No
36.	cricket	Yes	No
37.	flounder	Yes	No
38.	octopus	Yes	No
39.	elephant	Yes	No
40.	bee	Yes	No

41. You are a scientist and someone asks you '<u>what is an animal?</u>' What would you say to answer the question?

APPENDIX H : A FURTHER QUALITATIVE INVESTIGATION IN PHASE III

The quantitative survey was not intended, and therefore not designed, to elicit information as to the thinking of the students while they were answering the surveys. A small scale study was undertaken to investigate the rationale and thinking of some students, who had completed a reading-to-learn task and the two surveys.

Sample

As the main sample was to be retested after one month, a separate sample was used to elicit the additional information. The details of this small sample are given in Table 34. These students, like the main sample, were third formers who had not done class work on 'animal'. They had all (except Student 356) scored average results (Level scores 7, 8) on the P.A.T comprehension test, which had previously been administered by school personnel for school use. On a pre-survey, administered by the researcher to the whole class, they had all used a non-scientific meaning of the word 'animal', with respect to exemplars and characteristics. All nine students were members of the one science class.

Methodology

Each student was interviewed on a one-to-one basis in a small book room, during a timetabled science lesson. First, the student was encouraged to recall the pre-survey done by the whole class. Then, the researcher discussed briefly her or his answers on the pre-survey, in that, the meaning of the word 'animal' used by the student was slightly different to the meaning used by scientists. The student was then asked to read the text to learn how a scientist would answer the question 'What is an animal?'. Each student was alerted to the follow-up questions (the post survey), and then given as long as she or he wanted to read the pages.

TABLE 34: Information about the Small Study Sample, (N=8), in Phase III

Pre-survey

Student code	PAT Level Score	Is it an animal? Cow	Person	Whale	Spider	Worm	Main category of reasons for answers: other group	legs	warmblood	habitat	brain	feeds,breathes	Text Read
350-M	8D	✓	×	×	×	×		✓		✓	✓	✓	1
351-M	7D	✓	×	×	×	×	✓	✓		✓			2
352-F	8D	✓	✓	×	×	×	✓	✓					1
353-F	7B	✓	✓	×	×	×	✓	✓					2
354-F	8D	✓	✓	✓	×	×	✓	✓				✓	3
355-F*	8E	✓	✓	×	×	×	✓						3
356-M	10C	×	×	×	×	×	✓						1
357-M	8D	✓	×	×	×	×		✓	✓				2
458-M	8D	✓	×	×	×	×	✓					✓	2

Key ✓ Yes

x No

*Student 355 was interviewed on 2 separate occasions as the lunch break cut short the first interview.

Most of the nine students took approximately five minutes to read the text and did so only the once. Each student was required to read only one version of the texts (either Text 1, 2 or 3). Text 4 was not used as it was similar to Text 3 in that it was a control. As the quantitative Phase III study indicated less learning occurred with Text 2, more students were asked to read this one to ascertain why some students found this text less helpful for their learning. On completion of the task, they were asked to complete the post-survey. They were then interviewed on their choice of answers in the post-survey; on their understanding of the key sentences; on whether the text information made sense to them (i.e. a status probe); and on which parts of the text were most helpful in learning the scientific meaning of animal. The reading-to-learn task was similar to that done by students in the larger sample in that the task was uninterrupted and accompanied by immediate pre- and post-survey measures. Each interview and task took approximately thirty minutes. The interviews were audiotaped with the consent of each student and transcribed for analysis.

Results

The results of the post-survey are given in Tables 35 and 36. Three students (350, 352,356) learnt the scientific meaning of animal and used it to answer the post-survey.

Two students (351, 358) did likewise except for the oyster question.

Four students (353, 354, 355, 357) did not answer the post-survey as would a scientist on a varying number of questions.

TABLE 35: The Results of the Post-Survey in the Small Study, Phase III

Is it an animal to a scientist?

Student Code	lion	cat	lettuce	snail	carrot	car	earthworm	person	spider	butterfly	grass	cow	rock	fly	sparrow	lizard	whale	rabbit	chicken	fire	opossum	frog	grasshopper	snake	oyster	radio	deer	wasp	caterpillar	blackbird	chimpanzee	seagull	mosquito	apple tree	seal	cricket	flounder	octopus	elephant	bee
350	√	√	x	√	x	x	√	√	√	√	x	√	x	√	√	√	√	√	√	x	√	√	√	√	√	x	√	√	√	√	√	√	√	x	√	√	√	√	√	√
351	√	√	x	√	x	x	√	√	√	√	x	√	x	√	√	√	√	√	√	x	√	√	√	√	x	x	√	√	√	√	√	√	√	x	√	√	√	√	√	√
352	√	√	x	√	x	x	√	√	√	√	x	√	x	√	√	√	√	√	√	x	√	√	√	√	√	x	√	√	√	√	√	√	√	x	√	√	√	√	√	√
353	√	√	x	x	x	x	x	x	√	x	x	√	x	x	√	√	x	√	√	x	√	√	x	x	x	x	√	x	x	√	√	√	x	x	x	x	x	√	√	x
354	√	√	x	x	x	x	√	√	x	x	x	√	x	√	√	√	√	√	√	x	√	√	x	x	x	x	√	x	√	√	x	√	x	x	√	x	x	√	x	x
355	√	√	x	x	x	x	x	-	√	√	x	√	x	√	√	√	-	√	√	x	x	√	√	√	x	x	√	-	√	√	√	√	x	x	√	-	-	√	√	-
356	√	√	x	√	x	x	√	√	√	√	x	√	x	√	√	√	√	√	√	x	√	√	√	√	√	x	√	√	√	√	√	√	√	x	√	√	√	√	√	√
357	√	√	x	√	x	x	√	√	√	x	x	√	x	x	√	√	√	√	√	x	√	√	x	√	x	x	√	x	x	√	x	√	√	x	√	x	√	√	√	x
358	√	√	x	√	x	x	√	√	√	√	x	√	x	√	√	√	√	√	√	x	√	√	√	√	x	x	√	√	√	√	√	√	√	x	√	√	√	√	√	√

Key √ Yes x No
\- No answer

TABLE 36: Results of Q41 on the Post Survey for the Small Study, Phase III

Ideas in the Written Response

Student Code	Eats other living things	Consumer	Not a plant	Herbivores, etc.	Characteristics of living things	Groups of animals	Examples	Non-examples	Partially incorrect	Everyday characteristics
350	✓		✓							
351	✓					✓				
352	✓									
353	✓									
354								✓	✓	
355	✓									
356	✓									
357	✓						✓			
358				✓				✓		

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