UNIVERSITY OF SOUTHAMPTON

FACULTY OF LAW, ARTS AND SOCIAL SCIENCES

School of Education

ADOLESCENT DECISION-MAKING ABOUT BIOLOGICAL CONSERVATION ISSUES

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ABSTRACT

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by Marcus Matthew Grace

The conservation of biodiversity is an important socio-scientific issue, often regarded as a precondition to sustainable development. Effective conservation management requires joint consideration of the underlying scientific concepts and closely connected human values. The foundation for citizens' understanding of conservation issues is laid down in formal school education.

This research focuses on the views of 15-16 year old pupils about the importance of biological conservation, explores the concepts and values they draw upon during semi-supported decision-making discussions, and attempts to identify features of high quality discussions that science teachers might recognize and nurture in their classrooms. Findings reveal how important pupils regard the extinction of species in relation to economic development, and where they draw the line in conserving different types of living organisms. Some of these views appear to be gender-related. Results also indicate the realistic and positive value of having pupils take part in short decision-making discussions about conservation issues, guided by a structured framework, as part of their normal science classroom activities. Pupils increase their quality of argumentation, and modify their solutions to the issues. The study also begins to uncover features about pupils, as individuals and as members of discussion groups, which can be associated with high quality decision-making about conservation issues, and which teachers might realistically identify. The work calls for the need to cultivate these features, and integrate them appropriately with learning about the scientific concepts that underpin the theory and practice of conservation management. Such integration will facilitate the development of teaching strategies for dealing effectively with the complex topic of biological conservation; not just in terms of content, but in terms of how pupils are expected to engage with the issues.

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Marcus Grace
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Chapter 1 Introduction

1.1 Pupils making decisions about biological conservation issues

Thoughtful decision-making about conservation[1] issues, requires us to draw on relevant scientific knowledge, and the values which shape our attitudes towards the issues, and also calls for systematic consideration of possible alternative solutions to the issues. School can provide an opportunity for pupils to engage in informed decision-making activities, which can equip them with the means to handle decision-making challenges in adult life.

15/16 year olds were selected for this study because they were nearing the end of their compulsory schooling and as such had completed a substantial part of the science curriculum. Many would never study science again in a formal sense, and may consequently have limited opportunities to further their science subject knowledge. At this age, they may still be forming opinions on issues such as conservation. They may be mature enough to appreciate some of the complexities of the issues, but not sufficiently informed or prejudiced to be committed to particular ideologies.

The study aims to provide information about how pupils of this age view conservation issues and engage in decision-making about such matters, by exploring their use and integration of personal values and the essential biological concepts underpinning conservation management. The work attempts to use this information to identify features of high quality decision-making discussions about conservation. The research follows a survey approach to gather baseline data about their views on the importance of conservation, and then a case study approach to explore their values and conceptual understanding, and aspects of peer group interaction, without any specific additional teaching or intervention. Researchers in this field of science education (e.g. Osborne *et al.*, 2001a) have advanced the view that rational and analytical thought can be demonstrated by the way in which individuals change their ideas and actions; and that this change in one's thinking is only possible if there are opportunities to externalise that

[1] Throughout this thesis the word 'conservation' is used to mean 'biological conservation'.

thinking, and expose one's beliefs to scrutiny by others. This can only take place effectively by engaging pupils in some kind of discussion, and it is for this reason that the main focus of activity in this study involves pupils working in small discussion groups.

Gaining insights into these aspects of their deliberations could have valuable implications for science curriculum development in this area; particularly in the development of strategies that allow appropriate teacher intervention in managing class decision-making. Such strategies might take into account the curriculum order of biological concepts, the significance of values considerations, and the complexity of conservation issues. It would be particularly useful if we could identify indicators of 'high quality' argumentation or decision-making, which could be promoted, nurtured and evaluated by teachers.

Education for sustainable development is now part of the statutory National Curriculum for Science in England and Wales, which states that

> *...science provides opportunities to promote... education for sustainable development, through developing pupils' skills in decision making on the basis of sound science...* (QCA, 1999: 9)

However, despite the powerful rhetoric from central government in support of the Convention on Biological Diversity, and the importance of biodiversity in underpinning sustainable development, it is curious, and in my view regrettable, that the science curriculum does not include the terms 'conservation' or 'biodiversity'. It is therefore useful to explore how pupils, nearing the end of their compulsory schooling, handle decision-making discussions about conservation issues. Although pupils' reactions to environmental matters in general have been explored (e.g. Gayford, 1993; Rickinson, 2001), little is known about pupils' views and treatment of biological conservation issues. Values and scientific knowledge are intertwined in making judgements, and this interaction should be explored explicitly in formal education if we are to produce scientifically literate citizens.

1.2 Research focus

The specific research questions in this study are:

1. *How important do pupils regard biological conservation as being?*
2. *What biological concepts do pupils draw on in making decisions about conservation?*
3. *What values do pupils draw on in making decisions about conservation?*
4. *Are there recognizable features that characterize high quality group discussions about conservation?*

To address these research questions it is important to consider:

- The nature of biological conservation as a socio-scientific issue (i.e. as a science-based issue which has a potentially large impact on society). Recent changes to the science National Curriculum for England have strengthened the importance of socio-scientific issues. They are inevitably multi-faceted in nature, and often also have political, economic, technological, cultural and ethical dimensions. Conservation of the world's diversity of organisms and genetic resources is a particularly emotive socio-scientific issue, affecting (and affected by) human social and economic development, and it can be regarded as a precondition for sustainable development. The complex nature of biological conservation as a socio-scientific issue is discussed in chapter 2. To explore how people make decisions about conservation issues, it is necessary to define what we mean by the terms 'concepts' and 'values', and to have an appreciation of their understanding and views on the importance of conservation (as a part of environmental protection) in relation to the other complementary component of sustainable development – socio-economic development. This is also discussed in chapter 2.
- The educational context
  The pupil activities supporting this research take place (entirely and intentionally) within the context of the school science classroom, to deliberately emphasise the important part that science might have to play in socio-scientific matters.

The educational context is explored further in chapter 3, including:

- biological conservation within the National Curriculum framework
- approaches to teaching about conservation issues in schools
- pupils' understanding of and views about conservation issues.

- The processes of decision-making, argumentation and discussion and their place in the science classroom.

  The nature of group deliberations is explored in Chapter 4, and this includes a review of theoretical models that aim to measure quality of verbal discourse, and their use in the science classroom situation. The chapter also considers other aspects of group behaviour as possible indicators of group productivity.

1.3 Research methodologies

Chapter 5 gives the background to the research design, locating most of the research within a case study paradigm, and gives details of data collection methods used in the study. It provides a rationale for taking a descriptive case study approach to the research and the reasons for focusing on this particular age group in unsupported peer group discussions. A pilot study was undertaken prior to the main enquiry, and the findings from this are examined to provide a rationale for the methodology used in the main study. Figure 1.1 outlines the overall research design, and locates the research questions as an organizing device for the thesis.

The chapter then describes the research methodology used in the main study, and is divided into sections that relate to the four research questions. The first part addresses the first research question, describing a questionnaire survey which sought the views of 405 pupils (15/16 year-olds) on how important they regard the extinction of species in relation to economic development, and where they draw the line in conserving different types of living organisms. The second part relates to the other research questions, for which data was collected from the case study of 131 pupils directly engaged in decision-making discussions in a classroom situation. This data was collected in five phases:

1. A *pre-test questionnaire* asking pupils for their personal view of solutions to selected conservation issues.

2. *Audio-taping* these pupils in peer-groups while engaged in conservation decision-making discussions, in conjunction with a decision-making framework.

3. A *post-test questionnaire* immediately after the discussions asking pupils to re-state their personal views in order to gauge changes resulting from the peer-group discussions.
4. A *final questionnaire* at the end of pupils' compulsory schooling having completed the whole science curriculum (about a year after the decision-making activities), to see if their views on the issues had changed in the longer term, and to ask which areas of science they regarded as important in helping to make decisions about conserving animals.
5. A *semi-structured interview* with pupils to explore memories of the discussions in terms of issues discussed, decisions made, the decision-making framework they used, views of peers and the scientific concepts drawn upon.

This part of the chapter also gives details of the methods used to seek the views of science teachers and conservation 'experts', regarding the essential biological concepts that underpin conservation education. This data provides the background of expectations against which pupils' actions might be measured. The final part concentrates on the fourth research question, which is at the heart of the enquiry, namely:

Are there recognizable features that characterize high quality group discussions about conservation?

It describes the methodology used to further explore how the peer-groups engage in the decision-making process, with a particular focus on identifying features of high quality argumentation as part of the decision-making process, and other aspects of group behaviour, which could be identified and cultivated by science teachers.

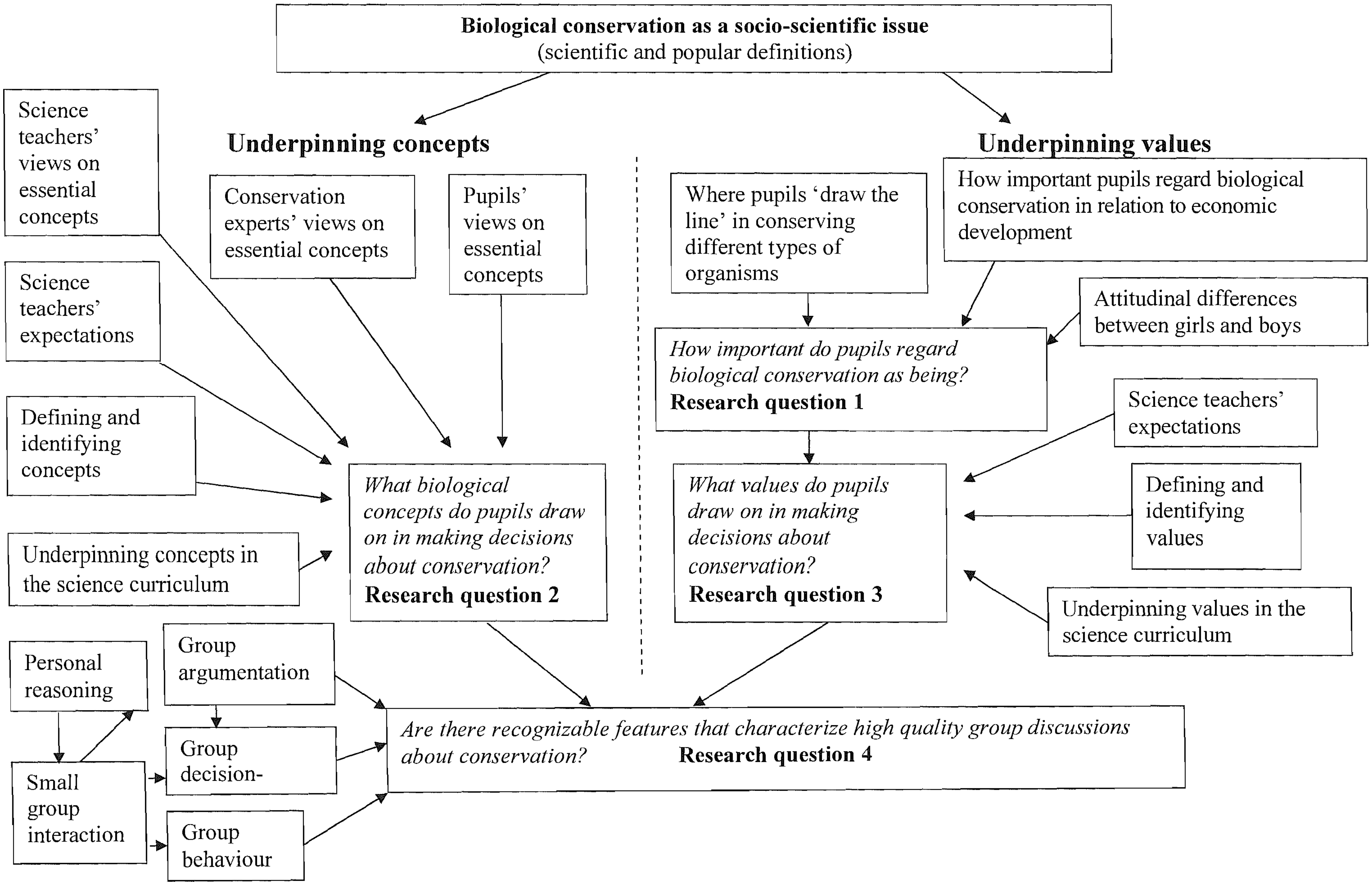
1.4 Research outcomes

Chapters 6, 7 and 8 present the results of the analysis of the research questions in order. Chapter 6 addresses pupils' views on the importance of conservation in relation to economic development (research question 1). Chapter 7 focuses on the science concepts and chapter 8 on the values that pupils draw on in making decisions about conservation issues (research questions 2 and 3). Chapter 9 then concentrates the effects of the discussions on personal reasoning, and how pupils engage in peer-group decision-making while discussing conservation issues, and explores some possible features indicative of high quality decision-making discussions about conservation (research question 4).

Chapter 10 attempts to examine the main findings in the preceding chapters of the study in relation to the research questions, compares these to findings in other studies, and considers the characteristics of high quality argumentation and decision-making, which could be recognized and promoted by teachers. The chapter ends by briefly discussing limitations of the design of the study.

Chapter 11 concludes the study by focussing on contributions the research makes to group discussion theory, and to conservation education theory, and makes recommendations for further research.

Figure 1.1 Organizing device for the thesis: an outline of the research design for the main study



Chapter 2 Biological conservation as a socio-scientific issue

> *Will it ever be possible to assess the ongoing loss of biological diversity? I cannot imagine a scientific problem of greater immediate importance for humanity.* E. O Wilson (1992: 254) The Diversity of Life

Introduction

Species extinction is a natural part of the evolutionary process; but due to human activities, species and ecosystems are more threatened today than ever before in recorded history. The *Millennium Ecosystem Assessment*, a recent and very large-scale research report (Millenium Assessment Board, 2005: 30) involving 1,300 leading scientists from 95 countries predicts with 'high certainty' a continued loss in local diversity of native species over the next fifty years. This accelerated rate of extinctions has environmental, economic, social, cultural and political implications. This chapter discusses the importance of biological conservation, and how it is defined both within the scientific community and by non-scientists at local, national and global levels, to help clarify its significance as a socio-scientific issue. For the purposes of this research, I am viewing socio-scientific issues as *issues that have a basis in science, whilst having a potentially large impact on society.* They are unavoidably multi-faceted, with closely intertwined environmental, economic and social dimensions, and this renders them controversial in nature. Real conservation issues involve a tension between protection of biological resources and socio-economic needs. Wellington (1986:149) stressed that a consideration of values is a fundamental facet of controversial issues, claiming that such issues

> *...cannot be settled by facts, evidence or experiment alone.*

The chapter therefore considers the importance of science knowledge in conservation education, and also attempts to define and categorize values that people (pupils in the context of this study) might draw upon when engaged in discussion about conservation issues. It ends with consideration of the connections between relevant knowledge, values, attitudes and behaviour, as some people misjudge the extent to which these are causally related.

2.1 The nature and importance of biological conservation

Conservation of the world's diversity of organisms and genetic resources is an emotive environmental issue involving some tough decisions about what and how to conserve. It inevitably affects (and is affected by) human social and economic development, and can be regarded as a precondition for sustainable development (Solbrig, 1991). Successful biological conservation management programmes depend on an understanding of the biology of the organisms concerned and how they interact with their surrounding environment, but as with all socio-scientific issues, politics, economics and cultural aspects also play an important role in this decision-making process. Some professional biologists believe that cultural, aesthetic or utilitarian values are in fact more important than biological factors in deciding conservation priorities (Spellerberg, 1996). Environmental issues are thus socially constructed, and even professionals are not always able to agree on approaches to conservation. However, this is not necessarily a problem, and the use of a variety of management techniques is sometimes considered desirable, as long as they are each carefully trialled and evaluated (Yaffee, 1999).

Conservation biology, in theory and in practice, is essential in conserving the Earth's biological diversity (biodiversity), by informing conservation management planning (Kohm, 2000). Conservation programmes that make a positive contribution to the conservation of biodiversity are well documented (e.g. Bruner *et al.*, 2001; McKinney, 2002; Brandon and Wells, 1992). However, the total number of species in the world is still not known with accuracy. There are estimates ranging from 3-10 million (May, 1990) to 50-100 million (Wilson, 1992). A United Nations Environment Programme (UNEP) report based on independent, critical peer-reviewed, scientific analysis estimated that the total was 13 to 14 million, of which only 13 per cent, or some 1.75 million, have been scientifically described. It also noted that the number of species that have been recorded as threatened with extinction is greatly underestimated, and the status of most of the described species - let alone the many millions of undescribed species - has never been fully assessed. Vertebrate animals and flowering plants have recently become extinct at a rate estimated to be 50 to 100 times the average expected natural rate (UNEP, 1995). Whatever the actual figures, there is no doubt that some biological resources are being critically threatened. Spellerberg and Hardes (1992) among others argue that we should not focus only on species conservation, but that it is the variety at different biological levels that is so important, and that this needs to be made clearer to a wider audience (these levels are shown in more detail in section 2.2.1.2). They view the conservation of biodiversity as important in ensuring that:

1. Our life support systems are sustained.
2. We use genetic variation to develop new strains or varieties of food crops or breeds of farm animals, while conserving wild populations.
3. We use living resources in a sustainable manner.
4. Future generations will enjoy the same or better levels of biological diversity than present generations.

The aim of biological conservation is thus to maintain the diversity of living organisms, their habitats and the interrelationships between organisms and their environment. Whether this goal can be realistically achieved and how it should be achieved is a matter of great debate. It is a complex field and not surprisingly there are differences of opinion about such matters as definitions of species, the relative value of species, numbers of organisms, rates of extinction, and implications for future generations.

Ecosystems of all kinds are under pressure worldwide, and we have now grown accustomed to media reports about the decline and even extinction of species – familiar or obscure, in local or in distant places.

The first major international initiative that helped shape and develop consensus among scientists, and bring biodiversity conservation issues to the attention of the public was the World Conservation Strategy (IUCN, 1980). It emphasised the importance of maintaining biological diversity and reducing environmental damage to species and their habitats. The strategy's three main objectives of living resource conservation were:

1. to maintain essential ecological processes and life-support systems;
2. to preserve genetic diversity;
3. to ensure the sustainable utilisation of species and ecosystems.

It was clear therefore, even more than twenty years ago, that aspects of genetics and evolution are as important as the ecological components of conservation. These objectives have since been endorsed by subsequent international conventions and reports on biological conservation, notably the 1992 Convention on Biological Diversity, and the 1995 UNEP Global Biodiversity Assessment which provided statements about the value and importance of biological conservation (more details of this are given in appendix 2.1).

While scientists and environmental organisations have long appreciated the need for biodiversity conservation, the issue only reached the global political agenda when over 150 countries ratified the Convention on Biological Diversity at the Earth Summit in 1992. This committed governments to developing and implementing national plans for conserving biological diversity and using biological resources sustainably. The Convention argues that biodiversity is valuable because

> *...future practical uses and values are unpredictable, because variety is inherently interesting and more attractive and because our understanding of ecosystems is insufficient to be certain of the impact of removing any component.* (Glowka *et al.*, 1994: 2).

In response to the 1992 Earth Summit, the UK Government published action plans for sustainable development (HMSO, 1994a) and biodiversity (HMSO, 1994b), highlighting the importance of making decisions based on the best possible scientific information, and increasing people's awareness of the part that their personal choices can play in delivering sustainable development. At the World Summit in 2002, the international community reaffirmed its commitment to the Convention, undertaking to significantly reduce rates of loss of biodiversity by 2010 (DEFRA, 2002).

As a science-based area of study, biological conservation includes aspects of ecology, genetics, taxonomy and biogeography. It provides us with a basis for management of ecosystems, habitats and living organisms, which all affect human quality of life. However, ecological research does not lead directly to conservation measures since the issues are set within the context of human society. This interdisciplinary focus plays an important role in shaping our view of biological conservation and new disciplines such as ecological economics are emerging which provide serious attempts to bridge the gap between science and policy (Barbier *et al.*, 1994; Swanson, 1998).

So, biological conservation is bound to interact with the diverse, often conflicting interests of complex human society, and it must draw knowledge and skills from other disciplines such as the physical sciences, engineering, sociology, economics, political science and law (Brussard, 1991). In order to protect an endangered species, conservationists have to work in a real-world context of laws and institutions that govern the day-to-day operation of society (Cox, 1993). They need to understand the ways in which human activities are likely to affect other species, and how conservation efforts can be realistically carried out within the constraints of the laws, funds available and public opinion. For example, as wildlife becomes increasingly squeezed into more intensively-managed areas, the culling of species is becoming more widely accepted as a necessary component of conservation programmes (Pinchin, 1994).

A multi-disciplined approach to conservation is vital, but little progress will be made without a fundamental understanding of the *biology* of the species concerned.

2.2 Difficulties with the term 'conservation'

The term 'conservation' has become widely used in many different contexts, which has resulted in a confusing variety of meanings. The spectrum of views and attitudes towards conservation now embraces politics, economics, law, education, culture and religion. Conservationists have been variously regarded as extremists of danger to society (Clark, 1993) or to themselves (Day, 1989), as members of a harmless, tree-hugging, sandal-wearing macrobiotic culture (Coward, 1990), or as managers of the Earth and its natural resources (Pepper, 1996). Similar confusion arises over the definition of the terms 'environment' and 'ecology' and their derivatives. Use of the prefix 'eco' (as in eco-friendly and eco-tourism) has served to undermine the integrity of ecology as a science and the importance of biological conservation, which is based on science (Spellerberg, 1996).

The meaning of the word 'conserve' in its broadest sense is described in the Chambers English Dictionary as

> *to keep entire: to retain: to preserve…as fruits in sugar…*
>
> (Chambers, 1989: 303).

Clearly the close meaning of the words 'conserve' and 'preserve' is understandable, at least to lay observers, in the areas of preserving fruit, or restoring and protecting paintings or other historical artefacts. However, it is important to differentiate between the two in the current environmental or biological sense, because they refer to fundamental differences in human attitudes, values and ethics. *Preservation* is the protection of nature and wildlife in static situations with minimal human intervention; whereas *conservation* implies that there is human intervention in the form of active management (Connelly and Smith, 1999; Stoett, 1997).

Enger and Smith (1991: 32) believe that people's environmental attitudes fall into one of three main categories: the development ethic, the preservation ethic and the conservation ethic. Each has its own

> *...code of conduct against which ecological morality may be measured.*

The development ethic seeks to maximise economic growth regardless of environmental damage, and strives to exploit the Earth's resources for the benefit and pleasure of the human race. The preservation ethic considers that nature is intrinsically special in itself. Different preservationists have different reasons for preserving nature. Some have an almost religious view, holding a reverence for life and respecting the right of all creatures to live, regardless of the social and economic costs. Other preservationists have an interest in the environment that is primarily recreational or aesthetic, believing that the environment is beautiful and refreshing and should be available for such pursuits as fishing, hiking, picnicking or just peace and quiet. Also included among preservationists are those whose reasons are essentially scientific, with a view that humans depend on and have much to learn from nature. All species and ecosystems, whether rare or common, should be preserved because of their known or assumed practical utility.

The third environmental ethic is the conservation ethic, which aims to strike a balance between uncontrolled development and absolute preservation. It extends the view of the scientific preservationists to consider the whole earth and for the indefinite future. It recognises the need for human quality of life, but seeks a balance between resource consumption and resource availability.

Today, these preservationist and conservationist ethical stances have manifested themselves as the 'deep ecology' and 'social ecology' movements respectively. The deep ecology movement represents an extreme example of preservationists, with a radical approach to environmental conservation and consequent controversy.

Devall and Sessions (1985) state the principles of the deep ecology movement as follows:

1. Humans have no right to reduce the richness and diversity of life except to satisfy vital needs.
2. The quality of human life and culture is compatible with a substantial *decrease* in the human population.
3. The flourishing of nonhuman life requires such a decrease.

One deep ecology organisation, *Earth First!,* achieves its preservationist goals through 'direct action'. Its promotional manual states:

> *...we do not believe that it is enough to preserve some of our remaining wilderness. We need to preserve it all, and it is time to recreate vast areas of wilderness in all the planet's ecosystems: identify key areas, close roads, remove developments, and reintroduce extirpated wildlife.* (Earth First!, 1998: 1)

The manual contains detailed information on so-called 'monkey-wrenching' techniques aimed at disrupting the work of land developers, such as sabotaging heavy machinery and spiking trees to damage saws.Social ecologists by contrast advocate a political solution to environmental issues, based on democratic socialism. They believe that solutions can only be found by tackling human ignorance and greed, redistributing wealth and food resources, and reforming human institutions through the political process (Enger and Smith, 1991). There are of course many variations on these ethical themes, but this discussion emphasises the range of attitudes people might bring into an environmental decision-making activity before the underlying scientific principles are even considered.

There are also difficulties with the term 'environmental conservation'. The 'environment' is often interpreted as meaning the natural environment, the environment as it existed before it was modified by human activities. However, very little of the familiar environment around us has remained free from human influence. In Britain, this is obvious in an urban setting and in farming landscapes, but less so when observing most forests, heathland and moorland which are also entirely human-created environments. The term 'environment' is now generally extended to include both natural and human environments; both are an important part of people's life and culture. The term 'environmental conservation' is similarly broad and generally refers to the protection of natural and human environments from damage. Conservation of historical and heritage sites, towns, buildings and urban open spaces is valued just as much as ancient woodlands or unimproved meadows.

2.2.1 Difficulties with the terms 'biological conservation' and 'biodiversity'

2.2.1.1 The popular view

Brussard *et al.* (1991) suggested that the term 'wildlife' should be used in the public domain rather than 'biodiversity' and that the two should be synonymous. They argued that 'wildlife' had a familiar meaning to almost everyone and that few people knew what 'biodiversity' meant, and were unlikely to in the near future. This remains the case in Britain a decade on, despite the UK Biodiversity Action Plan (DEFRA, 2002).

The popular view of biological conservation is one of protecting well-known animal species such as elephants and pandas, or exotic plants such as orchids, or perhaps the well-publicised threatened ecosystems such as rainforests. There has also been a recent focus on the conservation of urban green spaces and parks (Palmer, 1998). Spellerberg and Hardes (1992) asked 13-19 year olds for a definition of biological conservation, and found that there was some confusion between biological conservation and environmental conservation. 26 per cent of respondents said that it was about protecting the environment and natural habitats; 14 per cent protecting animals and plants; 10 per cent protecting threatened or endangered species; and 6 per cent preventing damage to natural areas.

While the terms biological conservation and biodiversity can mean many things to many people, it is important to adopt a precise, science-based meaning in order to facilitate policy formulation and decision-making at governmental levels. The following section outlines definitions of biological conservation proposed by scientists working in this field.

2.2.1.2 The scientific view

The applied objective of biological conservation today is to conserve biodiversity, but there has been a noticeable change in emphasis in conservation in recent times. Thirty years ago the emphasis was mainly on conservation of species, particularly plants, birds and some of the larger mammals. Fifteen years ago the emphasis was on conservation of habitats rather than species, ten years ago on entire ecosystems, and now on biological diversity. Spellerberg and Hardes (1992) describe various levels of conservation, of which biological conservation is one as shown in figure 2.1 below.

Figure 2. 1. Levels of conservation in order of increasing scale (after Spellerberg and Hardes, 1992)

Biosphere conservation

↑

Environmental conservation

↑

Biological conservation → levels of biological conservation: genetic material, gene pools, plant/animal populations, species, habitats, communities, ecosystems

↑

Nature conservation

↑

Bird conservation

The term 'biological diversity' has existed since the early 1980s. The zoologist Edward O. Wilson, played a significant part in bringing the concept of biodiversity into the public domain through his highly celebrated book *The Diversity of Life*, in which he defined biodiversity as:

> *The variety of organisms considered at all levels, from genetic variants belonging to the same species through arrays of species to arrays of genera, families and still higher taxonomic levels; including the variety of ecosystems, which comprise both communities of organisms within particular habitats and the physical conditions under which they live.* (Wilson, 1992: 393).

It has been suggested that this definition could be expanded to include other levels of biological organisation, from a molecular level to cultivars, breeds, populations, habitats, communities, and possibly even biogeographical units such as biomes. The definition is also sometimes extended to include interactions between species and ecosystem processes (Spellerberg, 1996).

Biological diversity was defined by the 1992 Convention on Biological Diversity as:

> *The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species and of ecosystems.* (Glowka *et al.*, 1994: 2)

This definition has become widely adopted around the world since the 1992 Earth Summit (see section 2.1).

In the 'scientific' sense, conservation of biodiversity therefore means conserving variety, and this encompasses the full range of variety at all levels, i.e. from conserving genetic variety to conserving biogeographical regions. Reference to biodiversity should therefore be qualified by specifying the particular level of biodiversity under consideration. The variety of species is the most commonly and easily studied level of biological diversity, and this is the reason that biodiversity is often thought to be a measure of number of species in an area - also referred to as species richness. Some biologists still equate biological diversity (biodiversity) with species richness, and others solely with genetic diversity.

The Biodiversity and Ecology Division of the School of Biological Sciences at the University of Southampton summarises biodiversity as:

> *...the area of biology which focuses on the differences between organisms, as opposed to the areas of cellular, physiological and biochemical biology which describe the structural building blocks common to all organisms. Biodiversity includes the areas of "whole organism" biology such as ecology, behaviours and evolution, in which the processes and interactions occurring between individuals are studied, rather than the processes which occur within individuals. The term "biodiversity" particularly emphasises the huge number of different species of living things, their multitudes of adaptations to the diverse environments in which they live, and the wide spectrum of ways in which man interacts with these organisms, from their exploitation in hunting and logging, through management in agricultural systems to their conservation for future generations.*
> (http://www.bed.soton.ac.uk/biodiv/ [accessed 24 February 2004])

This definition is particularly significant to note here because the present study seeks the views of experts in this field on the concepts underpinning biological conservation, and two of the experts consulted are leading researchers in the field from the University's School of Biological Sciences.

2.3 The importance of science in conservation biology

The above sections have outlined the theory and practice of conservation biology. An understanding of this aspect of science is vital in conserving the Earth's biodiversity, to inform conservation planning, and to achieve environmentally sustainable development (Meffe and Carroll, 1997). In Britain, the most important conservation areas are National Nature Reserves and Sites of Special Scientific Interest, and these are selected according to scientific (as opposed to social or economic) criteria. The European Union also protects the habitat of rare species by designating Special Protection Areas based on scientific principles.

However, the notion that nature conservation should be based solely on sound scientific principles is not universally held, and some believe that social factors are more important in deciding conservation priorities (as discussed in section 2.1). There are claims that the promotion of objective, value-free approaches to the scientific study of the natural world has taken the fun and enjoyment out of exploring nature, thereby divorcing it from popular support (Yearly, 1991; Harrison, 1993). Advocates of this view believe that nature conservation has become exclusively wedded to science, both in terms of epistemology and ontology, and they have sought to redress the balance by broadening the purpose of conservation to include ethical, social, cultural, and utilitarian considerations (Harrison, 1993). Biologists themselves are not always able to agree on approaches to conservation, especially when science is heavily driven by politics. Some authors actually stress the desirability of the heterogeneity of management approaches, as long as they are tested through experimentation and evaluation (Yaffee, 1999). Meffe (1999) believes that this apparent confusion among scientists, coupled with poor communication between scientists and land managers weakens public and media belief in the importance of science in conservation issues.

Despite this tension, many high profile science-based conservation projects indicate that science remains central to conservation planning. For example, in 1999 eighteen universities across the United States carried out a major study to analyse the science underpinning over 200 endangered species management plans, in order to learn from each other and facilitate recovery of these species (Meffe, 1999). Meffe and Carroll (1997) give priority to four basic principles of good conservation management:

maintaining ecological processes and biodiversity, minimizing external threats, conserving evolutionary processes, and creating a flexible, adaptive management programme. English Nature, the statutory advisory service responsible for maintaining biodiversity in England, still encourages owners of nature conservation areas to develop management plans according to directions produced in the 1980s. The plans include explicit criteria for evaluation, among which are: size, diversity, naturalness, rarity, fragility, 'typicalness' and position in an ecological unit (Nature Conservancy Council, 1991; Prendergast *et al.* 1999). These criteria apply to general conservation sites and all have underlying scientific principles. Genetic diversity is regarded as a key criterion by some biologists (e.g. Morrone, *et al.* 1996). On some sites, conservation objectives have to be highly focused, and the protection of one rare species may require the eradication of another (Fenner and Palmer, 1998), and in such circumstances, a thorough understanding of the biology of both organisms is necessary.

2.4 Biological conservation and sustainable development

As a socially constructed issue, conservation of the world's diversity of organisms and genetic resources (biological conservation) is generally regarded as a precondition for sustainable development (Solbrig, 1991). The concept of sustainable development combines aspects of environmental protection (which includes biological conservation) with social equity and the quality of human life. Not surprisingly its far-reaching, all-embracing aims are hard to define in a few words. Indeed, there are over 65 definitions of the term in circulation (Symons, 1997), but two of the most commonly quoted are:

> *Sustainable development means improving the quality of life whilst living within the carrying capacity of the supporting ecosystems.*
> (IUCN/UNEP/WWF, 1991).

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*
> (WCED, 1987).

Sustainable development therefore essentially incorporates two distinct tensions: the simultaneous struggle for environmental protection and economic development. The more developed countries have long experienced an uneasy relationship between these two goals, and it was only in the 1980s that they began to accept the notion that lack of 'development' (synonymous with poverty, disease, lack of green technologies, etc.) can damage the environment as much as development, if not more so. The conception that environment and development were compatible first became widely accepted by national governments at the United Nations Conference on Environment and Development (The 'Earth Summit') in 1992, which included:

- Agenda 21 - a comprehensive programme of action needed throughout the world to achieve a more sustainable pattern of development for the next century. Chapter 15 of Agenda 21 discussed 'Conservation and Biological Diversity'.
- The Biodiversity Convention: the agreement between countries about how to protect the diversity of species and habitats around the world (see section 2.1).

The UK Government repeated its commitment to these directives following the World Summit in 2002 (outlined later in section 2.7.1) stressing the importance of making decisions based on the best possible scientific information, and increasing people's awareness of the part that their personal choices can play in delivering sustainable development.

2.5 The connection between concepts and values

Research questions 2 and 3 in this study are to identify the biological concepts and values that pupils draw on in making decisions about conservation (section 1.2). The purpose of the following sections is to begin defining these concepts and values. Values and scientific ideas are closely connected in the human mind, and cannot be easily separated, since aspects of our value systems are often founded upon basic scientific principles. The use of language can also confuse meaning, particularly when scientific terms are also used in a different everyday sense.

Due to scientific advancements, as well as a growing appreciation of global and individual human needs, the knowledge base of education for sustainable development, and underpinning socio-scientific issues such as biological conservation, has inevitably become increasingly complex. Policies and practices are

Page 21 missing

photosynthesis is important because it provides us with oxygen), as terms central to this research, they require some definition. This is the purpose of the following sections.

2.6 Defining biological concepts

In this study I refer to a 'concept' as *a functional unit of the mind, a construct of mind depicting reality, which has a stable meaning to educators and students around the world, facilitates learning, and improves decision-making.* This definition is based on findings of a working group at an international meeting of biologists who showed that concepts in this sense can be universally recognized (McWethy, 1994). However, each concept exists as a continuum overlapping and interlinking with others. Different concepts also have different levels of complexity, and recognising a 'complex' concept demands an understanding of other more basic concepts. Biological conservation itself, therefore may be considered a concept.

2.7 Defining values

The science of conservation biology is also driven by the *value* of biodiversity, and the question of why we value biodiversity in the first place. Slater (1996) comments that the value of something is synonymous with its 'worthwhileness' and significance, and this is the general meaning adopted in the present study. The following discussion attempts to place values relating to biological conservation into categories often used by environmental philosophers and environmental scientists while attempting to determine the value of biological resources. This categorisation will also be useful in investigating pupils' values in relation to conservation issues in the present study, although pupils' values will be very much restricted to the value of the particular species under consideration. Huxham (2000) identified three basic types of value in relation to biological conservation: anthropocentric values (of value to humans), biocentric values (of intrinsic value to themselves), and theocentric values (of value to God). These are described more fully below.

2.7.1 Anthropocentric values (centred upon humans), which are utilitarian values, i.e. useful to humans in some way. The values of some species (such as commercial fish stocks) or ecosystems (such as forests as a source of timber) can be relatively easily quantified. Assigning economic values to all species, habitats, ecosystems and other levels of biodiversity is not so straightforward, but may be essential in future decision-making about biological conservation. Conservation efforts will be questioned, especially when concern for wildlife conflicts with the needs of the local economy. Conservation biologists need to be aware of the danger that placing a value on species or protected areas might open them up to market forces, and policy-makers might conclude that a price tag on a resource indicates that it is up for sale. The debate about wildlife conservation and its priorities will continue indefinitely because we all have different values.

It could be argued that all anthropocentric values are closely connected, particularly in the sense that they all have economic implications. Specific economically-oriented values may come into play when discussing conservation management issues, such as the obvious issue of *cost*, the *effectiveness of materials used and measures taken*, and aspects of *safety to humans* (Ratcliffe, 1996). When considering anthropocentric values of the biological resources themselves they may have direct or indirect value to us, and these can usually be discerned with relative ease:

Value as food

Agriculture depends on new genetic stock from natural ecological systems The majority of the world's population is sustained by limited varieties of just 20-30 plant species (Sattaur, 1989), and the agricultural practice of growing high-cropping varieties in large monocultural expanses, can lead to devastating attacks from pests and diseases. The solution is to find wild relatives with more resistant genetic traits that can be transferred to the food crops either through conventional cross-breeding or genetic engineering. The same principle applies to livestock raised in high-densities. Additionally, there may exist strains able to confer an ability to cope with less hospitable conditions such as areas of high salinity or extremes of temperature. The fact that we do not know which traits might be useful, and where they might be found, is therefore a strong argument for conserving all wild species.

Value as medicine

Many of the top best-selling drugs rely on plants, microbes and animals for their development. Most prescription medicines in the United States contain compounds derived from wild organisms (Grifo *et al.*, 1997), and these include familiar examples such as the contraceptive pill, aspirin and penicillin. Less developed countries are even more reliant on natural medicinal products, and these traditional medicines form the basis of primary health care for the majority of the people

(Wilson, 1992). Only a very small percentage of plants have been screened for their medicinal properties, which suggests that many potential cures for human diseases are as yet undiscovered, and they may be residing in any species - whether common or rare, eye-catching, visually uninteresting, or even microscopic. The antibiotics streptomycin and neomycin come from tropical soil fungi, and compounds which show great promise in the treatment of leukaemia and other forms of cancer, are extracted from unrelated species such as the Madagascan Rosy Periwinkle (*Catharanthus roseus*), the Pacific Yew Tree (*Taxus brevifolia*), and an obscure marine bryozoan (*Bugula neritina*) (Grifo *et al.*, 1997). Animals also contribute to medicine in several ways – for example, alantoin from blowfly larvae assists in the deep healing of wounds, bee venom is used to treat arthritis and hirudin from leeches serves as an anticoagulant (Spellerberg and Hardes, 1992). Animals also serve as models for the treatment of disease.

Value as raw materials for industry

Similar arguments raised above apply for conserving natural resources in case we discover compounds of industrial value. We already use plants for building and clothing materials and a vast array of other indispensable products including rubber, cellulose, dyes, waxes, resins, oils, gums, starch and biofules. Alternatives can sometimes be synthesised from petrochemicals, but the living resources will become ever more important as oil reserves become depleted.

Value through interdependence (environmental values)

There are many ways we benefit indirectly from living organisms, particularly through global environmental effects created by the interdependence of the organisms within ecosystems. Natural ecosystems provide a range of essential services including:

- Climate control e.g. forests and peat bogs act as carbon sinks and large areas of forest regulate rainfall.
- Recycling of essential elements such as carbon, oxygen, and nitrogen.
- Prevention of soil erosion by vegetation.
- Water resource protection, since water run-off is regulated by plants.
- Agricultural processes including pollination and the provision of natural predators for crop pests.

Wilson (1992) estimates that at least 40 per cent of the world's economy and 80 per cent of the needs of the poor are derived from biological resources. The richer the diversity of life, the greater the opportunity for medical discoveries, economic development, and adaptive responses to new challenges such as climate change. However, there is some disagreement among biologists about whether a reduction in the number of species in ecosystems will actually reduce the ability of those systems to function. In practice it is not possible to predict the consequences of losing individual species within the ecosystem, and a precautionary approach is therefore advisable; but detailed attention to this matter is beyond the scope of this study. Many of the environmental values mentioned above are not currently accounted for in the economies of most countries but the cost of providing these services in the absence of the ecosystems that provide them naturally, would be vast. One attempt to place a global value on the services provided by natural ecosystems, estimated a total value of $33 trillion. The gross national product of all the world's nations exceeds $18 trillion (Spellerberg and Hardes, 1992).

Aesthetic and cultural values

Values relating to conservation issues can be incompatible between, and even within different cultural groups[1]. A high-profile international example of this is the Inuit contention that they should continue whaling on the grounds that it is an intrinsic part of their culture. In Britain, there are well-known issues disputed by identifiable segments of the population, such as fox-hunting and fishing for North Sea cod. Such cases often involve emotive responses which appeal to feeling based on cultural, civil and human rights.

Closely tied in with these cultural values are the aesthetic aspects of wildlife from which humans derive pleasure and enjoyment – the shapes, colours, textures, sounds and movement - which ultimately affect the quality of our lives. This is demonstrated by the large numbers of people who visit zoos, museums and botanic gardens, the popularity of wildlife and gardening programmes, and the increasing membership of wildlife organisations. Nature tourism is now one of the fastest growing leisure activities among more developed nations.

[1] Rohner (1984) describes the term *culture* as a learned system of beliefs about the manner in which people interact with their social and physical environment, shared among an identifiable segment of a population, and transmitted from one generation to the next.

Wild species have inspired song and poetry and are often used as symbols of a country's heritage, as with the bald eagle in the U.S. or the kiwi in New Zealand. However, there are species less appealing to our aesthetic and cultural values, which receive less political support for conservation; in Britain people generally have more positive feelings towards badgers, robins and butterflies than visually unattractive species or those perceived as dangerous such as cockroaches, spiders, and snakes. Surveys indicate that these preferences vary between different cultures; but these findings are sometimes contradictory (Kellert, 1996). There is a widespread assumption that non-industrial communities possess a kind of deep-seated ecological wisdom, a view that is often dogmatically asserted by the more radical environmental groups, such as Earth First! (see section 2.3), who identify with and support the lifestyles of the original inhabitants of regions across the world. Many environmentalists, in trying to promote conservation, have focused on communities who apparently live in 'harmony' with their natural environment without destroying it, such as the Indians and rubber-tappers of Amazonia (Hildyard, 1989). The relationship that North American Indian societies had with the environment has been particularly appealing; in comparing their attitudes towards nature with those of Europeans, Callicott (1982) highlighted their belief in mutual dependence and equitable status of humans and other species:

> *These entities possessed a consciousness, reason, and volition, no less intense and complete than a human being's. The Earth itself, the sky, the winds, rocks, streams, trees, insects, birds and all other animals therefore had personalities and were thus as fully persons as other human beings.* (Callicott, 1982: 305)

However, in a review of connections between cultural diversity and environmentalism, Milton (1996) notes that such environmental groups rather naively look to non-industrial peoples not only for models of ecologically sound practice, but also for appropriate ways of thinking about the environment. She concludes that:

> *...non-industrial peoples do not think like environmentalists. Some of them may live their lives in ways that are environmentally sound, but ecological balance, where it exists, is an incidental consequence of human activities and other factors, rather than being an ideal or a goal that is actively pursued.* (Milton, 1996: 113).

This 'myth' of primitive ecological wisdom, also extends to wildlife conservation; Kellert (1996: 149) reports that people from less industrialised societies often have a less positive attitude towards wildlife, viewing it with fear and hostility.

However, of major significance is the pressure imposed on some cultures by industrialised countries through irresistible financial incentives, with potentially catastrophic effects for the local people. Reiss (1993) cites the case of villagers in the foothills of the Himalayas who clear-felled much of their slow growing forests for timber export, resulting in severe flooding, injury and deaths. The event received widespread publicity when a determined group of local women protesters (known as the 'Chipko Movement', or 'tree-huggers') successfully campaigned to halt and reverse the deforestation.

Socio-political values

Swanson (1998) claims that conservation matters can create some pernicious social ramifications, and he argues that the erosion of biodiversity in developing societies is often predetermined by the needs of their wealthier trading partners. For the rural poor and other indigenous populations, loss of biodiversity translates into loss of food, construction material, medicine and fuel. Loss of diversity in the first world increases alienation of people from the natural world, which in turn hinders the resolution of local and global environmental problems. On a global scale, loss of biodiversity can even threaten national security. There are many national and international conflicts over water, land, and other natural resources, and these environmental conflicts can lead to mass migrations of people that strain national budgets, public infrastructure, and international relations.

In recognising such potential social impacts, signatory governments of the 1992 Convention on Biological Diversity (outlined in section 2.1), accepted responsibility to develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity (Glowka *et al.*, 1994). Accordingly, the UK Government published documentation outlining how the UK aims to meet their commitments (HMSO, 1994b). One of its priorities was to increase public awareness through the targeting of key sectors including education. After the recent World Summit in 2002, the Government reaffirmed its commitment to the Convention, and published an updated strategy document called *Working with the Grain of Nature: A Biodiversity Strategy for England* (DEFRA, 2002). In its preface the Secretary of State for Environment states:

> *At the World Summit on Sustainable Development in Johannesburg this summer, we committed ourselves to achieving a significant reduction in the current rate of biodiversity loss by 2010...This Strategy sets out a work programme for the next five years. I am asking the England Biodiversity Group to take stock of progress every year and to publish a full report in 2006. I am hopeful that the turn of the millennium will be seen by history as a turning point for biodiversity in England.*
>
> *Our vision is for a country - its landscapes and water, coasts and seas, towns and cities - with wild species and habitats being part of healthy functioning ecosystems; where we nurture, treasure and enhance our biodiversity, and where biodiversity is a natural consideration of policies and* ***decision-making*** (emphasis added*).*

One measure set out in the strategy is to involve people and help make biodiversity part of their everyday lives through information, communication and education. Political support has therefore never been stronger. The political will that exists reflects the growing tide of concern. Young people in particular, consistently place environmental issues high on their lists of concerns and biodiversity issues frequently head this list (Morris and Schagen, 1996).

Altruism /future generations

Moralistic, yet still anthropocentric values may also surface in discussion in the form of *the right to the quality of life of people* who may have to compete for resources with wildlife. Another altruistic approach to resource conservation, and one of the main principles of sustainable development, is the requirement that present generations refrain from activities which are thought to adversely affect future generations (WCED, 1987). We cannot predict what knowledge, ability or resources will be available to future generations; the relative value of certain resources changes over time. British oak forests had immense value to the shipbuilding industry in Tudor times, but are of relatively little economic value now, although important for nature conservation purposes. Similarly we have no sure way of knowing what resources will be most valued by our descendents, so there is an argument for minimizing the depletion of all renewable and non-renewable resources. This principle also applies to biological conservation; species extinction, or the disappearance of genetic resources, deprives future generations of the potential value they may offer.

Research

Biological resources are also valued from a purely information-gathering point of view, whether this is funded professional scientific research or purely out of personal interest.

2.7.2 Biocentric values (centred upon life). As opposed to anthropocentric values, these are intrinsic or ethical values, inherently valuable as an end in themselves; i.e. based on a view that all species have value regardless of what people think about them. Many people would probably instinctively agree that it is morally wrong to wilfully allow a species to become extinct; but it is difficult to objectively defend such biocentric values. Fox (1996) provides an overview of the ways that philosophers have attempted to describe the criteria on which people base these biocentric values, emphasising two main approaches:

Pain and sentience approach

This is the ethical basis for the animal rights movement, that it is morally wrong to inflict suffering on an animal. The assertion immediately raises the question of what kinds of organisms (or individuals) can suffer? This is usually considered in terms of whether it can feel pain, and whether it is sentient. Sentience can be regarded as a condition of being aware of oneself, but it can also refer to a sense of having value to itself, i.e. having a 'need' to fulfil its natural behaviours. As part of a conservation ethic, this approach has little desirability in absolute terms. To most people, pain and sentience are not characteristics possessed by plants or lower animals, so based on these criteria their destruction would not matter. However, it is an approach which is used in real conservation situations to give relative value to organisms in deciding which should be conserved and which should be destroyed.

Another important aspect of this approach is that it values individuals rather than the species they belong to, and it places no higher value on rare species than on common ones (Huxham, 2000). We simply do not know for certain the extent to which other species are sentient or feel pain, and any attempt to do so inevitably involves an element of anthropomorphism, because we would have to gauge this in relation to our own experiences as human beings.

Right to life approach

This is an approach that respects (values) all life, and is sometimes entirely based on intuition; the problem being that we do not all share the same intuition. Deep ecologists (discussed in section 2.2) have attempted to provide a rational argument for intrinsic value, beyond the use of pain and sentience, by asserting that we should respect all living entities on the grounds that they have self-organising, self-maintaining abilities, and thus '*...embody an interest in themselves*' (Huxham, 2000: 161).

This discussion of biocentric values has so far centred around ethical reasons for conserving life forms; but there are also ethical reasons for allowing, or even encouraging their destruction. For example, some may argue that species extinction is a natural phenomenon, as evidenced by the fossil record. Furthermore, there is the question of how we should relate to human parasites such as tapeworms, pathogenic organisms such as malaria and the smallpox virus, and vectors such as mosquitoes which are responsible for spreading them among the human population; eradication of these would certainly prevent a great deal of human suffering.

Anthropomorphism

Anthropomorphic reasoning might also fall into this biocentric category. This refers to the idea that animals have values and emotions similar to those of human beings and thereby carry out actions in a premeditated, human-like manner. A number of studies have identified anthropomorphic reasoning as a factor contributing to misconceptions about the interrelationships between organisms (Jungwirth, 1975; Clough and Wood-Robinson, 1985a; Inagaki and Hatano, 1987; Leach *et al.*, 1996). Jungwirth (1975: 99) for example, reported that an '*appallingly high*' number of academically able 15-17 year old students in Israel believed anthropomorphic statements such as:

> *Pre-historic man...started to develop a spinal structure and musculature of a different type, in order to walk more upright.*

and

> *Insects are terrestrial organisms, therefore they provided themselves with air-breathing systems.*

He also showed that the students actually believed these statements, rather than simply using them as metaphors for more accepted views. He suggested that the language used by teachers and textbooks to explain the biology might be reinforcing these beliefs. In another study of anthropomorphic reasoning, also in Israel, Tamir and Zohar (1991) interviewed twenty-eight 15-17 year olds and found that most (82 per cent) regarded anthropomorphic statements as acceptable for inclusion in science textbooks. 62 per cent of the students also believed animals to have the human traits of 'wishing', 'trying' and 'striving' (29 per cent also applied these traits to plants). It is therefore reasonable to suppose that pupils discussing biological conservation matters will also draw on anthropomorphic values.

2.7.3 Theocentric values (centred upon God and religion). These are often disregarded as influential factors by conservation biologists (Callicott, 1997), but they may of course be of great significance among people with strong beliefs in divine creation. Such values may range from those associated with widely recognised world religions, such as Judeo-Christian stewardship conservation ethics, to traditional non-Western, sometimes regional, conservation ethics (Callicott, 1997). It may also include values such as those promoted by the New Age movement (Poole, 1995), and the Gaia hypotheis (Lovelock, 1991), although these overlap strongly with the biocentric values outlined above. It is beyond the scope of this study to survey conservation ethics across world religions, but it is a factor that should be borne in mind when considering pupils' discussions about such issues.

2.8 The relationship between environmental knowledge, values, attitudes and behaviour

Before proceeding to focus in the next chapter on young people's understanding of, and attitudes towards, biological conservation, it is appropriate at this stage to explore briefly the connections between knowledge, values, attitudes and behavioural outcomes, in relation to these and other environmental issues involving complex conceptual understanding and value judgements. People may assume that knowledge influences values and attitudes, which will in turn affect behaviour. However, while knowledge of an issue is undoubtedly a precursor to appropriate attitudes and action, many studies have now cast doubt on the clarity of these terms and the simplicity of this linear relationship (Fishbein and Ajzen, 1975; Hungerford and Volk, 1990; Gayford and Dillon, 1995).

Researchers often describe knowledge in terms of beliefs, which lie within the cognitive domain, whereas attitudes are restricted to the affective domain. Newhouse (1990: 26) defines beliefs as:

> *...the information that a person has about a person, object or issue.*

as opposed to attitudes which she defines as:

> *...an enduring positive or negative feeling about some person, object or issue.*

Although we can intuitively recognize differences between knowledge and attitudes based on these definitions, knowledge may be factual or based on personal opinion, and is thus difficult to disentangle from attitude.

Slater (1982: 90) asserted that it is important to clearly distinguish between values and attitudes, claiming that we have many more attitudes than values, and that values (such as honesty) are more fundamental, stable and enduring:

> *...probably because they are initially taught and learned in isolation from other values and in an absolute all or nothing manner.*

She argued that attitudes are 'value expressive', in that they are packages of beliefs that reveal our values in relation to a specific situation or object, and influence us in decisions. Fishbein and Ajzen (1975: 13) insisted that the term 'attitude' should only be used

> *...when there is strong evidence that the measure employed places an individual on a bipolar affective dimension.*

They consider that values can also imply bipolar evaluation and may thus be subsumed within the category of 'attitude'.

However, value and attitude are frequently used interchangeably in the literature (Horley, 1991); holding a certain attitude allows a person to express an important value. Indeed, Slater later conceded that:

> *We need not in fact divide off the meaning of words like 'opinion', 'attitude', 'preference' and 'value', as much as I have suggested in the past.*
> (Slater, 1994: 155)

She then defines values as strongly held, long-lasting attitudes to which we are deeply committed.

Much environmental education research to date has concentrated on the tangible, behavioural impacts of specific educational programmes. Although some actions may be easily recognized, evaluating behaviour is fraught with difficulties, particularly in real rather than contrived situations, and also with regard to cause-effect relationships. Apart from the value judgements involved in assessing actions relating to real problems, there are also limitations in the school context of assessing real behaviour with respect to socio-scientific issues, as pupils' actions tend to take place outside the classroom in 'everyday' life.

Given these practical difficulties in measuring behavioural outcomes, there has been a temptation to measure environmental attitudes instead as an indication of environmental action, on the assumption that attitude is one of the most important influences on environmental behaviour. However, this relationship has only been claimed in a minority of published work (Ramsay and Rickson, 1976; Bradley *et al.*, 1999). There is considerable evidence from socio-psychological research that attitude and behaviour are not necessarily directly correlated (Fishbein and Ajzen, 1975). Eiser (1986) pointed out how certain methods of persuasion can elicit attitudinal changes without directly producing behavioural compliance. He made reference, for example, to the ineffective behavioural response to anti-smoking campaigns and initiatives advocating the wearing of seat belts.

The theoretical framework developed by Ajzen and Fishbein (1980) in their theory of reasoned action led them to assert that behaviour is a function of behavioural intentions rather than one of attitudes. Behavioural intentions themselves, however, can be difficult to ascertain and there is evidence that general intentions of behaviour do not necessarily determine specific intentions of behaviour.

Shwartz (1978) also noted the difference between general and specific behavioural intentions, and his findings indicated that if people draw on *stable* general attitudes and values (such as an obligation toward wildlife conservation), in order to devise

specific attitudes (such as: elk should not be destroyed because of crop damage), these specific attitudes will be better predictors of the person's actions. Drawing on an *unstable* pool resulted in much less predictable behaviour.
Rajecki (1982) put forward some other potential causes for the discrepancy between attitude and behaviour, which included: temporal instability (i.e. the longer the time between collecting attitude data and behavioural data, the less consistent the correlation); a closer correlation through direct experience of an issue as opposed to indirect experience; and normative influences (i.e. social norms that prevent people from acting the way they would like to, given their attitude).

It is clear from the discussion above that behavioural changes are complex and difficult to evaluate; but from the point of view of the present study, it may be possible for pupils to clarify and modify their attitudes about conservation issues through discussion with their peers - even if behaviour remains unaffected. It is for this reason that I am focusing the research on attitude rather than behavioural responses.

2.9 Summary

Biological conservation is an important precondition for sustainable development, and a socio-scientific issue with far-reaching environmental, economic, social and political implications. Although conservation biology is rooted within a scientific paradigm, those involved in making decisions about it, including scientists, are motivated by their own personal values in their assessment of what wild species are worth. This is compounded by the uncertainty surrounding the issues. In contrast to many other sciences, there is still a great range of opinion even on certain basic theoretical issues. Gaps in data are enormous, and estimates can sometimes differ by orders of magnitude. The UNEP Global Biodiversity Assessment Project report (appendix 2.1) demonstrates that, while great advances have been made in recent years, scientists still have only a very incomplete understanding of the Earth's biological diversity. This uncertainty among conservation biologists conveys mixed messages to the public, exacerbating the problem of engaging in scientifically-informed decision-making about conservation issues.

In this chapter I have discussed the range of scientific and non-scientific aspects of biological conservation that might play a part in a decision-making discussion. Although it may seem obvious that we draw on our conceptual understandings and our personal feelings (i.e. concepts and values) when we discuss such emotive issues, it would be useful to identify these to see how much is understood and where individuals stand on the issues – particularly in relation to culling, which is central to many conservation management programmes. The definitions of biological concepts and values presented here will be used to help identify and categorise those which pupils draw on in this study, while engaged in conversation about biological conservation.

The socio-scientific facets of the issues have received considerable coverage at national and international conferences, and we might expect the UK Government's commitment to the 2002 World Summit's directives on biodiversity and sustainable development would be followed through in the school curriculum. Recent changes to the science National Curriculum for England have strengthened the importance of teaching about socio-scientific issues, and this educational context is discussed in chapter 3.

Chapter 3 Biological conservation in an educational context

Improved communication and education are essential to achieve the objectives of the environmental conventions... and the sustainable management of natural resources more generally.
Millenium Ecosystem Assessment Board, 2005: 161

Introduction

Having discussed in chapter 2 how people in general value biological conservation, the purpose of this chapter is to focus on the secondary school curriculum and the pupils themselves, in terms of their knowledge and values. The chapter locates biological conservation and decision-making within the context of the National Curriculum for England, particularly in the science curriculum, and reviews existing research about the conceptual understanding and attitudes among adolescents relating to conservation issues. In so doing the chapter develops the boundaries of the first three research questions:

1. *How important do pupils regard biological conservation as being?*
2. *What biological concepts do pupils draw on in making decisions about conservation?*
3. *What values do pupils draw on in making decisions about conservation?*

3.1 Biological conservation and decision-making within the National Curriculum

Section 2.4 discussed how biological conservation can be viewed as a precondition for sustainable development. Although there is no explicit mention of the terms 'biodiversity' or 'conservation' in the science National Curriculum for England (QCA 1999a), it is implied that as an underlying principle and precondition for sustainable development, pupils should reach a specified level of understanding and awareness about conservation issues and the need to protect living things. Sustainable development has been included in the geography curriculum (QCA, 1999b) for many years, although geography is not statutory for pupils beyond Key Stage 3 (i.e. beyond 14 years old). However, sustainable development has also now appeared for the first time in the overarching *Handbook for Secondary Teachers in England* (QCA, 1999c), in the recently introduced citizenship curriculum (QCA, 1999d), and in the latest statutory orders of the science National Curriculum for England (QCA, 1999a).

Statements within these current national curriculum documents often link education for sustainable development with science and with decision-making. The *Handbook for Secondary Teachers* states that:

> ... [the curriculum] *should develop their* [pupils'] *awareness and understanding of, and respect for, the environments in which they live, and secure their commitment to sustainable development at a personal, local, national and global level.* (QCA, 1999c: 11).

and:

> *Education for sustainable development enables pupils to* ***develop the knowledge, skills, understanding and values to participate in decisions*** *about the way we do things individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future. There are opportunities for pupils to develop their understanding of sustainable development within the school curriculum, in particular in their work in geography,* ***science****, PSHE and citizenship.* [my emphases] (QCA, 1999c: 25)

It is worth noting here that the non-statutory cross-curricular theme of 'Environmental Education' is no longer referred to in governmental curriculum documentation, and there is a general assumption that the subject no longer exists as a distinct part of the national curriculum, although it was never oficially removed. Government literature covering aspects of environmental education now tend to come under the umbrella of education for sustainable development (ESD), which is found principally in the science, citizenship and geography curricula.

3.1.1 The Science Curriculum

The science curriculum highlights the importance of jointly considering social and cognitive factors by stating that at Key Stage 4 pupils should be taught about the importance of sustainable development, and should consider

> *...science in addressing industrial, ethical and environmental issues, and how different groups have different views about the role of science.* (QCA, 1999a: 46).

Instrumental in ensuring that ESD gained a firm place in the statutory science curriculum was the Sustainable Development Education Panel, which was set up by the UK government to make practical recommendations for action on ESD in schools, further and higher education, at work, during recreation, and at home (DETR, 1999). The panel proposed seven '*Key Concepts of Sustainable Development*', and suggested specific learning outcomes associated with these concepts for children at the end of each Key Stage (appendix 3.1). Scientific knowledge and an understanding of the nature of science clearly underpin many of these key concepts, and there is specific mention of biological diversity, but this documentation remains non-statutory, and some science teachers remain unaware of its existence.

The World Conservation Strategy (discussed in Section 2.1) highlighted the importance of genetics and evolution as well as ecology, as key areas of science which form the basis of biological conservation. These disciplines form part of the statutory science curriculum programme of study, and at Key Stage 4 (in double science) they are specifically included in the *Life processes and living things* section as follows:

Variation, inheritance and evolution
Pupils should be taught:

Variation
a) how variation arises from genetic causes, environmental causes, and a combination of both
b) that sexual reproduction is a source of genetic variation, while asexual reproduction produces clones
c) that mutation is a source of genetic variation and has a number of causes
Inheritance
d) how sex is determined in humans
e) the mechanism of monohybrid inheritance where there are dominant and recessive alleles
f) about mechanisms by which some diseases are inherited
g) that the gene is a section of DNA
h) the basic principles of cloning, selective breeding and genetic engineering
Evolution
i) that the fossil record is evidence for evolution
j) how variation and selection may lead to evolution or to extinction.

Living things in their environment
Pupils should be taught:

Adaptation and competition
a) how the distribution and relative abundance of organisms in habitats can be explained using ideas of interdependence, adaptation, competition and predation
b) how the impact of humans on the environment depends on social and economic factors, including population size, industrial processes and levels of consumption and waste
c) about the importance of sustainable development

Energy and nutrient transfer
d) how to describe food chains quantitatively using pyramids of biomass
e) how energy is transferred through an ecosystem

f) the role of microbes and other organisms in the decomposition of organic materials and in the cycling of carbon and nitrogen
g) how food production and distribution systems can be managed to improve the efficiency of energy transfers. (QCA, 1999a: 49-50)

However, as stated above, the terms 'biodiversity' or 'conservation' are not specifically mentioned in the science National Curriculum, and there is no explicit indication of how these individual statements relate to each other in terms of understanding about conservation matters.

The introductory section of the science curriculum itself also stresses the importance of decision-making and values in this context, and states that:

> *...science provides opportunities to promote... education for sustainable development,* ***through developing pupils' skills in decision making on the basis of sound science****,* ***the exploration of values*** *and ethics relating to the applications of science and technology, and developing pupils' knowledge and understanding of some key concepts, such as* ***diversity and interdependence****.* [my emphasis] (QCA, 1999a: 9)

It is pertinent to note that the science National Curriculum for Wales is very similar to the English version, but one prominent difference in this context is that the Welsh curriculum replaces the section on '*adaptation and competition*', with '*adaptation, competition and conservation*', and includes the statement that pupils should be taught:

> *...about ways of conserving biodiversity in the varied environment of Wales and of protecting endangered species.* (ACCAC, 2000:49)

It is beyond the scope of this study to explore science curricula in other countries; but this difference, in my view, highlights the lack of emphasis on conservation as a topic in the English science curriculum and consequently a potential lack of linkage with other topics and decision-making skills.

Some GCSE syllabuses (e.g. all OCR science syllabuses) advise teachers in Wales to check this difference and ensure that teaching fully meets the statutory GCSE science examination syllabuses reflect the content of the national curriculum requirements in their country. Although there are GCSE Biology and Environmental Science courses and GNVQs in science which have more focus on conservation, most science syllabuses in England - in reflecting the national curriculum - omit the term 'conservation'. There are some exceptions to this. For example, the OCR GCSE in Science: Double Award (SALTERS) requires pupils to:

> *...understand the need to limit development in order to sustain biodiversity*. (OCR, 2005: 33)

and the Edexel Science B (modular) syllabus's 'Food production and the environment' module asks pupils to:

> *...explain how better conservation can lead to greater biodiversity.*
>
> (Edexel, 2005: 41).

The Welsh WJEC Science modular (B) puts more detail in the content by looking at: *Ways of conserving biodiversity and protecting endangered species.*

Candidates should:

- *understand that the destruction of habitat is due to increased land use for building, quarrying, dumping and agriculture so causing loss of species and a reduction in biodiversity.*
- *know that endangered species can be protected by CITES (Convention on International Trade in Endangered Species), SSSIs, captive breeding programmes, national parks, seed banks.* (WJEC, 2005: 21)

All science syllabuses for pupils in England make reference to communication or decision-making skills (directly or indirectly), but not in explicit connection to conservation. However, this connection is overtly expressed in the Welsh science syllabus. In developing communication skills, they suggest pupils should:

> *Take part in a one-to-one discussion and a group discussion about different straightforward subjects.*

and their suggested scientific issue is *conservation* (WJEC, 2005: 110).

3.1.2 The Citizenship Curriculum

The equivalent introductory section of the citizenship curriculum states that citizenship provides opportunities to promote education for sustainable development through:

> *...developing pupils' skills in, and commitment to, effective participation in the democratic and other **decision-making** processes that affect the quality, structure and health of environments and society and **exploring values** that determine people's actions within society, the economy and the environment.* [my emphases] (QCA, 1999d: 8)

Democratic decision-making is therefore a recognised part of the citizenship curriculum, and this includes consideration of ethical aspects of socio-scientific issues such as those relating to medicine, and the environment. There is clearly considerable overlap between citizenship education and education for sustainable development, and some educators working in this field regard them as one and the same thing (Peter Martin, Head of Education, WWF-UK, pers. com.). The two fields certainly share many of the same goals, and it is not unreasonable therefore to view biological conservation (as a component of education for sustainable development) as a significant socio-scientific issue underpinning citizenship education.

3.1.3 The Geography Curriculum

The content of the geography curriculum (and indeed that of the science and of the citizenship curricula) depends on what at any one time is deemed to be educationally worthwhile and societally desirable (Slater, 1982). Opportunities certainly also exist for pupils to discuss conservation issues within the present geography curriculum. Below are examples of statements in the Key Stage 3 geography curriculum; I have underlined key words and phrases to demonstrate that these clearly relate to my present research area, i.e. discussing biological conservation issues - particularly issues in which nature is in conflict with human activity.

Pupils should be taught:

(1a) to appreciate how people's values and attitudes, including their own affect contemporary social, environmental, economic and political issues, and to clarify and develop their own values and attitudes about such issues

(5a) to describe and explain environmental change and recognise different ways of managing it

(5b) to explore the idea of sustainable development and recognise its implications for people, places and environments

(6e) about ecosystems – how physical and human processes influence vegetation, including:
i) the characteristics and distribution of one major biome
ii) how ecosystems of this biome are related to...human activity

(6j) environmental issues, including:
i) how conflicting demands on an environment arise (QCA, 1999b: 22-25)

Of particular relevance in the present context is the explicit inclusion of attitudes and values in the first statement. According to Cowie (1978) geography is value-loaded and has never been value free, as environmental and social concerns covered in the geography curriculum reflect the value placed upon life. Slater (1982) outlined the difference in emphasis in the knowledge and skills promoted by science and by humanistic geography. She suggested that whereas the scientific approach puts an emphasis on numeracy, analytical thinking skills, data collecting and data processing, humanistic geography fosters

> *...the development of feelings and conscious introspection about people and places which requires the exercise of oracy and literacy rather more than numeracy.* (Slater, 1982: 89).

However, as highlighted in section 3.1.1, the new science curriculum has now also moved much more in this direction, and it is now more difficult to tease apart the approaches promoted by today's science and geography curricula.

3.1.4 Approaches to teaching about biological conservation in schools

Formal education in schools provides the greatest opportunities for pupils to learn about conservation issues. There is insufficient evidence about children's sources of information about conservation, but findings from science teacher focus groups suggest that popular television programmes have done a great deal to raise public awareness, whereas the press is thought to have had little impact (Gayford, 2000).

Biological conservation is clearly an interdisciplinary area, and this is evident from highly regarded education programmes (e.g. the American nationwide *Project Wild* programme, CEE, 1997) and popular guides (e.g. *Teach Yourself Conservation*, Foskett and Foskett, 1999) which bring all these aspects of biology, geography and citizenship neatly together in one place under the heading of 'conservation'.

Despite these strong links, the compartmentalisation of secondary school curriculum subjects inevitably means that inclusion of biological concepts is beyond the remit of geography lessons, and with the current general absence of cross-curricular opportunities, it is therefore expected that the science component of these issues would be taught in science lessons (or possibly in occasional citizenship lessons). It should also be noted here that there is no prescribed order in which the science topics in section 3.1.1 should be taught, and this may affect pupils' ability to make meaningful links between them. Another factor that may impede learning is the common practice of teaching these topics as value-free scientific disciplines. For example, in a study of American pupils, which included 169 fifteen year olds, Brody (1994) concluded that scientific knowledge related to ecological crises does not necessarily increase with age, and suggested that this is because such issues are not associated with science concepts taught in the classroom.

This emphasizes the need to integrate science with values when considering socio-scientific issues, and one well-established approach in achieving this goal within science lessons is STS education (science-technology-society). This has an emphasis on personal and societal decision-making, and gives equal prominence to society and technology as to science. Solomon (1993) recognizes the difficulty in defining STS education in a few words; but Ratcliffe (2001:87) refers to an enduring statement of purpose from the 1970s Nuffield Secondary Science literature:

> *...the opportunity to understand something of the scientific background and the implications of economic, social and moral problems which concern us all.*

Another approach to teaching about biological conservation within science lessons has been through the provision of fieldwork experience, although it does not feature as prominently as in geography lessons. Most geography teachers regard fieldwork as an essential part of geographical education to reinforce classroom ideas, and develop observation, interpretation and enquiry skills (Foskett, 2000). There is a wealth of literature supporting the value of fieldwork in promoting lifelong environmental, social and personal awareness and attitudes, and there are claims that childhood and adolescent experiences with nature are a key factor in developing adult attitudes toward the environment (e.g. Eagles and Demare 1999). Positive outcomes now closely connected with citizenship programmes, such as enhanced self-esteem, self-confidence and communication skills, have been attributed to outdoor education (Cooper 1994), and children who underachieve in the classroom often excel at outdoor activities (Freeman 1995). But outdoor education is not without its critics. Evidence of a correlation between early experience and attitudes or behaviour later in life is very difficult to demonstrate due to the complex and long-term nature of this type of research

(Chawla 1999). Some authors argue that it is unlikely that children will develop a more positive environmental ethic through a single fieldtrip in a natural setting, because such experiences have little relevance to their everyday lives, and they are not able to transfer what they have learnt from the experience back to their home settings (van Matre 1990; Simmons 1994). However, a study by Simmons (1994) found that children responded best in settings that are familiar to them, and other studies suggest that children's experience with the environment should begin with their local area (Simpson 1985; Neal and Palmer 1990).

Although many science teachers applaud opportunities for fieldwork and discussion-based activities of the type promoted in STS education, they are concerned about finding time to include it in their already crowded timetables. A national survey of 294 secondary schools in England and Wales by Tomlins & Froud (1994) identified lack of time as the main constraint to the delivery of aspects of environmental education. However, some science teachers have found ways of integrating values-oriented approaches into their teaching rather than regarding it as an extra add-on. For example, there is some reassuring evidence about this from evaluations which compared science courses with and without STS components. Aikenhead (1994), working in Canada, compared such groups (with the same timetabled slots for science), and found that for groups given some of this time for STS teaching, achievement was not impaired and there was often improved motivation and enjoyment of lessons. Despite such findings, STS education and indeed outdoor fieldwork, are still not central features of science lessons in English secondary schools, and biological conservation (as a socio-scientific issue) often remains delivered in an atomistic, value-free way as unconnected science curriculum topics, such as variation, inheritance, evolution, adaptation, competition, energy and nutrient transfer.

3.2 Young people's understanding of biological conservation issues

As discussed in section 2.2, the term 'conservation' is used to mean biological conservation and environmental conservation, and this could in part explain reports of confusion between the two among adolescents (Spellerberg and Hardes, 1992). Published research on children's knowledge about conservation matters tends to be limited to reports within the context of environmental education, although the work is usually undertaken as part of the school science curriculum. Young people's environmental factual knowledge varies considerably depending on the topic under consideration (Rickinson, 2001). Roper Starch Worldwide (1994) in the US found that students' self-reporting levels of knowledge about endangered animals were lower than those about recycling and air pollution, but higher than for water pollution. Research reporting these kinds of variations tend to relate findings to factors such as media coverage and the specific school curricula.

The same authors, for example, reported that:

> *...there appears to be a strong correlation between overall environmental knowledge and [the extent of] environmental education in schools.*
> (Roper Starch Worldwide, 1994: 65).

There is little research evidence suggesting that environmental understanding can vary with gender, schooling and socio-economic grouping, and there is virtually no statistical data available on the relative importance of such factors (Rickinson, 2001). With regard to gender, the limited evidence indicates that any existing differences in environmental understanding are more in the nature of understanding rather than the degree of understanding. For example, in a study of understanding about the environmental impact of motor vehicles, involving 713 British children (37 per cent of whom were 15/16 year olds), Batterham *et al.* (1996) reported that girls more often raised the idea of damage to the ozone layer, while more boys mentioned global warming. In the same study, more girls appeared to be aware of 'atmospheric' pollution in relation to its effect on humans in causing breathing difficulties, whereas more boys raised ideas about steps that manufacturers could take to reduce pollution, such as fitting catalytic converters. This supports findings from other studies, which suggest that girls are more aware of immediate, local problems relating to human health, whereas boys focus more on long-term, more abstract issues (Rickinson, 2001).

3.3 Young people's understanding of concepts that underpin conservation issues.

As discussed in section 3.1, a complete understanding of biological conservation requires pupils to draw on a range of biological concepts, principally in the areas of genetics, evolution and ecology. Research demonstrates that children's ideas about these areas of biology themselves abound with misconceptions, and this section outlines some of the main difficulties they encounter.

Genetics and Evolution

The poor understanding of genetics, inheritance and evolution among people of all ages is well documented (Shayer, 1974; Turney, 1995; Wood-Robinson, 1994). Shayer (1974) suggested that ideas contained within evolution are so difficult and abstract that the subject should only be introduced at A level. Wood-Robinson (1994), in a review of the ideas and beliefs held on inheritance and evolution, identified key areas where young people's views are in conflict with those accepted by the scientific community. These features of their thinking included: i) evolution applies principally to animals, ii) intraspecific variation in plants is due to environmental factors, iii) the belief in the inheritance of acquired characteristics, especially if the characteristics are repeatedly acquired over a long period of time,

iv) confusion between the adaptation of an individual to changed circumstances, and evolutionary adaptation within populations, v) anthropomorphic and teleological reasoning to explain adaptation and evolution.

More recently, Lewis and Wood-Robinson (2000: 190) studied the knowledge and understanding of genetics among 482 14-16-year olds using a combination of written and discussion tasks. They reported finding

> *...widespread confusion, uncertainty and a lack of basic knowledge.*

and concluded that the students' science education provided

> *...neither a firm basis for future training as a scientist nor a useful preparation for personal interactions with science in their adult lives.*

Although students were aware of the existence of variation, many seemed unaware of the genetic and environmental sources of variation. Very few seemed to know that there are different forms of a gene (i.e. alleles). There was little recognition that the main impact of sexual reproduction is to increase genetic variation, and less than half recognized that sexual reproduction occurs in plants. Half the students seemed unaware that genetic information is present in all living things, a quarter thought that genes were only found in certain organs, and there was widespread uncertainty about how genetic information is transferred between cells. Only one in five believed that all cells from one individual contain the same genetic information.

The genetic basis of natural selection is particularly poorly understood, and it is also difficult to grasp the considerable length of time required for adaptation to occur, as none of us have any experiential knowledge of the process. Brumby (1979) found that 59% of first year undergraduates with A level biology had a 'poor' understanding of the concept of natural selection, and only 18% could correctly link selection to evolutionary change. The majority exhibited a 'Lamarkian' interpretation of evolution, based on a belief in the inheritance of acquired characteristics, a feature also highlighted among secondary school boys by Deadman and Kelly (1978).

Engel Clough and Wood-Robinson (1985) recognised the problems that upper secondary school pupils have with the concept of evolution, but regarded it as of such central importance to modern biology that they believe instead that we need to find more effective ways of teaching the topic. In their study, nearly half of the 16-year olds used anthropomorphic and teleological reasoning to describe the relationship between organisms and their environment. Students often described adaptation as a conscious process, referring to the 'needs' or 'wants' of plants and animals. Pupils were able to use technical vocabulary of taught science, but generally failed to explain the genetic processes involved. However, the authors point out that this anthropocentric and teleological description of the process of adaptation, may be masking their actual understanding. They suggest that

> *One way to establish what students mean from what they say, and indeed to help them clarify what they do believe, is to provide more structured opportunities for them to* ***talk through ideas at length****. If alternative perspectives could be discussed and evaluated...* ***in small group and class discussion****, students would surely gain confidence in handling these conceptually difficult ideas.* [my emphasis]
>
> Engel Clough and Wood-Robinson (1985a:129)

Ecology

A number of studies of school and university students across the world indicate that the predominate thinking about ecosystems focuses on linear food chains, rather than food webs, interdependency or cycles of matter. Webb and Boltt (1990:189), working with 108 15-17 year olds and 54 first year undergraduate zoologists, found that while they could confidently answer questions about linear food chain relationships, '*almost the entire sample*' failed to appreciate that a change in one population could affect populations along more than one route in a food web. Similarly, Griffiths and Grant (1985) working in Canada, reported that almost all (95.5 per cent) of 200 15-year olds surveyed failed to consider that the effects of a change in one population could be passed along several different pathways in the food web. Their study also highlighted other misconceptions held by a substantial proportion of the pupils:

- 16 per cent of the pupils proposed that a change in one population would have no effect on another population unless they were directly related as predator and prey.
- 17.5 per cent assumed that a population higher on a food chain predates on all the organisms further down the chain.

Leach *et al.* (1996) studied progression in thinking about ecology among 200 British pupils across the 5-16 age range. Half of the 14-16 year olds thought about the balance of organisms in a community on the basis of the types of wildlife with which they were familiar, rather than considering any relationship between the organisms. Less than 20 per cent explained the balance in terms of interdependence, and only "a small number" (page 139) of 16 year olds offered explanations in terms of competition for more abstract 'resources' such as energy.

Leach and his colleagues also found that pupils responded to questions differently according to which organisms were 'removed' from a hypothetical food web. They made fewest links between the removal of the top predator and the rest of the food web. For example, removing mountain lions was considered less likely to affect other populations than removing grass and crops. Pupils also appeared more able to follow links up through the trophic levels than down. For example, when primary consumer populations were manipulated, pupils were more likely to trace the effects up to predators than down to producers: lack of food leading to starvation has a more obvious impact on population size than the absence of predators. This 'upward-thinking' preference through the food chain was also in part sometimes attributed to teleological reasoning, such as suggesting that populations at lower trophic levels were large in order to satisfy organisms at higher trophic levels. I note here that anthropomorphic reasoning can also result in misconceptions, and this is discussed in chapter 2 (section 2.5.2) in terms of underpinning values rather than conceptual understanding.

Adeniyi (1985: 314) reported a range of misconceptions and a lack of willingness to change alternative conceptions about feeding relations, pyramids of energy, and nutrient cycling existed among 13-15 year old Nigerian pupils. Some pupils had an image of energy building up along the food chain, so that the top carnivore would contain all the energy from the producers and the other consumers in the chain. Some ideas were anthropocentric as in

> *...people rear sheep...therefore there are more plant eaters than carnivores.*

Teleological reasoning was also common, such as

> *...producers have to be greater in number than herbivores, so that herbivores can be satisfied.*

Another component of ecosystems often undervalued or sometimes even overlooked completely are the decomposers. Leach *et al.* (1996) reported that 14-16 year olds were generally unsure of the role of micro-organisms in nature, particularly as decomposers and recyclers of minerals. The most common reason given for decay was as a natural 'fate' of organisms, without mention of decay as a chemical process and part of nutrient cycling within an ecosystem.

To conclude this section, it should be noted that eradication of misconceptions of the kind described above, may not necessarily lead to a better understanding of the larger issues. Studies in the field of environmental education indicate that students' factual knowledge about the science underpinning a certain phenomenon, does not necessarily reflect their understanding of the phenomena as socio-scientific issues. For example, Gambro and Switzky (1996) surveyed 1870 American high school students and found a 36% discrepancy between their knowledge that burning fossil fuels causes pollution, and the consequences of exploiting fossil fuels. They argue that most senior students

> *...lack the necessary understanding to go beyond the common recognition of an issue and use their knowledge to grasp the consequences of environmental problems or offer solutions for those problems.*
>
> (Gambro and Switzky, 1996: 31).

Although there is little specific research evidence of a similar nature about children's understanding of conservation issues *per se*, it is reasonable to imagine that the hypothesis also holds true in this situation, and reasonable to assume that an incomplete knowledge of the supporting key concepts may undermine an understanding of conservation issues.

3.4 Young peoples' attitudes and values in relation to conservation issues

The difficulty in separating concepts from values is discussed in section 2.5. It is well known, for example, that children have difficulty defining the term 'animal' in a scientific sense (Bell and Barker, 1982), and when Schaefer (1994) asked students to define the concept of 'life', only 12.8 per cent of the responses related to biological aspects of the concept, the rest were mainly associated with aesthetic, religious and emotional values. Comments made during discussions about conservation matters could thus have multiple interpretations, and may be difficult to categorize as 'scientific' or 'value' statements. For instance, competition between organisms is a scientific concept; competition between animals and humans is a values issue, depending on one's biocentric-anthropocentric viewpoint (discussed in more detail below).

The lack of correlation between environmental knowledge and attitudes (discussed in section 2.8) is not entirely surprising because of the multiplicity of factors that may be involved, such as the specific aims and content of the teaching programme, the characteristics of the students, and the quality and variety of teaching, learning and assessment employed in each situation. There is plenty of anecdotal evidence for a positive correlation, but some researchers have also reported that some forms of environmental education can actually create negative attitudes toward the environment (Kostka, 1976). As part of the Dutch National Assessment Programme, Kuhlemeier *et al.* (1999) surveyed 9,000 15-year olds, and found only a weak correlation between environmental knowledge and environmental attitude. When schools were compared there was a larger difference in average environmental knowledge than in environmental attitudes; lack of environmental knowledge did not appear to prevent pupils having a caring attitude towards the environment. Among other things, the majority expressed concerns about endangered plants and animals.

In another Dutch study of two hundred 13-15 year olds, De Jager and Van der Loo (1993) reported that about half of the students agreed that energy conservation in the home is necessary, and endorsed the need for a change in lifestyle. However, this willingness rapidly declined if energy conservation was seen in terms of costing them money or reducing their own personal comfort. The authors concluded that this demonstrated the importance of including with the science a cost/benefit (i.e. economic values) factor for each given alternative solution to the issue.

Values and attitudes are frequently used interchangeably in the literature (Horley, 1991); holding a certain attitude allows a person to express an important value. Value judgements can affect pupils' understanding of conservation issues in two ways. Firstly, the extent to which pupils value conservation may have a bearing on their motivation to learn, and secondly, if they let their personal values dominate their thinking, their scientific reasoning may be obstructed when considering such issues. Only a limited amount of research exists on these value-based aspects of conservation among adolescents, and as with research about knowledge and understanding, most evidence comes from work within the context of environmental education.

Some studies have indicated that despite increased media coverage and generally positive environmental attitudes, young people still fail to consider biological conservation as a high priority environmental issue (Stanisstreet *et al.*, 1993; Greaves *et al.*, 1993). A survey of over a thousand 15 and 16 year olds revealed that just 34% regarded the loss of animal and plant species a 'very serious' issue and it was ranked lower than loss of the ozone layer, destruction of the tropical rainforest, global warming and the greenhouse effect (Morris and Schagen, 1996). Respondents in this study were also more concerned about global environmental issues such as rainforest destruction than local matters such as local loss of habitats. Rickinson (2001) advises some caution with such findings, on the grounds that the research does not seek to discover *why* some issues are perceived as more important than others. He cites the work of Prelle and Solomon (1996) as one of the very few studies to address this. They asked 14 year old students in England and Germany to identify their three most important issues from a list of nine, and also give written reasons why they thought they were important. The three most commonly selected issues were ozone depletion, rainforest destruction and threats to wildlife; but they found that reasons for selecting threats to wildlife were more emotionally charged, whereas reasons for selecting ozone depletion were characterised by factual information (often erroneous). This suggests that it is not necessarily informative to ask students to rank issues in order of seriousness, because they feel differently about different issues; so their concern for rainforest destruction, for example, could be qualitatively different from their concern for species conservation.

Stanisstreet *et al.* (1993), exploring children's attitudes to various uses of animals, found that only 46 per cent of children agreed to conserving 'all animals'. However, there is surprisingly little research about the extent of this apparently negative response, and possible underpinning factors. One such factor might relate to pupils' differing views according to the actual organism under consideration. The applied objective of biological conservation today is to conserve all biodiversity, by avoiding extinction at any biological level (Caughley and Gunn, 1996). Many biologists even believe that deadly bacteria, viruses and fungi should be conserved with the same urgency as other species (Edwards, 1998). However, it is quite likely that many children (and adults) have far less concern for some organisms than others, although there is little research evidence to draw on to support this.

Furthermore, the existing research literature on anthropomorphic values (discussed in section 2.5.2) tends to relate to feelings about individual animals; very little information has been published about the values adolescents hold in relation to conserving species generally. One exception was a survey of 13-19 year olds (whose academic background was not specified) in which Spellerberg and Hardes (1992) reported that 24 per cent (the most common response) considered biological conservation to be primarily important because it is morally wrong to let or make species become extinct. Only 4 per cent mentioned genetics and species diversity. The authors divided the students' responses into four main "values" of biological conservation (figure 3.1), which correspond in general terms with categories described by Huxham (2000) discussed in section 2.7; but they did not indicate how frequently these values were mentioned by the students.

When the same students were asked how they thought they could contribute to biological conservation, 39 per cent did not know, and 24 per cent suggested joining an environmental/ conservation organisation. No other response category reached more than 8 per cent. (Examples included: avoid using harmful chemicals 8 per cent; don't destroy habitats and flowers 5 per cent; recycle 5 per cent; get involved in the 'politics' of conservation 3 per cent; study and learn about conservation 2 per cent). This lack of knowledge about ways of contributing to conservation may derive from the lack of opportunity to consider such issues in any depth, and it is possible therefore that engaging students in activities such as those explored in the present study, may alter their thoughts about how they can contribute to biological conservation at a personal level; although measuring these views is outside the scope of the present enquiry.

Figure 3.1
'Values' of biological conservation used by 13-19 year old students (after Spellerberg and Hardes, 1992)

1. Ethical and moral values.
   - The intrinsic value of nature
   - Natural world has value as human heritage

2. Enjoyment and aesthetic values
   - Leisure activities (e.g. birdwatching, walking)
   - Sporting activities (e.g. orienteering, diving)
   - Aesthetic value by way of seeing, hearing or touching wildlife
   - Enjoyment of nature depicted in art

3. Use as a resource for humans (utilitarian)
   - As a genetic resource for some of the following
   - Source of food
   - Source of working animals
   - Source of pharmaceutical products
   - Source of building materials
   - Source of materials for making goods
   - Source of fuel for energy
   - Source of organisms for biological control
   - For scientific research
   - Educational value
   - Inspiration for technological development

4. Maintenance of the environment
   - Role in maintaining CO_2/O_2 balance
   - Role in maintaining water cycles
   - Role in absorbing waste materials
   - Role in determining climate (global, regional and micro-climates)
   - Indicators of environmental change
   - Protection from harmful weather conditions (e.g. wind breaks, flood barriers)

Factors relating to the background of the pupils may be important determinants of environmental attitudes, and these may well also impinge on attitudes towards conservation. Newhouse (1990) suggests that environmental attitudes are more likely to result from life experiences than exposure to specific teaching programmes, and there is some evidence that they are also influenced by gender and socio-economic grouping, although again, little specific data on these factors in relation to conservation attitudes – particularly from Britain and Europe. In the United States, Kellert (1996) reports on findings from interviews with over three thousand Americans (adults) about views on conservation, carried out by himself and colleagues in 1980. They concluded that women consistently expressed greater 'moralistic' concerns and stronger affection and emotional attachment to individual animals.

One British study which has revealed gender-related findings was a questionnaire survey of 428 Year 11 pupils (15-16 year olds) from 19 schools by Morris and Schagen (1996). They found girls to be more environmentally aware and active than boys, tending to express a more 'sympathetic' view towards conservation. In his review of the small number of studies on environmental attitudes related to gender, Rickinson (2001) reports that females are more likely to be environmentally concerned and/or willing to be involved in environmental action. He cites, for example, the work of Chan (1996) who found that among 992 secondary school pupils in Hong Kong, gender was significantly related to environmental concern levels. Chan also reported a significant relationship between environmental concern and housing type. Students living in private (as opposed to public) housing showed more concern for the environment and were more willing to get involved in pro-environmental activities. Hampel *et al.* (1996:295) surveyed over 600 Australian adolescents and found that those from schools with low socio-economic catchment areas responded in a "significantly more materialist and less environmentally responsible way". These pupils were, for example, significantly less likely to believe in the need to recycle cans, and more likely to assert that people have a right to use their cars as they wished. It is also possible that academic ability and orientation may affect environmental attitudes, but Rickinson (2001) refers to the NFER report by Morris and Schagen (1996) as the only large-scale study to examine this interaction. They found no significant relationship between ability and environmental concern, although the highest scores on concern for the environment were found amongst pupils who enjoyed the subjects they studied.

Differences in cultural values are discussed in section 2.5.1, but there are few empirical studies focusing on environmental attitudes linked to the cultural background of young people. The British study by Morris and Schagen (1996: 20) suggested that Year 11 pupils from "ethnic backgrounds other than Asian" showed more concern for the environment, but no further details on this were provided. Lynch (1993), working in the U.S. highlighted some key difference between 'latino' and 'anglo' American views on the interrelationship between humans and the natural environment. Anglo environmentalism was characterised by finding technical solutions, and a view of nature as pristine and untouched by humans. Latino environmentalism was more reliant on communal solutions and views humans as an integral part of nature. Schultz and Zelezny (1998) reported discernable differences in ecological worldviews among college students from five countries. Just 31 per cent of U.S. respondents listed environmental problems as "extremely serious", which was a low score compared with respondents from Nicaragua (84 per cent), Peru (65 per cent), Mexico (63 per cent) and Spain (51 per cent). Schultz *et al.* (2000) claim that Latino respondents consistently answer poll questions in a pro-environmental manner, and found that foreign-born Latino Americans tended to maintain this attitude after settling in America, regardless of their education and income. Fleer (1999) stresses the importance of taking a socio-cultural research perspective, where the context in which research takes place is recognized as a significant factor in how children (especially young children) respond, and in how their responses are interpreted.

Summary

Since the 1992 Earth Summit, there has been increased media attention on sustainable development, and on biological conservation as one of its main components. The UK Government has subsequently published national action plans for sustainable development and biodiversity, which highlight the importance of making decisions based on the best possible scientific information, and increasing people's awareness of the part that their personal choices can play in delivering sustainable development. This has been delivered by the explicit inclusion of sustainable development in the National Curriculum for England, particularly in the subjects of science, geography and citizenship. An understanding of biological conservation issues requires pupils to have a basic understanding of underpinning biological concepts - particularly in the areas of genetics, evolution and ecology - and to have the ability to link these concepts together. Research shows that pupils' exhibit a range of deeply entrenched misconceptions in these areas of science and it is reasonable to assume therefore that they may lack the ability to argue about conservation issues on the basis of sound science. Conceptual understanding is also dependant upon pupils' attitudes towards conservation issues, and although research in this area is scarce and mostly reported within the context of environmental education, there are indications that females, individuals from a 'latino' cultural background, and those from more socio-economically advantaged backgrounds are more likely to be concerned about the environment, and willing to undertake environment action.

This chapter has discussed research findings on the range of pupils' knowledge and attitudes towards conservation. These findings are important in the context of this study as they could influence the content of pupils' decision-making discussions in this study, and possibly the way in which they respond to one another. The way in which pupils engage in the decision-making discussion process is explored in the next chapter.

Chapter 4
The processes of decision-making, argumentation and discussion

Introduction

The previous two chapters related to the first three research questions, which focus on the perceived importance of biological conservation and underpinning concepts and values. This chapter begins to consider the nature of decision-making discussions, which is at the heart of the fourth research question:

Are there recognizable features that characterize high quality group discussions about conservation?

Meaningful decision-making about socio-scientific issues requires participants to have some knowledge about the 'facts' of the field, such as the scientific concepts underpinning conservation issues, which can be drawn upon as evidence to support the scientific foundation of the discussion. However, of equal importance to knowing the relevant facts is an understanding of how to deploy the facts, to build sound and convincing arguments that relate to evidence and explanation (Duschl and Osborne, 2002). This chapter begins by characterizing and comparing the terms decision-making (particularly environmental decision-making) and argumentation, and proceeds to describe some models that identify criteria for good examples of both. The purpose of the chapter is not to review all the literature available, but to consider research that suggests features of good quality decision-making discussion - features that could be identified in the current discussions. It is worth noting here that although there is extensive literature on both decision-making and argumentation in such fields of research as psychology, economics, law, medicine, management and sociology, there is comparatively little educational research of this kind focusing on young learners.

4.1 Decision-making in practice

The term 'decision-making' can conjure up different interpretations. An immediate difficulty with the term is that it is used in a range of everyday contexts, from large-scale hypothetical situations down to real immediate problems of personal importance. Some decisions require more thinking than others. Aikenhead (1985) has distinguished between 'rational' decisions, which imply a narrow view, and 'thoughtful' decisions, which demonstrate an explicit awareness of relevant values and knowledge. A common method of making environmental decisions is cost-benefit analysis, in which all the perceived beneficial and detrimental aspects of the issues are given financial values. Among the problems with this utilitarian, 'consequentialist' approach are the impossibility of assigning monetary values to environmental amenities, and the difficulty of knowing all the consequences of the proposed actions (Adams, 1995). However, utilitarianism remains a popular approach for environmental decision-makers, as it gives the appearance of being objective and scientific (Sumner, 2000).

In environmental decision-making, there have been increasing calls for making the process more open and democratic by having the interests and values of diverse stakeholders represented alongside those of the experts. Popular examples of these participatory approaches include focus groups, citizens' juries and consensus conferences. There are now tentative moves towards more inclusionary approaches to environmental decision-making in both the private and public sectors. Proponents claim that although consensus may not be reached, inclusionary decision-making acknowledges the uncertain, value-laden nature of knowledge and is characterized by enhanced communication, mutual trust and understanding and the legitimacy of both process and outcome, which are regarded as inseparable (Merritt and Jones, 2000). This differs from the more traditional forms of participation, such as public consultation and public enquiries, which tend to occur late in the overall process and aim to achieve public support for controversial decisions, rather than social dialogue. It also represents a move away from the traditional domination of discussions by experts, although Purdue (1995) noted that in practice this is rarely achieved, by describing the proceedings of the first UK National Consensus Conference of Plant Biotechnology which:

> *...ranked people speaking about biotechnology in a distinct pecking order: 'experts', 'counter-experts' and the rest. Any questions that the lower orders asked were presumed to be answerable by those considered to possess expert knowledge...* (Purdue, 1995: 172).

Decision-making often also implies committing oneself (i.e. at an individual level) to a certain course of action. This is a main goal of proponents of 'naturalistic decision making' (NDM), which has emerged from psychological research and is now being used increasingly in management and business situations. NDM focuses attention on

> ...*real* teams performing *real* tasks in *real* settings." [emphasis in the original]
> (Lipshitz *et al.*, 2001:343)

For the purposes of the present research, although the socio-scientific issues used are real problems, I acknowledge that they are not necessarily ones that the pupils will want to take action over, or demonstrate commitment to the decision made. The tasks given to pupils in this study are ones in which they are encouraged to develop 'informed opinions', (i.e. engage in a process of attitude formation, where commitment is not necessarily present), rather than 'informed decisions' which imply finality and action (Ratcliffe, 1999). Although informed discussion may not change behaviour (as discussed in section 2.8), it might result in modified opinions, and this study is concerned with this opinion-forming aspect of decision-making.

4.2 Distinguishing between decision-making, argumentation and discussion

Although there is clearly considerable overlap between the two, research about decision-making, and research about argumentation[1], exist in largely separate bodies of literature. Both are goal-directed processes dedicated to achieving consensus, leading towards an end point or conclusion, although neither necessarily demand that the end point is reached, i.e. it may be the process that is important rather than the ending.

In justifying why argumentation is important in education, Siegel (1995:162) notes that:

> *When we engage in argumentation, we do not seek simply to resolve disagreements or outstanding questions in any old way – if we did, then instances of brainwashing...and issuing threats of force would count as episodes of argumentation, since these are ways of resolving questions and disputes...argumentation...is concerned with/dependent upon the goodness, the normative status, or epistemic forcefulness, of candidate reasons for belief, judgement and action."* [emphasis in the original].

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[1] The use of the term 'argumentation' in the literature usually denotes the process of constructing an argument.

In this way, educators foster rationality among their students, encouraging them to argue 'well' (i.e. attend to the process of argumentation) rather than to win arguments by virtue of their powers of persuasion.

In attempting to distinguish between argumentation and decision-making, it might be reasonable to claim that argumentation requires more than one person, whereas it is possible to engage in decision-making on one's own. Duschl and Osborne (2002:56) characterize an argument as a dialogic event carried out among two or more individuals, where each participant has to

> *...construct an argument that justifies the claims they espouse in the light of the evidence that they have to hand.*

However, Swain *et al.* (1999: 390) cite Vygotski's well known work on thought and language to alert us to the view that

> *...thinking with language is a form of internal dialogue: a conversation with one's self.*

and this might be considered one form of argument. Whilst the question of whether one can argue with oneself is interesting, I do not consider the issue relevant to the present study, which is restricted to group interaction.

The range of overlapping lay meanings for the terms decision-making and argument complicates the task of differentiating between them, and the confusion is further compounded by disagreement over the difference between the terms 'discussion' and 'argument'. Solomon (2001) describes discussion as seeing all sides of the problem then trying to make up one's own mind; whereas argument and debate, are more about taking one side in order to defeat the others (what she refers to as 'the football fan syndrome'), with the undesirable consequence that pupils will close their minds to other arguments. However, Duschl and Osborne (2002: 41) refer to a view of argumentation as

> *...a social and collaborative process necessary to solve problems and advance knowledge.*

which is largely analogous to Solomon's description of discussion.

Newton *et al.* (1999: 554) regard discussion as composed of a series of episodes of argumentation, and proposed that argument could thus be considered a sub-set of discussion, describing it as a verbal interaction

> *...focused upon the resolution of a specific controversy.*

However, they also appreciated the confusion between the terms and chose to use them synonymously.

Having acknowledged this potential for confusion, it is important to clarify that, in the present study, when referring to group interaction among pupils, I am using the terms 'decision-making', 'argument' and 'discussion' interchangeably, as meaning ***verbal interaction focusing on the resolution of a controversy*** (after Newton *et al.*, 1999). The pupils here are involved in decision-making discussions, which are composed of a series of episodes of argumentation. Although I accept that some authors (e.g. Kuhn, 1997) have used the term argumentation to describe how individuals 'argue' their point of view, in order to avoid confusion I will refer to argumentation within groups as <u>group argumentation</u> and an individual's argumentation as <u>personal reasoning</u>.

4.3 Argumentation and discussion in the science classroom

The central role that argumentation plays in science is endorsed by philosophers (Siegel, 1995) and psychologists (Kuhn, 1993), as well as science educators studying patterns of discourse (Bell and Linn, 2000; Driver *et al.*, 2000). Newton *et al.* (1999: 553) believe that

> *...pedagogies which foster argument lie at the heart of an effective education in science.*

Driver *et al.* (1994a) emphasise that learning science is not just acquiring facts about the way the world is, but is making sense of the practices of the scientific community, and it involves being initiated into the 'scientific ways' of acquiring knowledge. These practices include generating claims to knowledge, and using argument to assert, defend and sustain such claims. Argumentation is also an important part of language and often recognized as a particular type of language genre. Duschl and Osborne (2002) regard argumentation and debate around competing theories as a central feature of the language of scientific enquiry, and they maintain that an absence of dialogical argumentation from the classroom can result in learning being hindered or curtailed. A strong case can therefore be made for promoting argument within science lessons.

However, there are two distinct contexts for argumentation in science. There are arguments of a socio-scientific nature, which centre around the application of scientific ideas with their associated moral, ethical and social considerations. There are also arguments restricted to the context of scientific enquiry, which ignore other non-scientific considerations. There is a need to focus on pedagogical practices that promote argument in both contexts (Osborne *et al.*, 2001a), but for rational and thoughtful argument about socio-scientific issues, including conservation issues, pupils need to be able to distinguish arguments based on evidence from those based on personal values and beliefs. As discussed in section 2.5, concepts and values are difficult to separate, and in the present study I am not suggesting that one is necessarily superior to the other, i.e. values and scientific evidence have equal status as long as the argument is based on a degree of rational and analytical thought.

Discussion has often been at the heart of programmes promoting the teaching of controversial issues; for example the basic teaching strategy of The Humanities Curriculum Project was

> *...one of discussion rather than instruction"* (Rudduck, 1983:14).

Educationalists have frequently stressed the importance of discussion in science lessons (Barnes, 1977; Sutton, 1992), and promoted teaching that encourages pupils to try out and articulate ideas and cope with rebuttals (Solomon, 1998). However, in practice, whole class discourse is mostly teacher-led, focusing on 'facts' and tends to follow the pattern commonly known as the I-R-E sequence (teacher Initiation, student Response, and teacher Evaluation), a structure which does not actively promote reasoning skills (Macbeth, 2003). It is thus the teacher, not the pupils, who initiates most of the discourse in the classroom, and opportunities for argumentation are not a common feature of science lessons in the UK (Driver, *et al.* 2000; Hacker and Rowe, 1997; OFSTED, 2000). Newton *et al.* (1999) observed 34 science lessons from Year 7 (age 11) to Year 11 (age 15) in seven 'average' London schools, and found little evidence of pupil discussion during science lessons. They reported that deliberative interactions occupied less than two per cent of class time on average, and they saw only two cases where the teacher set a group discussion task – and these were both less than 10 minutes long.

Solomon (1998) offers some reasons why science teachers tend not to use discussion and argumentation as tools for teaching and learning, which include most obviously the lack of time, but she also suggests that teachers may not appreciate the value of discussion, or may be concerned about possible "embarrassing silences", or heated disputes, which they lack the skill to manage effectively. Driver *et al.* (2000) reported that science teachers are not sure how to structure argument in the classroom, and lack confidence to attempt such activities. Focus group interviews with 14 experienced science teachers carried out by Newton *et al.* (1999) also revealed that the teachers were concerned about putting wrong children together, having wrong seating arrangements, degeneration of discussion for disciplinary reasons, the need for pupils to have information about the issues, and the need for the pupils to have an interest in the issue to get them fully motivated.

4.4. Models of *quality* of argumentation and decision-making discussions

The present study attempts to reveal factors that might be used to judge why some arguments and decision-making discussions are better than others. The following sections highlight models that work towards identifying levels of quality in argumentation and decision-making - particularly models which have been trialled and evaluated with young people in a formal education setting. As discussed in section 4.2, I am using the terms 'argument' and 'decision-making' interchangeably. However, as they are so often discussed in separate bodies of literature, the following sections focus separately on models explicitly associated with argumentation and decision-making.

4.4.1 Factors indicating the quality of argumentation

In evaluating the quality of argument, it is necessary to hold a position on what one regards as 'good' or 'better' quality. In this study I am aligning my position with that taken by Toulmin (1958), and by Osborne *et al.* (2001a), that good quality argument exhibits rational and analytical thought, and that rationality[2] is demonstrated not by adhering to fixed ideas but by the way in which, and the occasion on which, a person changes his/her ideas and actions. A key factor in identifying a good quality argument (as part of a discussion) is therefore the extent to which participants change their minds – not in the simplistic sense of reversing their original view, but in refining their view and being better able to justify their position. Osborne *et al.* (2001a) believe that changing one's thinking is only possible if there are opportunities to externalise that thinking, and expose one's beliefs to scrutiny by others. This can only take place effectively by engaging pupils in some kind of discussion.

Much of the existing research about environmental attitudes has focused on attitudinal change, and Kinsey and Wheatley (1984) proposed that we should be testing the extent to which students can defend their environmental attitudes, rather than the extent to which they have changed them. I strongly support this view, as assessment of quality of attitudes *per se* raises questions of subjectivity (such as which attitudes are better?; who decides which attitude is better?). It would seem reasonable therefore to use a model of quality of argument that includes defensibility of attitudes among its criteria.

A number of analytical frameworks have been developed that provide an insight into the quality of argument. Toulmin's pattern of argumentation (Toulmin, 1958) is widely recognized and has been adopted by several subsequent studies as a basis for characterizing argumentation in science lessons (Russell, 1983). Toulmin identified the main components of an argument and used these to build up a pattern of analysis. He began with the assertion that an argument includes a *claim* (C) or conclusion, whose merits we seek to establish, and the facts or *data* (D) that are called upon as a foundation for the claim. In building up the layout of an argument, Toulmin then suggested that the data needs supporting by general rules or principles, referred to as *warrants* (W), which act as bridges and 'authorise' the step from data to claim (i.e. they justify connections between the data and the claim). The purpose of a warrant is to

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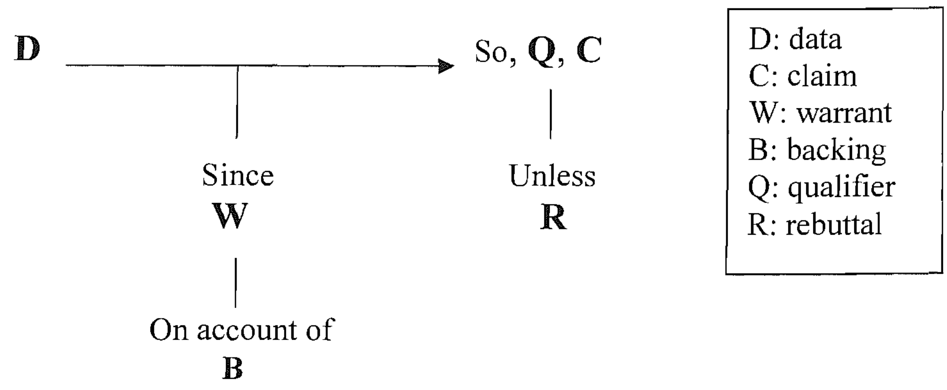
[2] Aikenhead (1985) makes a distinction between 'rational' decisions (based only on relevant knowledge) and higher order 'thoughtful' decisions, which also include consideration of relevant values. It is therefore important to note here that in this study I am regarding Toulmin's use of the term 'rationality' to be based on both relevant knowledge and values.

draw attention to the legitimacy of the step between the data and the claim; it may be explanatory or simply incidental. Toulmin distinguishes between data and warrants by stating that data are used explicitly, and warrants implicitly. Different warrants, however, confer different degrees of authority on the claims they justify, and the force of the warrant therefore needs signifying by including a *qualifier* (Q). The qualifiers specify the conditions under which the claim will be true. Another consideration is the extent to which the argument being proposed fits general rules, and whether special circumstances make the case an exception to the rule. These conditions of exception, Toulmin refers to as *rebuttals* (R). Rebuttals thus specify the conditions when the claim will not be true. One other point he stressed in completing the layout of an argument is the acceptability of the warrants, based on other assurances that give the warrants themselves authority and currency. These are referred to as the *backing* (B) of the warrants, and Toulmin highlighted the difficulties associated with the authority of the backing, as it will change as we move from one field of argument to another.

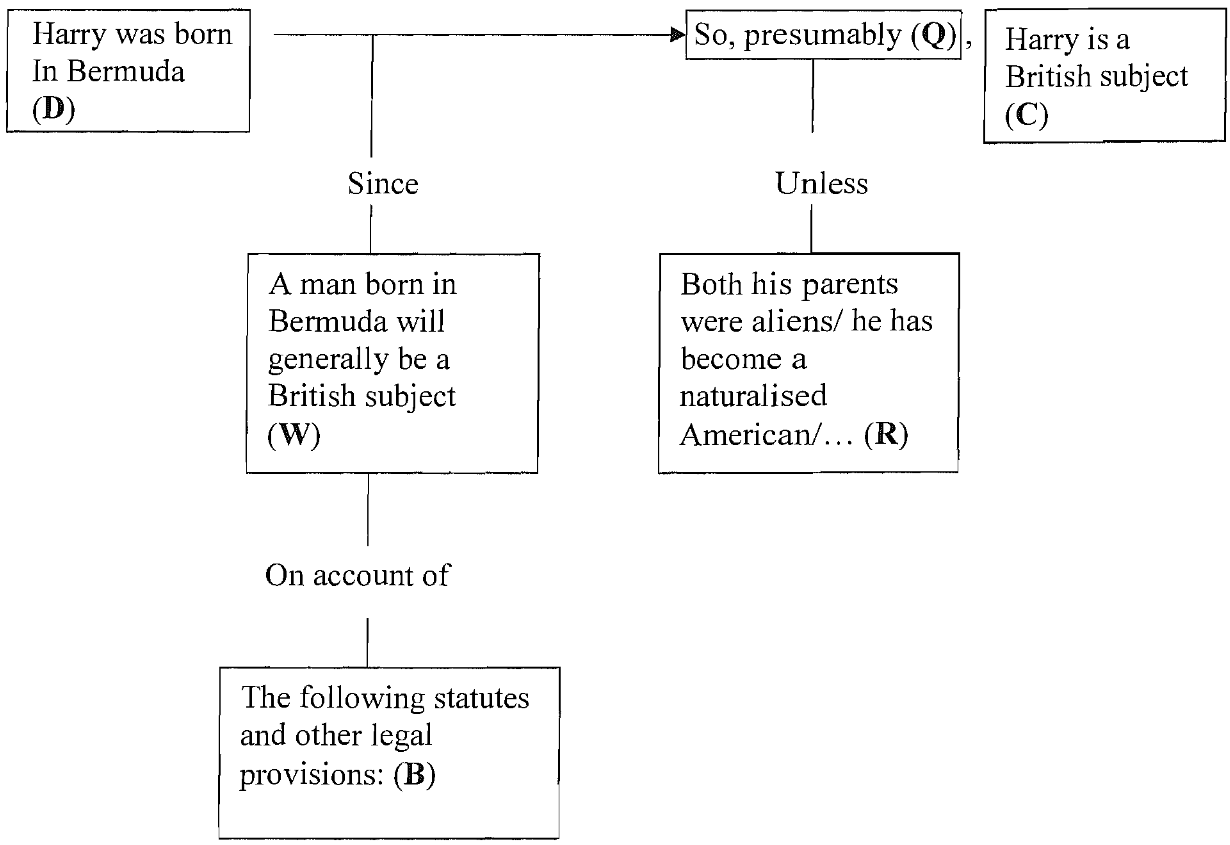
A summary of the layout of arguments incorporating the elements described above is shown in figure 4.1a, and an example provided by Toulmin himself is presented in figure 4.1b. Osborne *et al.* (2001a; 2004a) adopted Toulmin's model while exploring the quality of argument about scientific issues, using transcripts from Year 8 pupils' (aged 12-13) discussions. They related the components of the model to scientific ideas and supporting evidence – the claims are essentially the 'ideas' (consisting of hypotheses, theories and predictions) and data, warrants, backings, rebuttals and qualifiers are the 'evidence'. Although they found little difficulty identifying claims and rebuttals, the distinction between data and warrants was more problematic, as it depended on contextual information, which was either absent or ambiguous on the transcripts.

Figure 4.1 Toulmin's argument pattern (after Toulmin, 1958: 104)

a) The components of an argument



b) **Modified from an example provided by Toulmin**



They overcame this by analysing argument from a less detailed perspective, from which they identified five levels of quality:

Level 1 Arguments
Consist of a simple claim versus a counter-claim; or a claim versus a claim.
Level 2 Arguments
Consist of claims with either data, warrants or backings but do not contain any rebuttals.
Level 3 Arguments
Consist of a series of claims or counter-claims with either data, warrants or backings with the occasional weak rebuttal.
Level 4 Arguments
Consist of a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims as well, but this is not necessary.
Level 5 Arguments
This is an extended argument with more than one rebuttal.

This model therefore clearly highlights the crucial importance of rebuttals as criteria for the recognition of quality in argumentation, and has been used subsequently in science teacher education programmes (Zeidler *et al.*, 2003; Osborne *et al.*, 2004b)

An alternative argumentation framework, developed by Mercer *et al.* (1999), is based on language use in which the concept of exploratory talk is taken as indicative of effective argumentation, by helping children to collaborate more effectively, and improving their reasoning skills. They define exploratory talk as:

> *...that in which partners engage critically but constructively with each other's ideas. Statements and suggestions are sought and offered for joint consideration. These may be challenged and counter-challenged, but challenges are justified and alternative hypotheses are offered. In exploratory talk, knowledge is made publicly accountable and reasoning is visible in the talk.* (Mercer *et al.*, 1999: 97).

They contrast this with two other forms of talk: *disputational talk* in which children interact in an uncooperative, competitive way, and *cumulative talk* where they cooperate to share and build information but in an uncritical way. Working with 10-year old pupils, Mercer and his co-workers found that exploratory talk, and thus effective argument, was associated with the frequent use of some specific forms of language, notably: the hypothetical nature of claims is indicated by a preceding "I think"; claims are supported by the use of "because"; agreement is sought by a question such as "do you agree?"; and long utterances (arbitrarily defined as being at least 100 characters in length when transcribed). An analysis of problem-solving discussions among peer groups of pupils, showed that the incidence of these key linguistic features was more prevalent among groups engaging in talk that led to the right answers; the authors concluding that pupils using more of these elements are arguing better.

When discussing conservation issues it is possible, indeed likely, that not all of the groups will arrive at a definitive whole group answer. Some may agree to disagree, choose to accept several answers, or choose to test out their theories. These concerns were also expressed by Naylor *et al.* (2001) while endeavouring to analyse primary school pupils' discussions of 'concept cartoons', which depicted scientific concepts. In addition to encouraging pupils to decide whether the concepts were depicted correctly or incorrectly, they found it necessary to create a third possible outcome of "unresolved", and Naylor and Keogh (2000: 1) asserted that this option

> *...helps to reinforce a view of science as tentative, in which beliefs are justified by the evidence available but can be modified if additional evidence emerges.*

Naylor and his colleagues found almost the exact opposite of what was predicted using Mercer's model, in that discussions which led to a scientifically 'correct' answer contained fewer key linguistic features for effective argument than those which arrived at an 'incorrect' answer. They suggested that this discrepancy reflected differences in the types of discussion. Mercer's team began with the premise that an effective argument is one which leads to the right answer; in their research the pupils were answering multiple choice questions designed specifically to examine their ability to deduce logically. These questions were focused purely on the application of mathematical logic, and deliberately structured to avoid any need for prior learning. This is very different from the concept cartoons - and peer group discussions about conservation issues - where the pupils rely on everyday knowledge as well as material learned at school. Dissatisfied with existing models, Naylor *et al.* (2001) designed an alternative framework which they claim focuses on the pupils' productive science education experience through argument, rather than on the rules about the structure of an argument.

Their hierarchical model, trialled with primary school pupils, contains seven levels. Although they offer precise statements for comparison, the model relies on finding a position of best fit:

Level 1

Reflects a refusal, or inability, to enter into a discussion.
Can incorporate several different behaviours, all of which close down the argument and prevent reasoned discussion, e.g.

- fighting or physically attacking an opponent
- leaving the room or crying
- tutting loudly and fidgeting
- aggressive use of language such as threatening or swearing

Level 2

Makes a claim to knowledge.
Statements begin with "I think..." "I believe..." "I know..." or "I want..."
Agrees or disagrees with the claims of others.
May counter claims with an opposing position or repeat a claim made earlier.

Level 3

Offers grounds to support claim.
Offers a single reason to support his or her statement of position.
Uses words like "because".
Beginning to listen to others and answer directly to develop simple dialogue.

Level 4

Supports claim with further evidence.
Offers two or more reasons for the stance adopted.
Beginning to evaluate the "quality" or "validity" of reasons or different kinds of "proof"
Brings in personal first hand experience or knowledge from other areas to act as verifiers
Uses phrases that include "might", "definite", "sure", "maybe".

Level 5

Responds to ideas from others.
Listens to other contributors and adjusts position accordingly.
Demonstrates an awareness of the differing ideas of others and of the need to address those differences.
Gives due consideration to the views of others.

Level 6

Able to sustain an argument.
Uses skills necessary to sustain an argument e.g. listening to others' arguments, reinforcing, adjusting one's own position.
Invites others to voice an opinion, or direct questioning and challenging of what they say.

Level 7
Evaluates the evidence and draws conclusions.
Allows all parties to say their piece, then evaluates and comes to a reasoned judgement.
Can include recognition that the argument is never really over and any conclusion is provisional.
May recognise the need to gather further information including empirical data.

Whilst these level 7 factors are fairly straightforward to identify, the model has limited use in the present study as it was designed for use with primary school pupils, and higher expectations might be required of older children. The criteria also apply to individuals rather than to the quality of the overall group discussion.

An alternative approach to analysing argumentation focuses on the logic and content of the dialogue, and the underlying presumptions in the argument. Walton (1996) identified 25 argumentation schemes, commonly used to build arguments in everyday conversations based on what he calls 'presumptive reasoning'. These schemes involve claims which are supported by recognizable types of warrants. Examples include: 'argument from example' where examples and counterexamples are used to support generalizations; 'argument from commitment' where the proponent claims that the respondent is or should be committed to a particular action or line of conduct; and 'argument from cause to effect' which takes the form of a warning that one kind of event may cause another.
Walton (1996: 13) describes presumptive reasoning as

> *...meaning that if the premises are true (or acceptable), then the conclusion does not follow deductively or inductively, but only as a reasonable presumption in given circumstances of a case, subject to retraction if those circumstances should change.*

He stresses that an argument can be weakly or presumptively reasonable, even if it is inconclusive, without necessarily being a fallacious argument. He notes that arguments traditionally regarded as fallacious are actually

> *...quite reasonable, provided we lower our standard of what is a reasonable argument by including presumptively reasonable arguments. These are inconclusive and defeasible arguments that nevertheless have a practical function of shifting a burden of proof in a dialogue. (Walton, 1996: ix)*

Argumentation schemes based on presumptive reasoning concentrate on a person's use of evidence *and premises*, thus forcing the respondent to examine the premises held by the other. In so doing, there is a shift of the burden of proof from the person proposing the claim (the proponent, or assertor) to the respondent, i.e. the claim is true until proven otherwise. This lends further support to the importance of rebuttals in assessing the quality of argumentation as proposed by Toulmin (1958) and Osborne *et al.* (2001), and outlined above. A proponent can advance a presumption without offering evidence to back it up, and it is therefore up to the respondent to rebut the presumption by providing evidence against it. If the respondent fails to produce this evidence, the presumption holds, provisionally, until someone finds evidence to refute it.

Another feature of presumptive reasoning is that such arguments are based on the hearer's pragmatic interpretation of what the speaker is suggesting, rather than logical inferences that necessarily result from what the speaker asserts. Hence, Walton further describes presumptive reasoning as

> *...more rough-and-ready, more simplistic, and also more subject to defeat (and also error) than the logically tight deductive inferences that have traditionally been studied in formal logic.* (Walton, 1996:xiii)

However, he asserts that analysis of presumptive reasoning can help us understand how argumentation can influence people in everyday speech on all kinds of controversial issues. This view is particularly relevant to the present study in that all Walton's argumentation schemes are types of what he terms '*argument from ignorance*' (of the type in which the present pupils are engaged), as opposed to knowledge-based reasoning. Where the knowledge is available it should of course be collected and used; but in some cases, as in the present study, decisions are called for even in the absence of sufficient hard evidence to resolve the issue, and this is when presumptive reasoning is a useful and reasonable kind of argumentation. These kinds of arguments have been recognized among small collaborative groups of pupils during science lessons (Jimenez-Aleixandre, *et al.*, 2000), and Duschl and Osborne (2002) propose that it is worth exploring the use of Walton's schema based on presumptive reasoning as a framework for analysing students' argumentation. However, Walton's schemes are not hierarchical, and consequently not of direct use in my present attempt to establish a means of measuring quality of discussion.

As discussed in section 4.2, to help avoid confusion of terminology in this study, I am referring to argumentation within groups as *group argumentation* and an individual's argumentation as *personal reasoning*. An overtly hierarchical model of personal reasoning was developed by Kuhn *et al.* (1997) (although they referred to personal reasoning as 'arguments'). They found that dyadic interaction between peers significantly increased the quality of reasoning in early adolescence and young adults. They investigated discussions (dyadic interaction) between pairs of adolescents (seventh and eighth graders) of lower to lower middle socioeconomic status, to see how engagement in thinking about a topic (in this case capital punishment) enhances the quality of reasoning about that topic. There was no teacher guidance or intervention in the study. Participants completed a pre-test questionnaire stating their opinions about capital punishment on a 13-point opinion scale, and then took part in a series of five 10-minute dyadic discussions on the topic over a period of five weeks, each time with a different classmate to expose them to a range of views. They were then post-tested, alongside a control group to see how their views had changed. Key factors relating to quality of argument explored in the study were i) consideration of the function of capital punishment, and ii) justification for or against the practice. The researchers devised a scheme which presented these 'arguments' in the following hierarchical order of increasing quality:

1. <u>'Nonjustificatory arguments'</u>, which are not justified and consequently have little or no argumentative force. Most reasoning in this category was based on an unsupported appeal to sentiment.
2. <u>'Nonfunctional arguments'</u>, focus on the conditions that make (or do not make) capital punishment justified, but do not consider the functions of capital punishment.
3. <u>'Functional arguments'</u>, where justification for the judgement includes consideration of the functions or purposes of capital punishment. Within this category is reasoning that relates the judgement to other alternatives, and reasoning that simply offers reasons for or against the decision without considering its alternatives; the former type of reasoning is

   > *...the more adequate...based on the logical criterion of completeness as well as the psychological criterion of cognitive demand.*
   >
   > (Kuhn *et al.*, 1997: 293).

Kuhn and her colleagues found that the range of reasoning increased from pre-test to post-test, suggesting a social transmission of new knowledge, and they identified ten different types of qualitative improvement in reasoning, which did not occur among the control group. Principal among these was increased comparative reasoning, a shift from 1-sided to 2-sided reasoning (i.e. from a single, one-sided view to a view representing both pro and con positions), and the appearance of metacognitive statements. These are statements of uncertainty, which also refer to one's own view or that of someone else. An example of this cited by the authors is:

I have different feelings about the death penalty.

and: *I know some people believe it for other reasons, but that's my reason.* (Kuhn *et al.*, 1997: 295).

Also among their findings was the claim that, by comparison, one-off discussions failed to enhance the quality of reasoning, and that their data supported the view of Kruger (1993) that the tendency to contrast 'conflict' and 'cooperation' models of peer interaction is an oversimplification. This is a contrast often connected to that between Piaget and Vygotsky. The conflict model has tended to dominate on the assumption that powerful dialogue stems from opposing points of view, exposing participants to new perspectives that might be integrated into their own thinking. However, Kuhn *et al.* (1997) found that new forms of reasoning frequently appeared among pairs of adolescents who shared the same basic position on the topic of capital punishment, suggesting that cooperative reasoning could be an indicator of quality argumentation.

4.4.2 Factors indicating the quality of decision-making

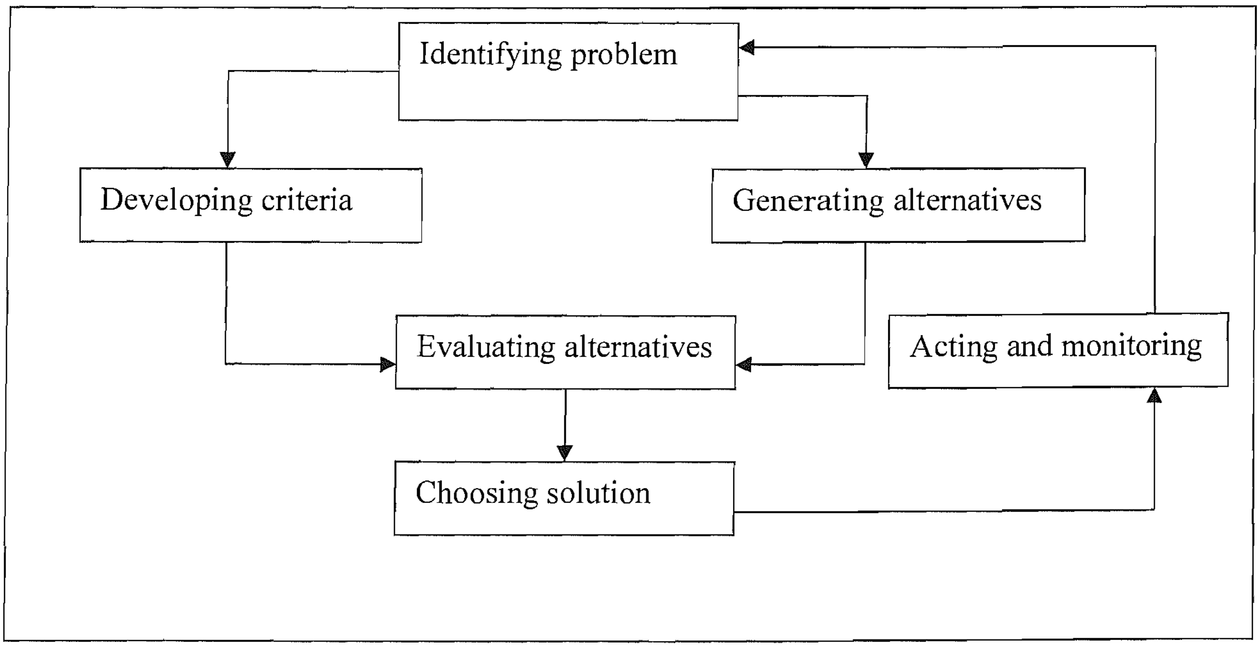
Two types of decision-making models are recognized in the research literature (Ratcliffe, 1997). Normative models attempt to provide a structure for how individuals *should* make decisions (e.g. Aikenhead, 1991; Baron and Brown, 1991; Janis and Mann, 1977). Descriptive group models attempt to describe how real decision-making happens, attending to the social dynamics as well as the cognitive aspects (e.g. Hirakawa and Johnston, 1989). Although a number of decision-making frameworks have been used with pupils, Beyth-Marom *et al.* (1991) consider that most fall short of demonstrating significant effects on decision-making skills. They argue that one main reason for this is the lack of consensus over what constitutes high quality decision-making. Indeed there are only a small number of models attempting to measure quality, among the more successful are those outlined below.

Kortland (1994; 2001) developed a normative model of decision-making, for use as an instrument to improve the quality of argument by individual pupils. He employed the framework in conjunction with data from questionnaires and small scale interviews, to explore pupils' 'level' of argument and decision-making abilities when discussing the issue of household garbage and packaging waste. The model draws on a step-wise sequence (figure 4.2) of identifying the problem, developing criteria, generating alternatives, evaluating the alternatives on the criteria, and finally choosing and implementing the best solution.

Kortland (1994) suggested that these decision-making abilities develop through the following levels:

- Everyday-life level. Patterns of argumentation involve choosing and defending an alternative solution.
- Ground level. Pupils present a more thoughtful argument as a result of being motivated to investigate their own questions about an issue.
- Descriptive level. Pupils more clearly articulate the relevant concepts and how they relate to each other.
- Theoretical level. (This level was not described).

Figure 4.2
Kortland's (2001: 90) model of a decision-making procedure



He tentatively proposed that these factors may be useful for designing appropriate teaching activities. Although such a hierarchical scheme has some potential in the present study, this step-wise approach requires considerable guidance by the teacher and is not aimed at enhancing argument within groups of pupils. Furthermore, Beyth-Marom *et al.* (1991:21) warn against the pragmatic use of such step-wise approaches stating that:

> *...if one does not execute these steps optimally, one can be rational without being very effective at getting what one wants.*

Ross (1981) regarded particular decision-making skills as developmental, and suggested separate strands in decision-making, each with five hierarchical levels:

A <u>Identifying alternative courses of action</u>
Level 1. single alternative identified
Level 2. a small list of alternatives
Level 3. brainstorming alternatives
Level 4. constructing alternatives by classifying
Level 5. constructing alternatives using criteria

B <u>Identifying appropriate criteria</u>
Level 1. no criteria
Level 2. good things and bad things
Level 3 self-referenced criteria
Level 4. criteria refer to other people
Level 5. criteria are general principles

C <u>Assessing alternatives by criteria</u>
Level 1. justification of a single alternative
Level 2. assignment of advantages and disadvantages
Level 3 assignment of positive and negative valences
Level 4. assignment of ordinal values
Level 5. assignment of interval scale values

D <u>Summarising information about alternatives</u>
Level 1. eyeball summary
Level 2. best alternative on most important criterion
Level 3 additive rule
Level 4. elimination of alternatives by criteria
Level 5. assigning weight that reflects the relative importance of each criterion (multiplicative rule).

E <u>Self-evaluation</u>
Level 1. rationalisation of choice
Level 2. repetition of decision-making process
Level 3 introduction of time dimension
Level 4. use of an alternative decision rule
Level 5. development and testing of a principle.

Ross developed a teacher-led sequence of exercises based on these skills and levels for grade 7 and 8 Canadian pupils, and this instructional package allowed pupils to practise each skill overtly and separately. The effect of the programme was assessed by giving pre- and post-test questionnaires to the experimental and control groups. The pre-test presented a problem about cigarette smoking, and the post-test focused on career choices. Whereas pre-test results were similar for both groups, the experimental group scored substantially over the control group in the post-test for skills A, C, D and E. Ross maintained that the programme resulted in improved performance due to the following factors:

- Providing opportunities for meaningful learning by addressing pupils at their existing level of competence.
- Fostering metacognition, and making processes more overt.
- Requiring pupils to contrast their cognitive strategies with a series of more sophisticated processes which were only slightly different from what they were already able to do.

These would appear to be important decision-making skills to develop, but the framework is not without its limitations. Ross raises the problematic aspect of transferring these skills from the classroom to real life experience. It might be impossible to verify that such skills are transferable

> *...because of the irresolvable difficulty of producing a valid measure of decision-making competence in out-of-school contexts.* (Ross, 1981:294)

He also reported that some teachers found the instructional strategies confusing, and that after the brief two-lesson programme students were actually less capable of selecting criteria, suggesting that improvements take place very gradually and would require a full year to master the required skills.

Ratcliffe (1996) examined decision-making strategies of individuals, by categorising responses to a range of socio-scientific decision-making scenarios in interviews with 15 year olds. Pupils were asked *how* they would make a decision. Ratcliffe produced an empirically-based model with hierarchical levels, based on the view that informed decision-making is expected to show features common to both normative and descriptive decision-making models. These include: identifying options; identifying and using criteria; evaluating information; and considering advantages and disadvantages.

Although the model was not based on Ross's (1981) model, there were similarities with the detailed structure:

Level 0.	No response
Level 1.	A decision is made, no reason given
Level 2.	A decision is made, reasoning is given
Level 3.	Response shows elements of criteria use, and /or the need to seek further information before deciding (either as a general strategy or by suggesting specific actions)
Level 4.	in addition, suggests an examination of the advantages and disadvantages of the alternatives (Ratcliffe, 1996: 131)

Level 4 is considered to be closest to informed decision-making. Responses at this level show strategies that include surveying advantages and disadvantages, and criteria use and information seeking. Level 3 responses show some elements of informed decision-making, but miss the crucial analysis of the pros and cons of alternatives. A Level 2 response is characterised by giving a justified decision, but failing to identify strategies for making the decision. Unjustified decisions are categorised as Level 1, on the grounds that justification brings certain criteria into the discussion.

4.4.3 Comparison of models of *quality* of argumentation and decision-making discussions

There are aspects of all the models described that can be used to help assess the quality of the present conservation discussions, but some models are more relevant than others. Their pros and cons are summarised in table 4.1, and I used these to decide which models to build on in constructing the research framework shown in the next chapter. These models are highlighted in bold in the table. Section 5.2.10.4 gives details of how these models were used to explore the quality of discussions in the present study.

Table 4.1
Models of argumentation and decision-making discussed in this chapter, highlighting their value and relevance to the present study. The models highlighted in bold are those used in constructing the research framework in the present study.

Model	Useful features	Inappropriate features in relation to the present study
Toulmin (1958)	Identifies the main components of argument as: claims, data, warrants, backings, qualifiers and rebuttals.	Does not contain hierarchical features of quality. Researchers have had difficulty distinguishing between some of the components.
Osborne *et al.* (2001a)	**Provides a less complicated perspective on Toulmin's model, highlighting the importance of rebuttals.** **Identifies levels of quality of argument.** **Emphasises the process of argumentation rather than the content.**	**Generally used with pupils under 15 years old.**
Mercer *et al.* (1999)	Identifies 'exploratory talk' as an indicator of quality argument, which includes long utterances of 100 words.	Does not contain hierarchical features of quality. Only relates quality to problems that have a scientifically correct answer. Work based largely on conversations among 10 year olds. The value of 'long utterances' might not apply to 15 year olds.
Naylor & Keogh (2000)	Identifies levels of quality of argument based on experience through argument rather than structure of argument.	Work based largely on conversations among 10 year olds. Criteria apply to individuals rather than quality of overall group discussion.
Walton (1996)	Identifies argumentation schemes based on 'presumptive reasoning' and 'argument from ignorance'.	Does not contain hierarchical features of quality. Gives emphasis to the content of the argument rather than the process.

Kuhn *et al.* (1997)	**An explicit pre- and post-test linking discussion with quality of reasoning. Identifies levels of quality of argument based on 'functional' and 'justificatory' features. Data taken from pre- and post-test questionnaires as a means of measuring change of thinking. Used with adolescents in discussion about social issues.**	**Not used in discussion of socio-scientific issues.**
Kortland (1994; 2001)	Identifies levels of quality of argument based on depth of level of thinking about issues.	Based on a step-wise approach which requires considerable guidance by the teacher, and is not aimed at enhancing argument within groups of pupils.
Ross (1981)	Identifies a series of decision-making skills: identifying alternative courses of action; identifying appropriate criteria; assessing alternatives by criteria; summarising information about alternatives; self-evaluation.	Each skill is practised overtly and separately. Requires considerable guidance by the teacher. May require a full year to master the required skills.
Ratcliffe (1996)	Empirically-based with hierarchical levels. Based on features of both normative and descriptive decision-making models, including: identifying options; identifying and using criteria; evaluating information; and considering advantages and disadvantages. Used with 15 year olds.	Used in interview situations with researcher, rather than unsupported discussion.

4.5 Factors relating to peer group behaviour

Another facet of group interaction, which has been related to quality of decision-making discussions, is the way group members behave towards each other on a verbal level. Gayford (1992) observed groups of 15 year olds carrying out biology problem-solving activities, and looked for identifiable and repeatable styles of group leadership and whether this had an effect on motivation and learning. Using a simple observation schedule, Gayford investigated planning and leadership among 421 mixed-ability pupils, from six different schools, usually working in groups of four. Pupils were allowed to work in self-selected groups - groups in which they were used to working. All the groups were set two open-ended problems:

1. To find a way of comparing different plant and animal tissues for the amount of enzyme present which is capable of catalysing the decomposition of hydrogen peroxide.
2. To compare different leafy shoots provided for the amount of water that they need.

Gayford found that 68 of the 104 groups showed common behaviour in both activities in terms of planning and implementation of the work. From these consistent groups he then identified five main styles of group behaviour:

Type A	'*Dominating leader*'. One pupil plans without involving the others in the group and then proceeds to do most of the work, but tells the others what s/he is doing. S/he may enlist the help of others from time to time.
Type B	One pupil does most of the planning and then explains to the others what needs to be done. S/he then proceeds to direct the work of the group.
Type C	'*Negotiated leadership*'. One pupil discusses a plan with the others and then negotiates with members of the group their role in completing the task.
Type D	'*Democratic team*'. There is a degree of discussion in which there is no clearly identifiable leader. A course of action emerges and then the group contributes as a team with a degree of consensus.
Type E	'*Critical group members*'. One or two students, not necessarily the leader, carried out most of the work while others watched, criticised or advised. This variant arose in a few cases which was more obvious at the implementation stage, but which could have been associated with any of the planning approaches of types A, B or C.

These categories were then related to data on pupils' performance (in terms of understanding and motivation), collected by questionnaires. Gayford reported some significant differences in performance according to the types of group behaviour; the 'negotiated leader' (Type C) and 'democratic team' (Type D) group behaviours resulted in better understanding and motivation than the other types. However, he advised some caution in interpreting the results, as the study was subject to considerable logistical problems, such as absenteeism and disruptions in the timetable.

In the United States, Hogan (2002) explored ideas and reasoning among eighth-grade pupils (13-14 year olds) while making decisions about environmental management. She found that four main categories of the substance of the discussions emerged:
i) Given Information (from the fact-sheets provided to pupils); ii) Interpretations, Elaborations and Inferences (based on the given information); iii) Value Judgements (personal opinions and preferences); and iv) Concerns with Uncertainty (concerns that they did not know enough to make informed decisions about the issues). Although all groups touched on all these aspects, a major finding was that most groups focused primarily on ecological aspects, or on values, or on uncertainty, without integrating these factors in their deliberations.

Individual roles within peer-groups

The subjects in the present study were purposely left in their usual peer-groups (for reasons outlined in section 5.5). Teachers sometimes assign managerial roles to group members, and it has been claimed that roles that emerge naturally in peer-groups are not always so productive (Salomon and Globerson, 1989). However, my study, as I was not particularly familiar with the pupils as individuals, an inappropriate allocation of compulsory roles may have resulted in even less productivity. Hogan (1999) also categorized the social cognitive roles exhibited by twenty-four American 8th graders while they were discussing the particulate nature of matter in peer-groups; each pupil was placed in a group of three, with at least one person they had nominated as a preferred partner. Hogan identified roles that remained consistent throughout the twelve-week unit, and these were divided into roles that *promoted* the group's reasoning process:

- Promoters of reflection (regarded as the most important act of any group member)
- Contributors to content knowledge
- Creative model builders (only one pupil clearly identified)

- Mediators of group interactions and ideas.

and roles that *inhibited* the group's reasoning process:

- Promoters of acrimony (outwardly hostile to fellow group members)
- Promoters of distraction
- Promoters of simple task completion or unreflective acceptance of ideas
- Reticent participants in collaborative knowledge building

The pupils in Hogan's study were heterogeneous with respect to their levels of academic achievement, and two types of group intellectual engagement patterns emerged: a tendency to engage in either 'surface' or 'deep' collaborative reasoning. She found that the three deep collaborative reasoning groups contained promoters of reflection, and that these groups made progress despite the presence of a promoter of acrimony and a reticent verbal participator. Hogan suggests therefore that promoters of reflection could perform a pivotal influence on the extent to which groups share and work with ideas.

A further personality trait is suggested by Ratcliffe (1999), that of information-vigilance, which may in practice resemble Hogan's promoters of reflection. This trait appeared to be stable among 14-year old boys (above-average achievers) who were engaged in group-based decision-making activities in relation to socio-scientific issues, using a guiding decision-making framework. Ratcliffe provides a pen portrait of an information-vigilant pupil who:

- is more fluent in oral work than written work;
- conformist in nature;
- sought and evaluated information, either as contributions from other group members, or as written information available;
- made several references to science content in group discussions.

This is the kind of pupil who is keen to follow the decision-making framework, keep track of verbal and written information, and incorporate it into the decision-making process. Ratcliffe (1999) concludes that information-vigilance, as part of a decision-making style, can result in thoughtful and skilful decision-making, and the presence of an information-vigilant individual might assist groups in clear reasoning about an issue.

4.6 Summary

A considerable amount of confusion exists in the literature over the meaning of the terms ' decision-making', 'argumentation' and 'discussion'. Some authors feel a need to distinguish between them; others treat them synonymously. In this study I am taking the latter view when referring to group interaction among pupils, and using the terms interchangeably, as meaning: *verbal interaction focusing on the resolution of a controversy* (after Newton *et al.*, 1999). The pupils here are involved in decision-making discussions, which are composed of a series of episodes of argumentation.

Good quality argument and decision-making aims at the rational resolution of issues, and this demands a degree of rational and analytical thought, and requires pupils to distinguish arguments based on evidence from those based on personal values and beliefs. Rational thinking (based here on both relevant knowledge and relevant values) is demonstrated by the way in which, and the occasion on which, a person modifies their ideas and actions, and if we believe, as I do, that the development of rationality is a key function of education, then we must be concerned with the quality of argumentation in terms of how pupils reason, how they present their arguments, and what criteria they use to support their arguments.

Models of the quality of argumentation and decision-making are presented here, and the pros and cons of these (shown in table 4.1) were used to determine which models to build on in designing instruments appropriate for measuring the quality of discussion among the peer-groups in the present study. To this end, the hierarchical models of Kuhn *et al.* (1997) for individual personal reasoning, and Osborne *et al.* (2001a) for group argumentation, were selected in constructing the research framework shown in the next chapter.

Aspects of peer-group behaviour are also reviewed in this chapter, and these will be drawn upon to help categorize groups and individuals in the present study in an attempt to identify key features of high quality discussions, which could hopefully be nurtured and evaluated by science teachers.

Chapter 5
Research Design and Methodology

Introduction

This study seeks to gather baseline data about the values and conceptual understanding among pupils in relation to biological conservation, and explores the nature of quality peer-group decision-making discussions. This chapter begins with a description of a substantial preliminary study, the findings of which were used to construct the research framework for the main study, which is in effect divided into two parts. The first part relates to the first research question:

1. How important do pupils regard biological conservation as being?

and uses a questionnaire-based survey approach to explore pupils' general views on biological conservation. The second part adopts a case study approach in addressing research questions 2, 3 and 4:

2. What biological concepts do pupils draw on in making decisions about conservation?

3. What values do pupils draw on in making decisions about conservation?

4. Are there recognizable features which characterize high quality decision-making discussions about conservation?

The case study is centred on peer-group discussions about specific conservation issues among fifteen/ sixteen year old pupils, in their normal science classroom setting, supported by a specified decision-making framework. Details of the case study methodology relating to research questions 2, 3 and 4 are preceded in this chapter by discussion of the value of descriptive case studies, and other aspects of group work among adolescents, which may have a bearing on the nature and content of the discussions.

The research therefore involves a variety of methods of data collection, each of which are explained in detail in this chapter. Data analysis throughout this study is carried out in the spirit of the ten principles and practices identified by Tesch (1990) that 'hold true' in qualitative analysis research (in addition to the fundamental principles of honesty and ethical conduct):

1. Analysis is not the last phase in the research process; it is concurrent with data collection or cyclic.
2. The analysis process is systematic and comprehensive, but not rigid.
3. Attending to data includes a reflective activity that results in a set of analytical notes that guide the process.
4. Data are 'segmented', i.e. divided into relevant and meaningful units.
5. The data segments are categorized according to an organizing system that is predominantly derived from the data themselves.
6. The main intellectual tool is comparison.
7. Categories for sorting segments are tentative and preliminary in the beginning; they remain flexible.
8. Manipulating qualitative data during analysis is an eclectic activity; there is no one 'right' way.
9. The procedures are neither 'scientific' nor 'mechanistic' (i.e. there are no strict rules that can be followed mindlessly, but the researcher is not allowed to be limitlessly inventive).
10. The result of the analysis is some type of higher level synthesis. (i.e. while much of the analysis process consists of ' taking apart', the final goal is the emergence of a larger, consolidated picture.

(adapted from Tesch, 1990:95-97)

For the preliminary study and main study, I paid serious attention to issues of research ethics and access to pupils, in line with suggested methods detailed by Cohen and Manion (1998). At each school, I explained to the head of science the purpose of the work, intended methods of data collection and how the information would be used. I did not begin data collection until the heads of science had received oral approval from their headteachers for the work to proceed. At the beginning of each session with the pupils, I explained the main purpose of the research (essentially to seek young people's views on conservation issues, which would hopefully provide information about effective ways of teaching the topic). I also emphasized that anything they said about the subject would remain confidential (i.e. they would not be publicly connected with statements they made), and any quotes or reference to statements made by pupils cited in the report would be anonymous (with the use of pseudonyms).

5.1 Preliminary study

Preliminary work was carried out to inform the research design for the main study. The main aims of this pilot work were:

i) to see whether pupils found some scenarios more stimulating than others;
ii) to see whether there are obvious differences in discussions among pupils from different schools

iii) to see if I could identify pupils' use of science and values during these conversations;

iv) to see whether the pupils could engage in decision-making about conservation scenarios, without teacher intervention;

v) to look for obvious differences among the conversations which might relate to their teachers' perspectives on encouraging pupils to discuss socio-scientific issues.

The preliminary study took place with ninety-three, academically able Year 10 pupils (fifteen year olds) in three different co-educational secondary comprehensive schools – one class from each school. These schools were chosen because they were local and well-known to me, and the teachers were willing for me to work with their pupils. As socio-scientific issues, including sustainable development, have a place in the science curriculum, I anticipated that pupils would not find discussion of aspects of biological conservation a particularly unusual activity. At each school, pupils came directly from their science lesson in their usual science peer groups to a nearby quiet room without distractions. The discussions took place consecutively during the same science lesson. At the end of each discussion session I asked pupils for their views about how concerned they were about these species.

Informal discussions, each about fifteen minutes long, also took place with the three science class teachers, one from each school, to explore their views and practices relating to pupil discussion of issues.

5.1.1 Data collection in the preliminary study

Data-collection of pupil discussions involved audio-taping conversations about a variety of conservation scenarios, i.e. scenarios in which species were threatened with extinction. Fifteen groups took part in this preliminary study, five from each school, ranging in size from four to nine pupils - some were single sex groups, others were mixed. The discussions were each about 15 minutes in length. All groups were given a picture stimulus (a picture of the species involved, shown in appendix 5.1), and a very brief verbal introduction to a conservation scenario (appendix 5.2).
The groups were then managed in one of three ways to gauge the extent to which pupils could discuss the issue without teacher intervention:

i) One group from each school was left to discuss the issue unaided; I stayed in the room but remained detached from the discussion. They were simply given the following question at the beginning:

What should be done about this problem, how and why?

ii) With two groups from each school, I gave pupils a simplified decision-making framework to follow as an aid (appendix 5.3), based on the framework used by Ratcliffe (1997). I stayed in the room but remained detached from the discussion.

iii) With two groups from each school, I led the discussion throughout, asking the same questions presented in the decision-making framework.

Each group was given one conservation scenario to discuss, but I used four different scenarios to tentatively gauge their relative value as a stimulus for discussion.
The four scenarios were as follows (these scenarios are described in more detail in appendix 5.2):
<u>1. Mink and water voles.</u> This was provided as an example of a high profile, local conservation issue which had received a considerable amount of local media coverage. A few months prior to the activity, a large number of mink (*Mustela vison*) had escaped from a New Forest mink farm and were being hunted to prevent them from attacking domestic animals and threatening the vulnerable population of water voles (*Arvicola terrestris*) with local extinction.

<u>2. Puffins and rabbits</u> This was a more remote scenario from the pupils' experiences. Although puffins (*Fratercula arctica*) do not live in the region, their brightly coloured plumage and 'comical' faces make them well-known among children. This scenario presents the dilemma of having to control the population of rabbits (*Oryctolagus caniculus*) in order to save the puffins from extinction.

<u>3. African Elephants</u> This is an even more remote scenario, but African elephants (*Loxodonta africana*) are well-known and widely admired. This differs from those above in that elephant conservation is very much a social issue, having considerable

impact potentially on local economies through tourism, the ivory trade and crop destruction.

4. Wax caps This scenario was the most remote from the pupils' everyday experiences. It was very unlikely that any of the pupils had heard of the pink waxcap mushroom (*Hygrocybe calyptriformis*), and it was chosen for its obscure nature. *Plantlife*, the country's leading plant conservation organisation, had a keen interest in developing a waxcap conservation management plan at that time.

There were some instances where the same scenario was discussed under the same conditions by two groups, each from a different school. Differences between these discussions might indicate differences between the cohorts at each school. A summary of the scenarios given to each group is shown in table 5.1.

Table 5.1
Scenarios discussed by groups in the preliminary study. *(Italics highlight where the same scenario was discussed under the same conditions by two groups, each from a different school).*

School	Unguided groups	Groups with decision-making framework	Groups with discussion guided by researcher
A	Voles	Voles	*Voles*
		Waxcaps	*Puffins*
B	Puffins	Puffins	*Puffins*
		Elephants	*Voles*
C	Elephants	*Elephants*	Elephants
		Waxcaps	Waxcaps

5.1.2 Summary of results of preliminary study

In the short time available for these sessions, I was not able to identify individuals, and so pupil interaction was not systematically analysed. However, the audiotapes and field notes highlighted general features of the discussions, which enabled me to address the aims of this preliminary study:

i) Were some scenarios more stimulating than others?

Informal conversations with pupils after the sessions indicated that the waxcap discussions were the least interesting/ stimulating. Members of the three groups discussing waxcaps also declared that they were not particularly concerned about the conservation of waxcaps. These responses were in marked contrast to the other groups, which all showed an interest in the conservation of voles, puffins and elephants. The relative lack of interest and concern for waxcaps prompted me to investigate, as part of the main study, where fifteen year olds 'draw the line' in terms of what is worth conserving. These value-judgements will presumably have a bearing on the values they use in decision-making.

ii) Were there obvious differences in discussions among pupils from different schools?
None of the groups reached a clear decision in the short time available, partly because they rapidly produced a range of possible alternative solutions. A comparison of the discussions about the same scenario, under the same conditions, is highlighted for the range of solutions in table 5.2, for the scientific ideas in table 5.3, and the pupils' values in table 5.4. Although the sample is small, it is evident that despite being from different schools, these groups raised almost identical solutions, scientific ideas and values. This suggests it would be acceptable practice to select able science classes from several local mixed comprehensive schools for the main study, and merge the findings, without a need to differentiate between the school background of the pupils.

Table 5.2
Number of solutions suggested by each discussion group
(italics refer to instances where the same scenario was discussed under the same conditions by two groups, each from a different school. The numbers indicate which solution was raised by both groups).

	Unguided discussion	Discussion guided by decision-making framework	Discussion guided by researcher
Voles	• Culling mink by shooting • Catching and relocating mink using traps	• Culling mink by shooting • Culling mink by poisoning • Culling mink by using dogs • Catching and relocating voles using traps • Catching and relocating mink using traps	• *Culling mink by shooting (2)* • *Culling mink by poisoning (2)* • *Culling mink by using dogs (2)* • *Catching and relocating voles using traps (2)* • *Catching and relocating mink using traps (2)* • *Improving habitat for voles*
Puffins	• Culling rabbits by shooting • Catching and relocating rabbits using traps/nets • Separating rabbits and puffins with fences/ nets	• Culling rabbits by shooting • Culling rabbits by poisoning • Catching and relocating rabbits using traps/nets • Catching and relocating puffins using traps/nets • Sterilising of rabbits • Separating rabbits and puffins with fences/ nets • Introducing natural predators (foxes)	• *Culling rabbits by shooting (2)* • *Culling rabbits by poisoning (2)* • *Culling rabbits by using dogs (2)* • *Catching and relocating rabbits using traps/nets (2)* • *Catching and relocating puffins using traps/nets (2)* • *Sterilising of rabbits (2)* • *Separating rabbits and puffins with fences/ nets (2)* • *Introducing natural predators (foxes) (2)* • *Improving habitat for puffins*
Elephants	• Culling elephants by shooting	• *Culling elephants by shooting (2)*	• Culling elephants by shooting • Culling elephants using tranquilising darts

	• Sterilising elephants • Separating elephants and humans with fences (game parks)	• *Catching and relocating elephants using tranquilising darts (2)* • *Sterilising elephants (2)* • *Separating elephants and humans with fences (game parks) (2)*	• Catching and relocating elephants using tranquilising darts • Sterilising elephants • Separating elephants and humans with fences (game parks) • Scaring elephants away (game patrols, noise)
Waxcaps	(not sampled)	• *Separating orchids and waxcaps with fences (2)* • *Mowing the grass (2)* • *Introducing grazing animals (sheep/rabbits) (2)*	• Separating orchids and waxcaps with fences • Mowing the grass • Introducing grazing animals (sheep/rabbits) • Creating a new reserve for waxcaps

iii) What science and values did pupils use during these conversations?

In discussing the problem presented in the scenarios, pupils drew on a range of scientific ideas (table 5.3), but seldom used scientific terminology – for example very few groups actually used the term 'food chain', but they all spoke about something eating something else. Some of the ideas presented were scientifically flawed, but there was insufficient time for pupils to explore these issues in depth, so these results should be treated with some caution.

Table 5.3
A comparison of the scientific ideas used in discussions (italics refer to instances where the same scenario was discussed under the same conditions by two groups, each from a different school. The numbers indicate which scientific idea was raised by both groups).

Discussion groups Scenarios	Unguided discussion	Discussion guided by decision-making framework	Discussion guided by researcher
Voles	food chain population control rarity species	food chain habitat population control rarity species relocation	*behaviour (2)* *food chain (2)* *habitat (2)* *population control (2)* *rarity (2)* *species (2)* *relocation (2)*
Puffins	behaviour habitat population control relocation	behaviour competition food chain habitat population control rarity species relocation	*behaviour (2)* *competition* *food chain (2)* *habitat (2)* *population control (2)* *rarity (2)* *species (2)* *relocation (2)*
Elephants	extinction food chain population control rarity species	*behaviour (2)* *extinction (2)* *food chain (2)* *habitat (2)* *population control(2)* *rarity (2)* *species (2)* *relocation (2)*	extinction food chain habitat population control rarity species
Waxcaps	(not sampled)	*competition* *food chain (2)* *habitat (2)* *rarity (2)* *species (2)*	food chain habitat rarity species

Discussion of personal values appeared to dominate over science in all discussion groups. The science and values discussed appeared to be context-dependent, depending on pupils' familiarity with and concern for the welfare of the species involved. This context-dependency warranted further exploration in the main study. The intrinsic 'right to live' was at the heart of most animal discussions, but this aspect never surfaced in the waxcap discussions (table 5.4).

Table 5.4
Values used in discussions

Discussion groups **Scenarios**	**Unguided discussion**	**Discussion guided by decision-making framework**	**Discussion guided by researcher**
Voles	aesthetic non-humans' right to live	aesthetic non-humans' right to live cost	aesthetic non-humans' right to live cost effectiveness of measures
Puffins	aesthetic	aesthetic non-humans' right to live cost effectiveness of measures	aesthetic non-humans' right to live effectiveness of measures
Elephants	aesthetic non-humans' right to live effectiveness of measures	aesthetic non-humans' right to live cost effectiveness of measures humans' right to live	aesthetic non-humans' right to live cost humans' right to live
Waxcaps	(not sampled)	cost	aesthetic

iv) Could pupils engage in discussion about conservation scenarios, without teacher intervention?

Tables 5.2, 5.3 and 5.4 show that pupils in the unguided groups tended to draw on fewer scientific ideas and values, and produced fewer solutions to the problems. These groups rapidly lapsed into shallow, circular, or off-task discussion results for the other groups were very similar. However there was little difference (in terms of the scientific ideas, values and solutions) between the groups guided by me and those guided by the decision-making framework. These groups remained on task, and discussed the issues in more depth. This suggested that teacher intervention was not essential for pupils to engage in the decision-making process, as long as they were provided with a meaningful framework to work with.

v) Were there obvious differences among the conversations, which might relate to their teachers' perspectives on encouraging pupils to discuss socio-scientific issues?

There was some variation in the views and approaches the three teachers had in relation to teaching socio-scientific issues. Teacher A said that he encouraged teacher-led whole-class discussions about science issues on a regular basis. However, this was generally of an *ad hoc*, spontaneous nature, and was seldom incorporated into his lesson planning. Teacher B was keen to encourage peer discussion, she frequently had the pupils working in peer groups, but had not encouraged discussion of socio-scientific issues, mainly due to time constraints and to lack of confidence in managing such activities. Teacher C was fairly sceptical about the place of issues-based discussion in the science classroom and did not practice such approaches, but he was still willing to let me involve his pupils in the process. None of these teachers had previously had their pupils discuss conservation issues. Despite the three teachers' very different approaches to teaching socio-scientific issues, there appeared to be little difference among the pupils in terms of engagement with the tasks and breadth and depth of discussion.

5.1.3 Implications for the main study

These preliminary findings indicated that some scenarios are more stimulating than others, and that these tend to be scenarios involving organisms which they are keen to conserve. They also appeared to be more willing to discuss the more stimulating issues in greater depth and breadth. It followed that the main study should investigate scenarios involving species which pupils are most keen to conserve. It would also appear that that teacher intervention is not essential for pupils to engage in making decisions about conservation matters, as long as they were provided with a meaningful framework to work with.

The relative lack of interest and concern for waxcaps raises the question of i) where fifteen/sixteen year olds 'draw the line' in terms of what is worth conserving, and ii) how important they regard biological conservation in relation to other socio-economic issues. These value-judgements will presumably have a bearing on the values they use in decision-making and the nature of the peer group interaction. Pupils clearly draw on a mixture of values and science during the discussions. Some consideration of categorising these factors would be necessary in the main study to make direct comparisons between groups, and with the views of science teachers and biologists.

The elephant and puffin scenarios were discussed in more depth and breadth in terms of possible solutions, scientific ideas and values (as indicated in tables 5.2, 5.3 and 5.4 respectively). I felt that these more complex scenarios, with a range of possible solutions, involving species which pupils are most keen to conserve, would be most likely to draw on science and values needed to help make decisions. The science and values that emerged appeared to depend on the scenario being discussed. It would therefore seem necessary to analyse discussions of more than one scenario in the main study, to search for aspects of context-dependency. Research has shown that pupils' understanding of biological concepts, and thus their relevance to other issues, may be dependent on the context. For example, in investigating understanding of inheritance among 12-16 year-olds, Engel Clough and Wood-Robinson (1985a) found that whereas nineteen per cent believed that mice with surgically removed tails would produce tailless offspring, only two per cent thought that gardeners' children could inherit calluses. The same authors also used two scenarios (survival of caterpillars and arctic foxes) to probe secondary school children's understanding of adaptation. They found inconsistency in use of pupils' frameworks across the two contexts – many responded that the foxes would adapt in response to a need for change, whereas the caterpillars would simply move to a more favourable environment (Engel Clough and Wood-Robinson, 1985b).

5.2 The main study

The main research questions as stated in chapter 1 are:

1. *How important do pupils regard biological conservation as being?*
2. *What biological concepts do pupils draw on in making decisions about conservation?*
3. *What values do pupils draw on in making decisions about conservation?*
4. *Are there recognizable features which characterize high quality decision-making discussions about conservation?*

To address these research questions it is necessary to capture underpinning data as outlined in chapter 1 (figure 1.1), and a number of different research instruments were used for this – a questionnaire-based survey approach to question 1, and a case study approach to questions 2, 3 and 4. The following sections describe these in relation to the main research questions.

5.2.1 Data collection methods for research question 1

(How important do pupils regard biological conservation as being?)

In order to probe the extent to which pupils value biological conservation, the approach taken here is to gauge where they mentally 'draw the line' with regard to what they think is worth conserving. This was considered at two levels. Firstly, focusing on biodiversity conservation as a fundamental component of sustainable development, exploring whether they regard species extinction as a justifiable consequence of some human economic activities. Secondly, focusing on the organisms themselves, eliciting views about which kinds of organisms they consider worth and *not* worth conserving. Identification of negative views can be as informative, if not more so, than focusing on positive values. An appreciation of the gaps between the views of children and those advocated by scientists can be useful to educators planning new teaching programmes in line with the science national curriculum.

405 pupils from four mixed-sexed comprehensive schools (city, suburban and semi-rural) in the south of England took part in this part of the study (details are shown in appendix 5.4). These pupils were either at the end of Year 10 or the beginning of Year 11, and were all above average achievers in science. They were given a questionnaire (the final version of which is shown in full in appendix 5.5), which sought responses to the questions listed in figure 5.1. The numbers of pupils from each school completing the questionnaire are shown in appendix 5.6.

There are several advantages of using questionnaires over other methods of collecting data - they can provide a large amount of data in a relatively short amount of time and at relatively low cost; they are generally more straightforward to administer and analyse; and they provide standardized responses with reduced possibility of misinterpretation due to the wording of the answer. However, while ticking boxes is comparatively undemanding, respondents may also find it restricting and frustrating. Another important consideration is that questionnaires offer little opportunity for the researcher to check the truthfulness of the responses; unlike interviews, which allow the researcher to note contradictory answers and probe matters further. There is also sometimes a tendency for the response options to be structured or limited in a way that reflects the researcher's thinking rather the respondent's, thus biasing the findings towards the researcher's way of seeing things (Denscombe, 1998).

The questionnaire was piloted with 59 pupils to attempt to minimise such potential disadvantages, and subsequent discussion and scrutiny of the answers indicated that they had all completed it without difficulty. All pupils in the pilot groups showed an adequate understanding of the terms 'commercial forestry' and 'intensive farming' and the meaning of 'conserve' and 'extinct' in the biological context. 405 pupils (216 girls and 189 boys) completed the final version of the questionnaire.

Wildlife conservation can be an emotive issue, and conscious steps were taken to avoid responses, particularly gender stereotypical responses, that might result from peer pressure. To ensure that pupils' answers best reflected their own real views, pupils were asked not to confer, and the questionnaire was administered during normal class time, under 'examination conditions' and under the supervision of their usual class teachers. Pupils were assured that it was not a test, and that only the researchers would see their individual responses. They were asked to think carefully about each statement and indicate their response by ticking the appropriate boxes.

The questionnaire was in two parts. In the first section, pupils were presented with a list of human economic activities that may be in conflict with biodiversity conservation, but which are also fundamental to economic growth or human quality of life and may be included in any strategy for sustainable development. The economic activities selected were known contributors to the destruction of natural or semi-natural habitats, and this is the major cause of current losses in biodiversity (Spellerberg and Hardes, 1992). Pupils were asked whether these activities were acceptable even if they threaten intelligent or beautiful species with extinction. This question was based on the findings of other authors (Stanisstreet *et al.*, 1993) that intelligent or beautiful animals receive the most positive attitudes. This would then present pupils with a 'best case scenario' – if any living things were worth saving it would be these.

The second section asked the pupils to note to what extent they agreed or disagreed with statements about conserving certain categories of organisms. These were chosen to span the whole attitude range. Mammals and birds are known to receive the most favourable attitude responses (Greaves *et al.*, 1993), and the categories at the other end of the spectrum, such as disease-carriers, viruses and human parasites, were chosen after informal discussion with some of the pupils who took part in the preliminary study. To explore this in more depth, the pupils in the main study were asked to provide reasons for any negative responses.

A Likert attitude scale was used with five options available for each question: *strongly agree*, *agree*, *uncertain*, *disagree*, and *strongly disagree*. The responses were coded on a five-point scale (essential = 5; not at all important = 1). A high score thus indicates a positive attitude and an average score of 3 represents a neutral attitude. Scores were then averaged to obtain an overall attitude rating among the respondents. The Likert scale is a reliable instrument for roughly comparing people (in a minimum sample size of around 100 respondents) with regard to a particular attitude (Oppenheim, 1992). The point scale provides more precise information about the strength of agreement or disagreement, and respondents generally prefer this to being given a simple agree/disgree option.
Attitude scales such as this are acknowledged as being fairly crude measuring instruments from which we must not expect too much. They do not provide us with deep insights into the thoughts and minds of individuals in absolute terms, but they serve to divide people roughly into a number of broad groups according to their particular attitudes, and place them on a continuum in relation to one another (Oppenheim, 1992). The main criticism of Likert scales is that the same average score may be obtained in different ways, thus raising the possibility that two or more identical scores may have totally different meanings. For example, the presence of similar numbers of strongly positive and strongly negative responses would effectively cancel each other out. For this reason, the pattern of responses is often more meaningful than the averaged score, and standard deviations are useful in this situation as a measure of the spread about the mean. It is also important to note that the neutral point (the '*uncertain*' category in this case) is not necessarily the midpoint between the two extremes. Respondents may select these midpoint scores due to a lack of attitude, a lack of interest, or a lack of knowledge about the issue.

However, as long as we do not forget that identical scores may have different meanings, the Likert scale is very reliable in ordering of people with regard to a particular attitude.

Figure 5.1
Questions asked in the biodiversity questionnaire
(the full questionnaire is in appendix 5.5)

Section 1
Do you think the following human activities are OK if they threaten an intelligent or beautiful species with extinction?
Commercial forestry
Intensive farming
Military or defence activities
Recreation or leisure activities
Building houses
Building roads
Industrial activities
Hunting

Section 2
We (humans) should try to:
a. Conserve all threatened habitats
b. Conserve all living things threatened with extinction
c. Conserve all animals threatened with extinction
d. Conserve all mammals threatened with extinction
e. Conserve all birds threatened with extinction
f. Conserve all plants threatened with extinction
g. Conserve all insects threatened with extinction
h. Conserve all disease-carrying species threatened with extinction (such as flies and mosquitoes)
i. Conserve all deadly bacteria and viruses threatened with extinction
j. Conserve all human parasites threatened with extinction (such as fleas, ticks and tapeworms)

If you disagreed or strongly disagreed with any of these, please say why.

Following analysis of the responses, (two weeks after pupils completed the questionnaires) semi-structured interviews were carried out with fifteen of the respondents, to help clarify the reasoning behind the responses given in the questionnaire. This was a smaller sample than I had hoped for, but there was only one 45-minute lesson available to carry out these interviews, and the teacher could not release more pupils at that time. These pupils were all from the same science class, and interviewed in their normal peer groups (one group of six, one group of five, and one group of four) during their normal science curriculum time, in a quiet room adjacent to the science laboratory. These brief interviews each lasted about fifteen minutes.

As well as being a primary means of gathering information, interviews are often also used in conjunction with other research methods to test hypotheses, follow up unexpected results, and help identify variables and relationships (Cohen and Manion, 1998).

Given the brief time available, the semi-structured interview approach was used as the most appropriate workable compromise between an inflexible and rigid structured interview, and an entirely unstructured approach, which could take an unpredictable direction. This compromise approach is often considered the most valuable (Wellington, 1996), using a broad checklist of questions (figure 5.2), while being fairly flexible over the range and order of questions asked, and allowing interviewees to discuss and develop ideas more widely.

Figure 5.2
Checklist of questions used in semi-structured interviews following analysis of biodiversity questionnaires

- Do you feel strongly in favour of any of the human activities mentioned in the questionnaire?
- How do you think each of these human activities affect living things?
- If you agreed to conserving 'all animals' did this include insects, etc?
- When answering the questions did you think of insects and tapeworms as animals?
- Where do you draw the line about conserving things?
- Which would you rather save, the deadly bacteria and viruses, the disease-carriers or the parasites?

Group interviews were obviously less time-consuming than one-to-one interviews, but there were other advantages to this approach. Wellington (1996: 30) states that

> *...interviewees may feel safer, more secure and at ease if they are with their peers (this may be especially true of infants, or even teenagers or teachers). They are also more likely to relax, "warm-up" and jog each other's memories and thoughts.*

There are also potential disadvantages of group interviewing such as the presence of dominant individuals who monopolise the discussion, or as Wellington (1996) points out, there may be individuals who "invisibly threaten" others by their presence. Without knowing the individuals well, it is difficult for an outsider to be aware of these subtle tensions between individuals. However, in this study I discussed such matters with their science teachers – as people witnessing the everyday interactions among the pupils – and they reassured me that they were not aware of any significant tensions of this nature. I made a conscious effort to offer all pupils in the groups opportunities to contribute to the discussions, and this was facilitated by seating them around a table to allow proper eye contact at all times.

5.2.2 Case studies

Research questions 2, 3 and 4 are addressed using a case study approach. This research takes an interpretive and semi-naturalistic approach to the case study, as described by Wellington (1996). It is interpretive in the sense that I am seeking to gain insights into pupils' decision-making by exploring perspectives and shared meanings, and although I am attempting to minimise intervention, I accept that the observer affects the observed – and the findings are *my* interpretation of reality. Rather than being 'experimental' research, i.e. carried out as a controlled, clinical laboratory experiment using experimental groups and control groups, it is 'semi-naturalistic' research in the sense that it takes place in a normal (natural) science classroom setting/context, but the activity itself is slightly unusual for the pupils.

Whereas research design based on questionnaire and test data give a limited view of children's learning, in-depth case studies are useful in helping to analyse and interpret the complexity of learning (Ratcliffe, 1999). Wals (1999: 26-27) describes it as an approach that

> *...allows for the learner to dig for meaning, as opposed to scratch the surface, by focussing on one concrete example for a longer period of time. Taking sufficient time to study a particular issue in-depth is essential and is preferred over studying multiple issues in a superficial way.*

A case study in educational research revolves around one single unit, which may be a single school, a single classroom setting within the school, or even an individual student or teacher (Wellington, 1996). Bogdan and Biklen (1982: 58) characterize a case study as

> *...a detailed examination of one setting, or one single subject, or one single depository of documents, or one particular event.*

But these single units do not exist in isolation and they are often closely interconnected, and an approach is often required that involves a wide range of different methodologies. This criticism about the importance of the context of the unit, and the extent to which findings can be generalised is often levelled against case studies. The unit may be seen as too subjective, and is a matter of judgement, which depends on the nature of the case study itself. Schostak (2002) cautions against a view of case studies as 'self-contained spheres' – a unit around which one draws an imaginary boundary.

> *The case is a convenient way of labelling a complex, a conglomeration, but dealing with a complex is not the same as dealing with a singularity. With a singularity, boundaries are clear and distinct; with complexes they are 'fuzzy' and confused, permeable at best.* Schostak (2002: 22)

He argues that case studies are only meaningful if

> *...the processes through which generalization becomes possible in the social world are the focus of the study....The case only appears after a series of explorations of the ways in which such generalizations are made by the actors involved; it does not precede those explorations.*(Schostak 2002: 23)

Case studies have been classified by several authors (Stenhouse, 1985; Bogdan and Biklen, 1982; Stake, 1994). Stake (1994) distinguished between three types: i) the intrinsic case study, which aims to gain a better understanding of a particular case because it is intrinsically interesting in itself; ii) the instrumental case study, where the actual case is of secondary importance and is chosen to gain a better understanding of an issue or to clarify a hypothesis; iii) the collective case study, focussing on a number of similar or dissimilar cases, which are chosen to generate theories about a larger collection of cases. I regard the present research as falling mostly into the third category; but these types are difficult to separate and it has elements of all three kinds.

5.2.3 Adolescents as the research population

Fifteen/sixteen year olds were selected for this study because they were nearing the end of their compulsory schooling and as such had completed a substantial part of the science curriculum. Many of them would never study science again as a formal subject and may consequently have limited opportunities to further their science subject knowledge. At this age, they may still be forming opinions on issues such as conservation, but may be mature enough to appreciate some of the complexities of the issues, and may have well-developed decision-making abilities. It is important here to recognize issues which may be relevant to the behaviour of adolescents engaged in decision-making discussions, particularly in terms of the status of adolescents' values, and the development of decision-making skills in adolescence.

5.2.4 The status of adolescents' values

Adolescence can be a turbulent time during which individuals are continually re-evaluating their rights and responsibilities, and the legitimacy and status of their values and actions are subject to confusion. Accountability in autonomous decision-making is encouraged in some areas and discounted in others. The legal system limits adolescents' rights to make personal decisions. For example, fifteen year olds are regarded in law as having the same criminal responsibility as adults, and acknowledged as understanding the moral implications of their actions. On the other hand they are not considered sufficiently mature to have electoral rights. Taylor *et al.* (1984) surveyed young people's opinions about the proper age for making personal decisions. The subjects' views were that the age for decisions depended on the type of decision being made. For decisions concerning everyday activities (such as friends, TV viewing and clothes) they believed that the age should be, on average, 12.3 years; the age for decisions about major life events (such as marriage and leaving home) should be, on average, 14.8 years; and the age for decisions about health (such as birth control and discontinuing medication) should be, on average, 15.1 years. Against this background of uncertainty about the status of their decisions, adolescents may have varying confidence in their own opinions on issues, and the teacher as an authority figure may or may not influence their opinions.

5.2.5 The development of argumentation and decision-making skills

In a review of research about risk-taking among adolescents, Furby and Beyth-Marom (1992) concluded that studies have produced conflicting evidence as to whether decision-making skills develop between adolescence and adulthood. However, there is some evidence that fifteen and sixteen year olds are as competent at making decisions as adults. Weithorn and Campbell (1982) presented twenty-four subjects, at each of the ages nine, fourteen, eighteen and twenty-one, with decision-making scenarios related to health care issues. The subjects were evaluated with respect to:

- understanding and making inferences from available information;
- ability to make a choice;
- attention to the relevant considerations in deciding;

- reasonableness of the decision as judged by relevant professionals.

The results of the study showed that the fourteen year olds were as competent as the older subjects based on these criteria. However, the authors acknowledged that this competency may depend to some extent upon the specific decision-making context, and they caution against generalising, as the subjects were white, healthy, academically able individuals from middle class American background.

In a later study, Mann, *et al.* (1989) argued that competent decision-making can be demonstrated by the nine "Cs": choice; comprehension; creativity; compromise; consequentiality; correctness; credibility; consistency and commitment. They concluded that:

> *...by age 15 years adolescents have achieved a reasonable level of competence in most of the nine components identified.* (Mann, *et al.*,1989: 275).

There are also contrasting findings in the literature about the time required to develop group argumentation skills. Zohar and Nemet (2002) found significant improvements in group argumentation about human genetics after relatively short intervention, whereas other studies suggest it is a long-term process requiring recurrent opportunities to engage in argumentation (Osborne *et al.*, 2004a; Zoller *et al.*, 2002). However, Osborne and his colleagues strongly believe that all these findings show that

> *'...improvement at argumentation is possible if it is explicitly addressed and taught.'* (Osborne *et al.*, 2004a: 1015)

5.2.6 The status of talk as a source of data

It is largely through listening and talking that we locate ourselves socially, and develop our concepts of self, by recognizing our own values, rights and obligations, and those of others (Edwards and Westgate, 1987). Talking provides an opportunity to learn how to negotiate communicatively, and this process is described by Bruner (1984) as:

> *...the very process by which one enters the culture.*

Talk is thus an important and rich source of data, and its close inspection can help to reveal how pupils strive to assimilate knowledge and transfer it to new situations. However, it is necessary to guard against over-reliance on transcripts alone as evidence; more is understood than ever said, and classroom interaction is shaped by the range of pupils' experiences, in and out of school, so we cannot always take it at face value.

5.2.7 Using ground rules and procedural guidance

Research suggests that guidance in appropriate ground rules and procedural guidelines for collaborative discussion helps pupils to organize their discussion more effectively (Duschl and Osborne, 2002; Osborne et al, 2001a; Ratcliffe, 1997; Keogh *et al.* 2001). Herrenkohl *et al.* (1999) looked at the role of guidance for discussions among upper elementary school pupils, to help build theories and models from data. Their work highlighted the importance of establishing procedural guidelines in designing activities which promote argumentation. There is of course a risk that structured rules might reduce spontaneity and inhibit the flow of the conversation; but in reviewing conditions for productive small groups, Cohen (1994) warns that an absence of guidelines and highly structured guidelines can have an equally negative effect on the quality of discourse, and she emphasises the importance of providing guidance for activities which require collaboration, to encourage dialogic discourse among the pupils. It is on this basis that I chose to provide pupils in the preliminary study with a decision-making framework (discussed in section 5.1.1), and later in the main study (discussed in section 5.2.10.4). Pupils were asked to follow the sequence of questions in the framework to help guide them through the decision-making process. They were also asked to consider any factors they thought important in making these decisions, but to focus particularly on the scientific information needed. In order to keep teacher intervention to a minimum (see next section), save time, and preserve a semi-naturalistic approach (section 5.2.2), only one further ground rule was set - that recommended by Dillon (1994) of encouraging pupils to challenge each other's ideas but not their character.

5.2.8 Teacher and researcher intervention and influence

Discussion can be interrupted and stifled by teacher intervention. There is often a tendency for the self-directed nature of pupil talk to disappear when the teacher arrives (Harwood, 1989). Cohen *et al.* (1989) report on a finding in the U.S. that the rate at which the teacher used direct instruction when students were working in small groups, was negatively related to the rate at which pupils talked and worked together. If the teacher intervenes, assuming the position of an authority figure, pupils will not assume responsibility for their task engagement.

In analyzing argumentation among 7-9 year olds as an aspect of learning in science education in primary classrooms, Keogh *et al.* (2003) found that the teacher's presence had a clear impact on the conversations. With the teacher present, the children no longer talked to each other, but tended to engage in dialogue with the teacher. The teacher became the most dominant voice in the discussion, controlling the direction of the conversation, asking direct questions of individuals and adjudicating when they responded. The authors viewed this as a common occurrence, reporting that

> *...when transcripts recorded the presence of a teacher the shift in the group dynamics appeared to disempower the children and reduce the length and intensity of their involvement in argumentation.* (Keogh *et al.*, 2003:16)

Cohen (1994) argues that there is thus a need to minimize teacher intervention by providing sufficient structure to guide pupils through the task, but not enough to stifle their opportunities to think for themselves and gain the benefits of interaction.

The nature and degree of participant observation in case study research is an important consideration, i.e. the extent to which the researcher is observer and participant. Hammersley and Atkinson (1983: 93) provide a useful spectrum of observation:

complete participant	Participant as observer	observer as participant	complete observer

The 'complete participant' role has been used in studies where, for example, the researcher poses as one of the group and the research activities are hidden. In the present study, my role is largely at the other end of the spectrum, observing rather than participating, and a particular feature of the peer-group discussions is to observe pupils' interaction without teacher/researcher intervention. Despite this semi-naturalistic, non-interventionist approach, I am aware that my very presence in the classroom rendered the situation unusual for the pupils. To this extent it was a novel situation, but I remained detached from discussions as much as possible and I was ignored by the pupils once discussions were underway. The novelty of the tape-recorders also wore off after a few minutes, and raised very few comments. This, coupled with off-task talk which they would probably prefer teachers not to hear, suggested that the tape-recorders had little or no effect on their discussions.

I am also aware that my own values and experiences have an impact on the research, and although I have endeavoured to remain objective and impartial throughout the study, it is important for me and for anyone who reads this research to bear in mind that as an educator in biology I have a strongly held belief and professional interest in the importance of raising pupils' ability to engage in making informed decisions about conservation issues, and I am strongly in support of maximising conservation of the world's biodiversity and genetic resources, on both anthropocentric and biocentric grounds. Researchers are often called upon to include their relevant biographical details as part of their analysis (Denscombe, 1998), and I believe that the reflexive account provided here in considering some possible limitations of the work enables me to reduce subjectivity, and allows the reader to make a more accurate judgement about the claims I make in this thesis.

5.2.9 Cooperative learning in small peer groups

My view in this study supports that of Duschl and Osborne (2002) that discourse promotes the process of reflection, through which pupils acquire conceptual understanding. Glaser (in Bransford, *et al.*, 1999: 19) identifies the importance of 'social participation and social cognition' and as one of seven main principles of instruction:

> *The social display and social modelling of cognitive competence through group participation is a persuasive mechanism for the internalization and acquisition of knowledge and skill in individuals. Learning environments that involve dialogue with teachers and between peers provide opportunities for learners to share, critique, think with, and add to a common knowledge base.*

Driver *et al.* (1994b) suggest that discussion with peers is important in the social construction of knowledge by providing opportunities for individuals:

- to make previously implicit ideas explicit and available for reflection;
- to clarify their own ideas by articulating them in front of others;
- to build on each other's ideas to reach a solution.

Group size is an important factor to consider. McClelland (1983) stressed the need for groups not too big as to inhibit members or cause sufficient delay before a member can make a contribution. This could create an 'inner' group of major contributors and an outer docile, disaffected group.

> *Lack of contribution does not necessarily mean absence of participation but assumptions about potential benefits require even greater acts of faith.*
> McClelland (1983: 131)

Small group discussion is not a widely-used pedagogic practice in science classrooms (Newton *et al.*, 1999), but Osborne *et al.* (2001) claim that for pupils to engage properly in the process of argumentation it is necessary for them to work in small groups. Small groups offer special opportunities for substantive conversation and active learning (Nystrand, 1986), and there is now a substantial body of research to suggest that the benefits of cooperative learning hold true for pupils of all ages, across all subject areas, and for a wide range of tasks including problem-solving and memory skills (Johnson and Johnson, 1985; Cohen, 1994). Encouraging children to work in small groups has been used to good effect in Britain and abroad as a strategy for promoting mutual acceptance among pupils in classes with a range of academic and ethnic heterogeneity; but also for improving learning and the development of higher order thinking skills. Indeed, some researchers (e.g. Noddings, 1989) have taken a social constructivist view that higher order thinking cannot be achieved without high-level discourse within small groups.

While peer groups may sometimes impose pressures on individuals to conform and relinquish autonomy, Mann *et al.*, (1989) believe that their influence should not be overestimated. They cite the work of other authors who view that while peer groups may exert a strong influence on decisions about personal habits and style (such as dress and music), in most families parents have a stronger influence over decisions about key values (Feather, 1980), decisions of long-term consequence, such as subject and career choice (Coleman, 1980), and pregnancy decisions (Rosen, 1980).

The pupils in the present study are interacting in small peer groups without immediate teacher intervention, and this is a key feature of 'cooperative learning'. Cohen (1994: 3) defines cooperative learning as

> *...students working together in a group small enough that everyone can participate on a collective task that has been clearly assigned. Moreover, students are expected to carry out their task without direct and immediate supervision of the teacher.*

She stresses that cooperative learning should not be confused with small groups that teachers sometimes set up for direct instruction, such as reading groups. Group productivity can be measured by comparing the individual rates of participation of pupils within the group; but there is some contradictory evidence about the relationship between achievement gains and frequency of interaction. However, in her review of literature about productivity in small groups, Cohen (1994) concludes that a linear relationship is most likely if pupils are engaged in: i) tasks that are inherently *group tasks* (i.e. tasks that cannot be carried out by individuals alone) requiring exchange of ideas and information, and ii) tasks that do not have one right answer, and are 'ill-structured'. From this she derives the proposition that:

> *...given a problem with no one right answer and a learning task that will require all students to exchange resources, achievement gains will depend on the frequency of task-related interaction.* Cohen (1994: 8)

The decision-making discussions in the present study are semi-structured group tasks of this nature, and the relationship is worthy of exploration as one possible underlying factor that promotes high quality discussions.

The following sections describe the methodology used to further explore how the peer groups engage in the decision-making process, with a particular focus on identifying features of high quality decision-making, argumentation and other aspects of group behaviour, which could hopefully be recognized, nurtured and evaluated by science teachers.

5.2.10 Data collection methods for research questions 2, 3 and 4

It is logical to consider these three questions together because much of the data was collected from pupils in the same case study group and the same audio-taped sessions.

<u>Research question 2:</u>

What biological concepts do pupils draw on in making decisions about conservation?

<u>Research question 3:</u>

What values do pupils draw on in making decisions about conservation?

<u>Research question 4:</u>

Are there recognizable features which characterize high quality decision-making discussions about conservation?

Although the pupils' actions (personal views and peer interaction) are at the heart of the study, it was important to gather background information about factors which might influence their actions. As outlined in chapter 1 (figure 1.1) and discussed further in chapter 3, pupils' actions may depend upon the views and pedagogical approaches of their teachers, and the teachers' actions may in turn rely on the formal school curriculum and the views of experts in the field of conservation. The following sections explain how this background information was collected, and table 5.5 at the end of this chapter summarises the key data collected relating to each main research question, with the number of subjects involved in each area of the research.

5.2.10.1 The place of biological conservation in science lessons

To provide some background information against which teachers' views and pupils' views could be considered, a short questionnaire (shown with summarised responses in appendix 7.1) about how and when aspects of conservation were taught in schools was given to twenty-three experienced science teachers. These teachers were mentors to trainee science teachers on the Postgraduate Certificate of Education programme at the University of Southampton.

5.2.10.2 Experts' views on biological concepts underpinning conservation

Chapter 2 discussed how effective conservation programmes require a thorough understanding of the biology of the organisms concerned. To explore the concepts that pupils draw upon, it was necessary firstly to identify these concepts by consulting biological conservation 'experts', and it is also useful to compare the pupils' discussions with the views and expectations of science teachers. Conservation management also depends on concepts from physical (non-biological) science, geography, geology, and management, but due to time and space constraints the purpose of this research is to explore the underpinning *biological* concepts only. A logical place to begin considering which biological concepts underpin conservation was to consult expert scientists working in the field of conservation biology. Twelve such experts were selected, each with extensive experience as both theorists and biological conservation managers. Structured interviews were carried out with four experts in Britain from universities, and environmental government and non-governmental organisations. I drew up a provisional list of biological concepts, and asked these experts to construct the list of biological concepts they considered 'essential' for 16 year-old school leavers to study in order to make decisions about biological conservation issues (the interview schedule is shown in appendix 5.7). These experts' views were supplemented by email discussions or telephone interviews with eight more experts from Australia, Japan, the USA and the UK (details are shown in appendix 5.8). The final list was re-circulated among the experts to form a consensus of views.

5.2.10.3 Science teachers' views on concepts and values underpinning conservation

As discussed in chapter 3, the views and pedagogical approaches used by science teachers might also influence pupils' actions. I therefore provided a sample of thirty-four science teachers with the experts' list of concepts, and asked how important they thought the individual concepts were for pupils to study in order to make decisions about biological conservation issues. All were experienced science teachers working in the south of England and were mentors to local trainee teachers. Ten of these teachers were purposefully sampled as the science teachers of the pupils who took part in the study. Teachers rated the concepts on a Likert five-point scale of importance, and were then provided with the brief for the puffin conservation scenario (the same as that given to pupils – see appendix 5.2), and asked what values and biological concepts they thought pupils would include while making decisions about the issue. The questionnaire given to the teachers is shown in appendix 5.9.

5.2.10.4 Pupils' views and actions

Pupils' views and actions are at the heart of this study. The following section gives details of the data-collection methods used as a result of the findings from the preliminary study (outlined in section 5.1.3). Decision-making exercises were given to 131 fifteen year old pupils (61 girls and 70 boys) from top science sets at four different co-educational schools in the south of England. They took part in twenty-four small peer groups (seventeen groups of six, one group of five, and six groups of four pupils), these were the groups they normally worked in during science lessons. Above average achievers in science were chosen because i) discussions among high achievers might be expected to produce the highest quality of group decision-making without teacher intervention, or explicit training in argumentation, and ii) there is some evidence that pupils with higher levels of civic knowledge are

> *...more likely to expect to participate in political and civic activities as adults.*
> (Kerr *et al.*, 1995: 4).

The tasks related to one of two real conservation issues, one concerning the conservation of elephants in Africa, the other the conservation of puffins (a familiar British seabird) in competition with rabbits. Elephants, puffins and rabbits were chosen for the study as species that these pupils would have a relatively strong desire to conserve. They are all familiar species to the pupils, and they can be regarded as 'intelligent' or 'beautiful', categories identified by Greaves *et al.* (1993) as receiving the most positive attitudes among young people.

In introducing the materials to pupils, care was taken to avoid explicit mention of the concepts listed by experts. The scenarios were similar in the sense that elephants and puffins are endangered species. However, they differ in that elephant conservation is very much a social issue, having considerable impact potentially on local economies through tourism, the ivory trade and crop destruction. The puffin conservation scenario on the other hand, is presented as a less complex issue in that there is no significant impact on the local human population. Puffins are seabirds which nest in burrows in the soil above cliffs and islands around the coast of Britain. Expanding rabbit populations cause soil erosion and compete for space.

The data needed to explore pupils' views and actions was collected in five steps:

1. *A pre-test questionnaire.*
2. *Audio-taping of peer-group discussions, in conjunction with a decision-making framework.*
3. *A post-test questionnaire.*
4. *A final questionnaire.*
5. *A semi-structured interview with each peer-group.*

Pre-test and post-test questionnaires

These were provided to reveal changes in individuals' views about the conservation scenarios.

The pre-test questionnaire introduced the conservation scenario by way of a picture stimulus (appendix 5.1) and brief written information about the animals involved (appendix 5.2). This stated the scenario and sought the pupils' personal view by asking the question:

What do you think should be done about the puffin/elephant problem, why, and how?
The 'how' and 'why' tags on this question were included in an attempt to draw out the functional and justificatory aspects of respondents' decisions, recognized as key features of high quality reasoning (Kuhn *et al.*, 1997), as discussed in section 4.4.1. Slater (1982) also endorses the use of such questions to encourage pupils to explore their opinions and become more aware of the values underlying their choices.
Pupils were also asked about their interests and experiences in relation to wildlife conservation. Wildlife conservation can be an emotive issue, and conscious steps were taken to avoid responses, particularly gender stereotypic responses, that might result from peer pressure. To ensure that pupils' answers best reflected their own real views, pupils were asked not to confer, and the questionnaire was administered during normal class time, under 'examination conditions' and under the supervision of their usual class teachers. They could ask the teacher questions about the text of the questionnaire if anything was unclear. Pupils were assured that it was not a test, and that only the researchers would see their individual responses. The text of the questionnaire is shown in appendix 5.10.
The post-test questionnaire was administered no more than a week after the decision-making activity (usually during the next science lesson), and under the same conditions as the pre-test questionnaire, and asked pupils exactly the same question about their view of solution to the problem, with exactly the same amount of space to respond. They were also asked in this questionnaire for their thoughts about discussing problems in groups like this, as opposed to making decisions on their own (appendix 5.11).

Research on the quality of decision-making and argumentation (discussed in chapter 4) suggests that one way of exploring such underpinning factors is to consider the success of the discussion based on the extent to which individuals modify their thinking during the discussion, particularly in terms of justifying their opinions (Toulmin, 1958; Osborne *et al.*, 2001a). The approach taken here therefore was to measure the extent to which individuals changed their thinking, by comparing and coding their pre-test and post-test views in two respects. Firstly, by looking for responses that advocated or rejected culling – an issue central to these conservation scenarios. Secondly, by using the hierarchical scheme shown in figure 5.3. This draws on elements proposed in the pre- and post-test scheme on personal reasoning proposed by Kuhn *et al.* (1997), outlined in section 4.4.1, the validity of which is shown in section 4.4.3.

Figure 5.3

Hierarchical scheme for the quality of personal reasoning about biological conservation (based on principles proposed by Kuhn *et al.*, 1997)

Level 1. Nonjustified arguments. Decisions that lack any supporting justification.
Level 2. Nonfunctional, partially justified arguments. There is an attempt to justify the decision, but without considering the practical nature of the decision.[1]
Level 3 Nonfunctional, justified arguments, with no consideration of alternatives. There is an attempt to justify the decision in the form of a simple assertion supported by a single line of argument with some practical basis. There is no consideration of the comparative effectiveness of alternatives.
Level 4. Nonfunctional, justified arguments considering alternatives. There is an attempt to justify the decision, with some consideration of the comparative effectiveness of alternatives, but without explicit consideration of the function or purpose of biological conservation.
Level 5. Functional, justified arguments considering alternatives. There is an attempt to justify the decision, with explicit consideration of the function or purpose of biological conservation, and of the comparative effectiveness of alternatives.

This scheme could be used as a measure of the level of individual reasoning, but also to identify the pupils who demonstrated improved qualitative reasoning between the pre-test and post-test responses. As discussed in section 4.4.1, changing one's mind is a product of rational thought, which is a feature of good quality argument (Osborne *et al.*, 2001a). It could therefore be reasoned that the group discussions of high quality were those containing pupils arguing at level 5, and/or those containing pupils who 'changed their thinking' by moving to level 5 from a lower level. Groups containing these individuals, could then be investigated to see whether these supposedly 'high quality' discussions exhibit any readily identifiable common features. I am referring to these groups as the 'high quality' discussion groups (asterisked in table 5.5 and discussed later in chapter 9).

Audio-taping peer-group discussions in conjunction with a decision-making framework.
As previously stated, the same pupils were divided into twenty-four 'peer groups' (4-6 per group, some single sexed and some mixed), which were small groups of their own choice (i.e. with friends), and tended to be groups they often worked in as part of their normal

[1] There were a substantial number of pupils who partially justified their decisions using tautological statements (e.g. "*Deport the rabbits so that they are no longer present.*"), or statements relating to biocentric values (as described in section 2.7.2; e.g. "*We shouldn't kill animals because it's wrong.*"). Although these values are not necessarily regarded as less important or less worthy than anthropocentric values, the arguments did not advance any practical solution to the problem.

science lessons. This grouping was organised on the basis that peer groups are likely to be more relaxed in each other's company (Wellington, 1996; see section 5.2.9) and encourage a greater degree of reflection.

Pupils' conversations about the conservation issues were audio-taped with their (and their schools') consent. Audio-taping had an advantage over written responses in that the *context* in which words and terms were used could be analysed. Pupils were arranged around a table, and tape-recorders were placed in the centre of the table. Pupils were asked to put name cards in front of them, so that I could make a note of their names and features of their voices to assist later analysis of who was speaking at particular points during the discussions.

As with the pre-and post-test questionnaires, each group was provided with the colour photographs of the animals involved (appendix 5.1), and the written brief about the conservation scenario (appendix 5.2), and they were given a decision-making framework to guide them through their discussion, based on a model used with pupils of the same age by Ratcliffe (1997). This version of the framework (figure 5.4 and appendix 5.12) was more detailed than that used in the preliminary study, as the discussion sessions were longer allowing pupils time to review the decision-making process. Ratcliffe's framework in turn drew on extensive research on decision-making in theory and practice using normative and descriptive decision-making models (outlined in section 4.4.2). Pupils in the present study were asked to follow the sequence of questions in the framework to help guide them through the decision-making process. They were also asked to consider any factors they thought important in making these decisions, but to focus particularly on the scientific information needed. As mentioned in section 5.2.7, the one ground rule set was that recommended by Dillon (1994), to challenge a person's ideas not their character; but to keep teacher intervention to a minimum, I made no attempt to enforce this rule.

Figure 5.4
Revised version of decision-making framework (after Ratcliffe, 1997)
(full version of the sheet given to pupils is shown in appendix 5.12)

DECISION-MAKING GUIDE

Follow these steps and note down the answers to the questions as you go.

1. OPTIONS
What are the options?
(Discuss the possible solutions to the problem and list them in the first column of the table overleaf.)

2. CRITERIA
How are you going to choose between these options?
(Discuss the **important** things to consider when you look at each option, and add them to the table.)

3. INFORMATION
Do you have enough information about each option?
What science is involved in this problem?
What extra scientific information do you need to help you make the decision?

4. ADVANTAGES/ DISADVANTAGES
Discuss the advantages and disadvantages of each option, and add them to the table.

5. CHOICE
Which option does your group choose?

6. REVIEW
What do you think of the decision you have made?
How could you improve the way you made the decision?

The audio-tapes would obviously not capture visual responses, or all the background utterances, but it would encapsulate the main features of the conversations. The taped discussions were listened to several times, and transcribed in order to gain a picture of processes undertaken during the course of the discussion. The content of individual utterances was recorded and obvious inflexions of voice were noted (e.g. questions, emphasising points, raising voices). The transcripts were analysed for clear mention of values and biological concepts, although the frequency with which these concepts and values were raised was not measured. They were also analysed for more subtle peer interaction to explore the nature of the decision-making process, and the level of group argumentation using the model proposed by Osborne *et al.* (2001a) (see section 4.4.1).

Several attempts were made to find an appropriately detailed coding system before settling on the final version. Off-task talk was omitted from the transcripts, although the time spent off-task was measured to see if this related to quality of discussion. With the groups of six pupils, it was not possible to associate each utterance with specific individual pupils, but longer utterances were noted, again to see if this could be a sign of quality of discussion as claimed by Mercer *et al.* (1999) described in section 4.4.1.

Final questionnaire

This was administered just prior to the end of the pupils' compulsory schooling in Year 11, and under the same conditions as in the pre and post-test questions. Its purpose was to check views at the end of their compulsory schooling after they had completed the whole science National Curriculum – by comparing their views, interests and experiences with those stated in the pre-test and post-test responses.

The questionnaire also sought to check which biological concepts they thought relevant to conservation, using the list of concepts that professional conservation biologists regarded as essential in understanding conservation issues (appendix 5.13). This is particularly important to discover at this stage, as many of them would never receive any more formal education in this area of the curriculum. [The list also included one item ('human skeleton') which has little relevance to conservation issues, as a means of gauging whether pupils were ticking items at random, or without reading them].

Semi-structured interviews with each peer-group

The value of engaging pupils in semi-structured interviews was discussed in section 5.2.1. These interviews took place at the end of the pupils' compulsory schooling (almost one year later), i.e. when they had completed the science curriculum. This was carried out for ten to fifteen minutes with each group to explore memories of the tasks, to see what they recalled about the issues and the decision-making process, to see what science and values they recalled drawing on, and to see how motivating the exercise was.

Some pupils had obviously left or were new since the decision-making exercise. The latter were invited to join the interview sessions for their own interest, but as passive non-participants. The interview schedule is given in appendix 5.14, but the basic questions were:

- How did you work as a group to make the decision? (including thoughts about perceptions of group leaders, who makes the decisions in the group, who's best at science, etc.).

- What do you remember about the issues and decision-making tasks.
- Can you remember any of the steps in the decision-making guide?
- Can you remember any views on the subject that were different from yours?
- Can you remember any science that your group considered to help make the decision?
- What decision did you make? (if any)

These interviews were audio-taped, and fieldnotes were taken throughout.

5.3 Summary

Decision-making tasks were trialled and modified accordingly for the main study. The preliminary work presented in this chapter indicated that when suitably motivating conservation scenarios are selected, peer groups of pupils can remain engaged in discussion without teacher intervention. The teachers of the three classes sampled in the preliminary study claimed to have markedly different approaches to teaching about socio-scientific. Despite this, there was little difference in the scientific ideas, the values and the suggested solutions to the problems raised by pupils from the three schools. This indicated that it would be appropriate to include pupils from several schools in the main study, provided they were of similar ability in science. A number of sets of data are needed to explore each research question, and this requires a selection of research methods. Analysis began as soon as data was collected, and this analysis guided further data collection. The key data collected related to each research question are summarised in table 5.5, and the findings of the analysis are presented in the following chapters in the same order.

Table 5.5
Summary of key data collected relating to each main research question, with the number of subjects involved in each area of the research.
* refers to the five 'high quality' discussion groups revealed later in chapter 9, containing pupils who 'changed their thinking' by moving to level 5 argumentation from a lower level (as described in figure 5.3)

Main research questions	Data collected to support the research question	Number of people involved
Question 1: *How important do pupils regard biological conservation as being?*	• Pupils' views on the importance of economic (human) activities in relation to conservation. • Pupils' views on the relative importance of conserving habitats a range of organisms.	405 pupils 405 pupils
Question 2: *What biological concepts do pupils draw on in making decisions about conservation?*	• Background data about how and when biological conservation is taught in schools • Conservation experts' views • Science teachers' views • Biological concepts discussed by pupils	23 teachers 12 'experts' 24 teachers 131 pupils
Question 3: *What values do pupils draw in making decisions about conservation?*	• Science teachers' views on values • Values discussed by pupils	24 teachers 131 pupils
Question 4: *Are there recognizable features which characterize high quality decision-making discussions about conservation?*	• Individuals' pre-test/post-test change in thinking about culling • Comparing individual decisions about culling with group decision • Pre-test/post-test change in level of personal reasoning (after Kuhn *et al.,* 1997) • Quality of argumentation (after Osborne *et al*., 2001a) • Features of group behaviour (after Gayford, 1992; Hogan, 1999 Hogan, 2002) • Equality of participation within groups (after Cohen, 1994) • Proportion of time group spent on task • Inclusion of 'long utterances' (after Mercer *et al*., 1999)	131 pupils 131 pupils 131 pupils 23 pupils* 23 pupils* 23 pupils* 23 pupils* 23 pupils*

Chapter 6

How important do pupils regard biological conservation as being?

Introduction

This chapter presents findings relating to the first main research question:

How important do pupils regard biological conservation as being?

Two dimensions have been identified in chapter 5 as important in seeking to answer this question:

i) the extent to which pupils regard species extinction as a justifiable consequence of human activities, and ii) the extent to which pupils feel certain organisms are worth saving from extinction (methodology in section 5.2.1).

Section 6.1 compares results for all four schools to see whether there is any significant difference between the responses. Section 6.2 explores pupils' views on the importance of human activities in relation to conservation, and section 6.3 looks at their views on the relative importance of conserving a range of organisms. Chapter 3 discussed the limited evidence found in the literature that there may be gender-related differences in the nature of environmental understanding (section 3.2) and views on conservation (section 3.4). The sections in this chapter therefore focus on gender differences to explore this matter further. The chapter ends by probing the reasoning behind pupils' negative responses towards conserving certain kinds of organisms.

6.1 Comparison between the responses of pupils from each of the four schools.

This was based on the questionnaire (appendix 5.5) given to 405 pupils from four different schools, as described in section 5.2.1. Table 6.1 gives a breakdown of the numbers of girls and boys who completed the questionnaire at each school.

An important first step in analysing the questionnaire responses was to look for any significant differences in the patterns of responses of the four school groups. If these four sets of results are not significantly different, it would be possible to merge them and treat them together as one larger dataset. Significant differences were measured for each of the categories surveyed in the questionnaire using a chi-square test of independence (Hinton, 1999). Pupils' responses are shown in full in appendix 6.1. Details of chi-squared calculations are shown in appendix 6.2, and these show that there was no significant difference (at 0.05 level of significance) in the patterns of responses of the four schools regarding: i) the importance of biological conservation in relation to economic (human) activities, and ii) the importance of conserving habitats and a range of organisms. The results of the four schools were therefore merged and subsequently analysed collectively as one large set of data.

Table 6.1
Pupils completing the final version of the questionnaire about the importance of biological conservation in relation to economic (human) activities (405 pupils in total; 216 girls and 189 boys)

	Girls	Boys	Total
School 1	54	34	88
School 2	41	52	93
School 3	63	60	123
School 4	58	43	101
Total	216	189	405

6.2 Pupils' views on the importance of economic (human) activities in relation to conservation

To gain a clearer idea of where these pupils 'draw the line' with condoning human activities, it is helpful to focus on what they regarded as an unacceptable threat to species extinction, i.e. the negative responses to the questions. Using the raw data in appendix 6.1, pupils' negative responses to human activities are highlighted in table 6.2 (and presented in figure 6.1). Most pupils, girls and boys, viewed species extinction as an unacceptable consequence of activities associated with hunting, industry, recreation/ leisure, road-building, housing and military/ defence activities, in decreasing order. However, there was a greater degree of uncertainty, among girls and boys alike, about intensive farming (44% of girls, 50% of boys) and commercial forestry (46% of girls, 59% of boys), and only a minority committed themselves to stating that these activities were unacceptable.

On interviewing pupils it became apparent that there was considerable confusion about how farming, and particularly forestry could really contribute to the decline of species. Many pupils were of the opinion that most of our wildlife lives on farmland (regardless of agricultural practices), and that all forests (including monocultures) are generally good for wildlife.

One girl summed this up by commenting:

> *I don't think forests can cause species to become extinct – we need more forests.*

This indicates a need for consideration within the science curriculum of specific widespread practices, including farming and forestry, when teaching about the environmental impact of human activities. Some pupils may cover these aspects in geography, but it should be noted that geography is no longer statutory at key stage 4 (i.e. for pupils over 14 years old), so many pupils would not have the opportunity to consider these topics at an older age, towards the end of their compulsory schooling.

Table 6.2
Responses to the question: Do you think the following human activities are OK if they threaten an intelligent or beautiful species with extinction?
(405 pupils in total; 216 girls and 189 boys. Numbers are given here as percentages; negative responses – i.e. aspects regarded as unacceptable - are highlighted)

Activity	**%Yes**			**%No**			**% Uncertain**		
	Girls	Boys	All	**Girls**	**Boys**	**All**	Girls	Boys	All
Commercial forestry	17	21	19	**37**	**20**	**29**	46	59	52
Intensive farming	16	24	20	**40**	**26**	**34**	44	50	46
Military/ defence	4	32	17	**67**	**34**	**52**	29	34	31
Recreation/ leisure	4	21	12	**70**	**63**	**67**	26	16	21
Building houses	4	17	10	**61**	**51**	**56**	35	32	34
Building roads	3	22	12	**77**	**50**	**64**	20	28	24
Industry	1	14	7	**81**	**67**	**75**	18	19	18
Hunting	0	9	5	**89**	**80**	**84**	11	11	11

The possibility of differences between the environmental views of boys and girls is well-documented although seldom proven (as discussed in section 3.4), and it is a factor that may influence discussions about biological conservation. The negative responses of boys and girls (shown in appendix 6.1) were therefore compared statistically and shown in table 6.3, and the method of calculation is shown in appendix 6.3.

For each category, more girls than boys rejected the activity (figure 6.1), and there is a statistically significant difference between the numbers of girls and boys who rejected each activity, with the exception of recreation/leisure activities.

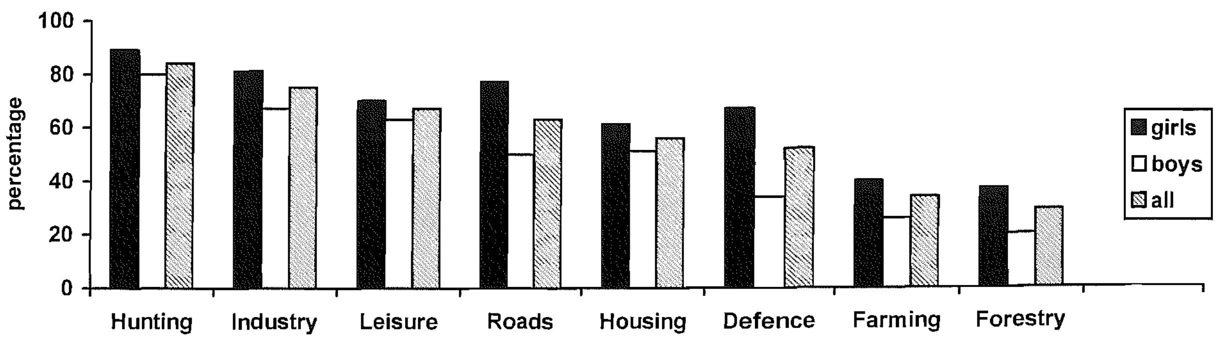
Table 6.3
Chi-square (χ^2) comparisons between the numbers of girls and boys who rejected each human activity as an acceptable threat to species extinction.
(Numbers are taken from the raw data in appendix 6.1; method of calculation is shown in appendix 6.3).

Activity	χ^2 with one degree of freedom	Significance of difference between girls and boys
Commercial forestry	14.38	p< 0.01 (**very significant**)
Intensive farming	10.60	p< 0.01 (**very significant**)
Military/ defence	31.10	p< 0.01 (**very significant**)
Recreation/ leisure	3.79	p> 0.05 (not significant)
Building houses	5.68	p< 0.05 (**significant**)
Building roads	9.19	p< 0.01 (**very significant**)
Industry	3.96	p< 0.05 (**significant**)
Hunting	4.68	p< 0.05 (**significant**)

The largest gender-related difference in opinion was over military/ defence activities. Although most girls (67%) rejected the relative importance of military or defence activities, only 34% of boys found this unacceptable, and a further 32% of boys accepted it. Subsequent interviews revealed strongly polarised views between the sexes on the importance of military activities. One boy reflected the views of many by saying

We need to defend our country at all costs. If there is a war, we might not have any animals left to look after anyway...or houses, or factories or anything!

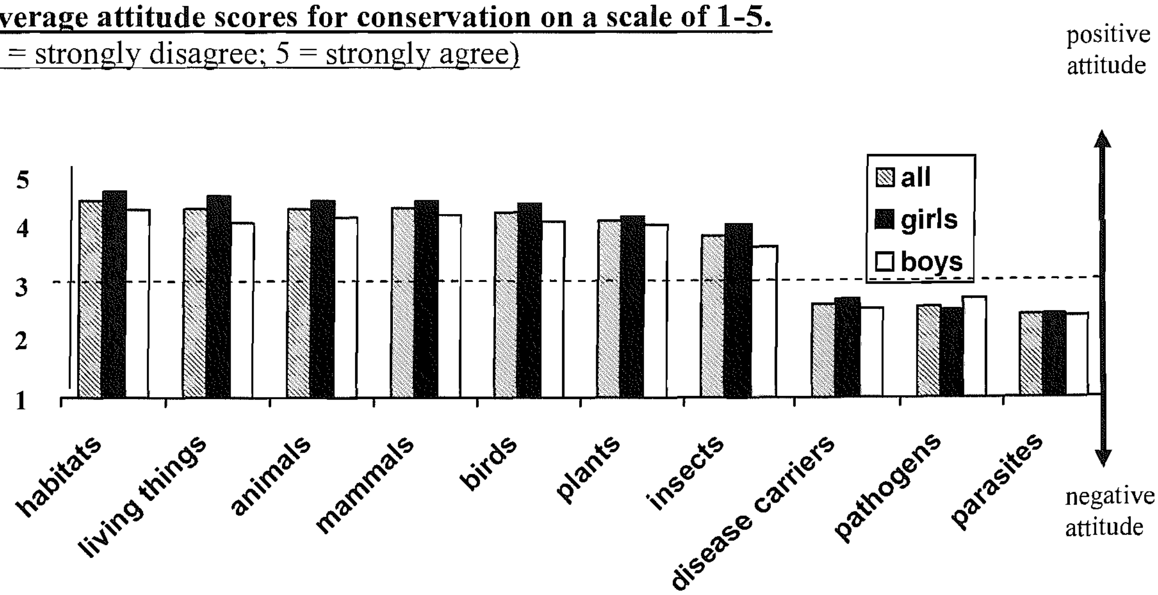
Figure 6.1.
Percentage of pupils giving negative responses to the question: Do you think the following human activities are OK if they threaten an intelligent or beautiful species with extinction?



6.3 Pupils' views on the relative importance of conserving habitats and a range of organisms.

Responses to the question: *We (humans) should try to conserve: all mammals [etc.] threatened with extinction,* are shown in appendix 6.4 (the questionnaire is in appendix 5.5). When five-point Likert scale values are assigned to these responses collectively (e.g. strongly disagree = 1, and strongly agree = 5) an indication of overall views emerges for each category, i.e. a score above 3 is positive, and below 3 is negative. These collective results (in figure 6.2) show that pupils generally have a positive attitude to conserving all categories except disease-carriers, pathogens and parasites. It also shows that for all categories except disease-carriers, pathogens and parasites, girls demonstrated a more positive attitude to conservation.

Figure 6.2.
Average attitude scores for conservation on a scale of 1-5.
(1 = strongly disagree; 5 = strongly agree)



As an indication of the significance of this gender-related difference, a comparison was made between boys and girls who agreed or strongly agreed to conservation measures (in table 6.4). Chi-square analysis (in table 6.5) indicates an existing gender-related difference. Significantly more girls than boys agreed or strongly agreed with conservation of all categories except parasites and disease-carriers.

However, significantly more boys than girls agreed or strongly agreed with conserving all pathogens.

Table 6.4
Pupils agreeing or strongly agreeing with conserving habitats and a given selection of organisms (*We (humans) should try to conserve: all mammals* [etc.] *threatened with extinction*).
405 pupils in total; 216 girls and 189 boys. Numbers are given as percentages. (G = girls;
B = boys).

Category	% Strongly Agree			% Agree			Total % Agreeing and strongly agreeing		
	G	B	All	G	B	All	G	B	All
Habitats	55	27	41	30	49	39	85	76	81
Living things	51	24	38	32	47	39	83	71	77
Animals	44	25	35	34	43	39	78	68	73
Mammals	46	29	38	40	38	39	86	67	77
Birds	41	27	33	35	38	35	76	65	71
Plants	26	23	24	54	37	46	80	60	70
Insects	21	18	19	46	22	34	67	40	54
Disease-carriers	2	8	6	11	4	7	11	12	12
Pathogens	4	14	9	8	25	17	12	39	26
Parasites	2	9	5	4	3	4	6	12	9

Table 6.5
Chi-square (χ^2) comparisons between the numbers of girls and boys who 'agreed' or 'strongly agreed' with conserving habitats and a given selection of organisms.
(Numbers are taken from the raw data in appendix 6.1; method of calculation is shown in appendix 6.3).

Category	χ^2 with one degree of freedom	Significance of difference between girls and boys
Habitats	5.17	$p< 0.05$ (**significant**)
Living things	6.16	$p< 0.05$ (**significant**)
Animals	6.42	$p< 0.05$ (**significant**)
Mammals	11.89	$p< 0.01$ (**very significant**)
Birds	5.90	$p< 0.05$ (**significant**)
Plants	12.59	$p< 0.01$ (**very significant**)
Insects	20.49	$p< 0.01$ (**very significant**)
Disease-carriers	0.51	$p> 0.05$ (**not significant**)
Pathogens	23.04	$p< 0.01$ (**very significant**)
Parasites	2.19	$p> 0.05$ (**not significant**)

Figure 6.3 shows strong views indicated by pupils on the questionnaire. Strong positive views (strong agreement) about conservation were expressed more frequently by girls than by boys; significantly more girls than boys ($p<0.01$) strongly agreed with conserving all habitats, living things, animals, mammals and birds. However, more boys than girls indicated strong negative views about conservation (strong disagreement); significantly more boys than girls registered strong disagreement with the statements about conserving all disease carriers ($p<0.05$) and pathogens ($p<0.01$).

Follow-up interviews failed to reveal any specific reasons for these gender differences.

Figure 6.3
Percentage of respondents *strongly agreeing* or *strongly disagreeing* with the conservation of selected categories

% strongly
agreeing

% strongly
disagreeing

6.3.1 Pupils' reasons against conservation

Pupils were asked to give reasons for not wishing to conserve any of the selected organisms on the questionnaire, and fifteen were asked to elaborate on their reasoning in semi-structured interviews (methodology in section 5.2.1). 52% of girls and 59% of boys noted a negative attitude to at least one category. The comments were conceptually categorised and ranked as shown in figure 6.4. There is likely to be some overlap between these categories, and as the categorisation was not checked by another assessor, their reliability should be treated with some caution. However, most responses were unambiguous, and some typical examples are quoted below. The most frequent response (51%) was that there was no need to conserve living things if they were in any way harmful to humans. This included comments about flies being 'dirty' and creating health hazards. Most comments in this category referred to disease-carriers, pathogens and human parasites, many demonstrated tautological reasoning such as:

I don't like human parasites because they live on us.

A few respondents mentioned other examples:

I don't think we should try to conserve stinging nettles and poisonous plants.

More than a quarter of the responses (31%) mentioned that humans are more important and effectively superior to other organisms:

People are more important than other creatures.

Almost one fifth (19%) of the comments suggested that some organisms had no value to humans or to the environment:

Some things like wasps are completely useless in the environment – and they are a nuisance.

A small number of respondents (7%) did not agree with conserving some organisms that irritated them personally:

I really don't like moths and flies that just fly around and annoy you. I don't want to protect them.

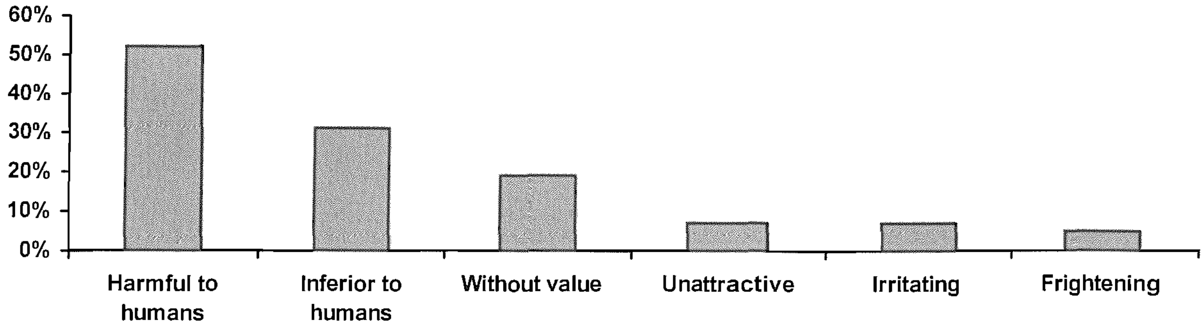
There were a few responses (7%) expressing doubts about conserving organisms on aesthetic grounds:

I don't think we should save slimy, ugly creepy crawlies.

Responses such as these emphasise the gaps between the rhetoric of scientists and educators and the realities of the deeply entrenched views that some children hold. Some 5% expressed their fear of certain creatures:

I'm really afraid of spiders and personally I would be glad if they were extinct – sorry!

Figure 6.4.
Percentage of comments associated with negative views about biodiversity conservation



6.4 Summary

This summary highlights the main findings described in this chapter.

Comparison between the responses of pupils from each of the four schools.

There was no significant difference in the patterns of responses of the pupils in the four schools regarding: i) the importance of biological conservation in relation to economic (human) activities, and ii) the importance of conserving habitats and a range of organisms. Since the responses among pupils from the four schools are not significantly different, the results could be merged and subsequently analysed collectively as one large set of data.

Pupils' views on the importance of economic (human) activities in relation to conservation

The majority of pupils viewed species extinction as an unacceptable consequence of all the human activities presented to them except farming and forestry. This lack of certainty about the 'unacceptability' of intensive farming and commercial forestry could have been due to a lack of clarity of the question in the questionnaire. However, the pupils were all above average achievers in science (see section 5.2.1) and I believe that the uncertainty about farming and forestry was possibly due to a misunderstanding about these practices, thus indicating a need for consideration within the science curriculum of specific widespread practices, including farming and forestry, when teaching about the environmental impact of human activities.

There were also some gender-related differences in opinion. With the exception of recreation/leisure activities, statistically more girls than boys rejected the acceptability of all the other proposed human activities if they threatened species with extinction.

Pupils' views on the relative importance of conserving habitats and a range of organisms.

Pupils collectively held a positive attitude towards conserving all plants and animals in the survey, except pathogens, parasites and disease-carriers. This would therefore appear to be where pupils 'draw the line' with conservation. The commonest reason given for rejecting conservation measures was if they were in any way harmful to humans. Gender differences were also apparent; significantly more girls exhibited strong positive views about conserving habitats, living things, animals, mammals and birds; but significantly more boys were strongly against conserving disease carriers and pathogens.

Pupils have their own personally and socially constructed ideas and views about the natural world. Effective science teaching needs to take pupils' existing ideas into account in order to provide activities which enable them to move to a more scientific view (Driver *et al.* 1994b). It is not particularly surprising that pupils prefer to conserve mammals more than parasites, but the findings presented in this chapter indicate where they mentally 'draw the line' with the need for conservation, and the extent to which they might consider protecting less alluring organisms such as flies and wasps. As a rough measure of this, figure 6.2 shows that most pupils will conserve insects but not disease-carriers, parasites or pathogens. Although many begin with a biocentric view that all things have a right to live, further consideration reveals the more anthropocentric view, that we should conserve things as long as they are not harmful to us. This information may be useful when designing activities about conservation issues; but pupils' views on the significance of conservation are also important in providing a background against which their contributions to discussions can be better understood. This background is taken into account when discussing outcomes of the study in chapter 10.

Chapter 7
Biological concepts pupils draw on in making decisions about conservation

Introduction

This chapter presents the findings relating to the second main research question:
What biological concepts do pupils draw on in making decisions about conservation?
It begins with the results of a questionnaire given to science teachers about the position of biological conservation in the curriculum, and then explores pupils' responses and compares these with those of conservation experts and science teachers.

The chapter is structured as follows:

7.1 the place of biological conservation in the science curriculum;
7.2 experts' views on biological concepts;
7.3 science teachers' views on biological concepts;
7.4 a comparison between the views of experts and science teachers;
7.5 biological concepts discussed by pupils during decision-making discussions;
7.6 similarities between the biological concepts used by pupils discussing the elephant scenario and the puffin scenario;
7.7 differences between the biological concepts used by pupils discussing both scenarios;
7.8 the views of pupils at the end of their compulsory schooling about important biological concepts underpinning conservation;
7.9 a summary of the findings.

7.1 The place of biological conservation in the science curriculum

To provide a context for the pupil responses in this study, twenty-three experienced science teachers - who were mentors to trainee science teachers at the University of Southampton - were given the questionnaire in appendix 7.1 which enquired about how and when aspects of conservation were taught in schools. The results shown in tables 7.1 and 7.2 reveal the existence of a variety of approaches to teaching about conservation among schools. Although the term 'conservation' is not mentioned explicitly in the science national curriculum and most science GCSE examination syllabuses (see section 3.1.1), none of the teachers stated that they did not teach their pupils about the topic. While some schools teach about biological conservation each year, others only teach it in year 10 or year 11, and there is a range of other alternatives (table 7.1).

Table 7.1
Teachers' responses to the question: ***In which year(s) do your pupils learn about animal/plant conservation?***

Year	**No. of responses** (n=23)
All years	**4**
7, 10, and 11	**6**
11 only	**2**
8 and 11	**2**
9 and 10	**2**
10 only	**5**
8 and 10	**2**

Table 7.2 shows that the time pupils spend studying plants and animals first-hand in the field also varies considerably, ranging from possibly nothing at all to a whole day's fieldwork. Although most schools in the survey (15 out of 23) provided two or three lessons in the field at key stage 3, over one third of schools (8 out of 23) at key stage 4 provided 'very little, if any' (paraphrasing these respondents' comments).

Table 7.2
Teachers' responses to the question: ***How much time do your pupils spend studying animals/plants in the field?***

At Key Stage 3			**At Key Stage 4**	
Time spent doing fieldwork	No of responses (n=23)		Time spent doing fieldwork	No of responses (n=23)
6-7 lessons	3		1 day	4
2-3 lessons/year	15		4 lessons	2
1 lesson/year (depending on the teacher)	1		2-3 lessons	7
Very little, if any	4		1 lesson/ two years (depending on teacher)	2
			Very little, if any	8

The survey also revealed that most schools (15 of the 23) did not teach animal/plant conservation in conjunction with any other subjects, such as geography or PSHE, or citizenship.

The order in which certain topics were taught is presented in table 7.3. Apart from environmental conservation and animal/plant conservation, these are the main topics covered in the science national curriculum at key stage 4 which relate to or underpin biological conservation. Again, the results indicate an assortment of approaches among the schools in the survey. Almost 40% of them (9 out of 23) had no set order for teaching the topics, and a further 30% (7 out of the 23) of schools taught conservation as a topic before teaching underpinning topics such as inheritance and evolution. However, at least 10 schools taught the topic of adaptation and competition before biological conservation.

The timing and prominence of topics taught is likely to have some impact on pupils' responses. If, for example genetics and inheritance topics are taught after conservation issues, as is the case in many of these schools, pupils will be in less of a position to include these topics in conservation discussions.

Table 7.3
The chronological order in which pupils learn topics related to biological conservation at key stage 4, according to science teachers (n =23)

	No. of times a topic was ranked at this number						
Topic	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Animal/plant conservation		**7**			**1**	**6**	
Cell activity	5			6	3		
Variation		6		4	4		
Inheritance			5	2		7	
Evolution				3	1		10
Adaptation and competition	10		2		2		
Energy and nutrient transfer	8	2	1	3			
Environmental conservation			8		2		4
9 respondents reported no set order of topics.							

7.2 Experts' views on biological concepts

Biological conservation is a complex science and is inevitably underpinned by overlapping lower order scientific concepts (discussed in section 2.6), but the twelve conservation experts in this study (see section 5.2.10.2) were in very close agreement over the basic concepts and principles underpinning biological conservation. They agreed on a final list of forty-five concepts, and when they were asked if they could prioritise these concepts and the general consensus was that they could not – all were essential. The final list is shown in table 7.4, and this acts as a list against which teachers' and pupils' responses could be measured.

7.3 Science teachers' views on biological concepts

The science teachers' views on the science involved in biological conservation are thus also summarised in table 7.4. All of these concepts were rated positively overall by science teachers (i.e. rated above 3.0 in table 7.4), but they rated 'ecological concepts' more highly than 'genetics concepts' in relation to this issue; the average rating for concepts relating to genetics and inheritance never exceeded 3.9. Variation within species, for example, was rated as 'essential' by less than 13% of the respondents. This is surprising since the importance of genetics to conservation issues is well established. The World Conservation Strategy (IUCN, 1980) emphasised the preservation of genetic diversity as one of three main conservation objectives (section 2.1). 63% of the teachers stated that they teach conservation as a topic before topics on genetics and inheritance, and this may relate to the lack of explicit mention of conservation in the English science curriculum and the absence of links made between these topics in examination syllabuses (as discussed in section 3.1.1). Biological classification also received a comparatively low rating by teachers. Children learn how to classify organisms from an early age, but they do not learn the purpose of classification as a tool for conservation management. None of the teachers suggested further biological concepts, indicating that the experts' list covered everything taught in the curriculum.

Table 7.4
Science teachers' views on the relative importance of biological concepts (identified as essential by experts) in teaching about biological conservation.
(Science teachers rated the individual concepts on a five-point scale of importance: essential =5; not at all important =1 (as described in section 5.2.10.3). Scores were then averaged to obtain an overall attitude rating among the teachers (Oppenheim, 1992). Low standard deviations, indicate a good extent of consensus among the teachers.)

Concept	Mean rating	SD	Concept	Mean rating	SD
food chains	4.9	0.4	environmental indicator species	4.0	1.1
food webs	4.9	0.5	animal or plant physiology	4.0	1.0
populations	4.9	0.6	decomposers	4.0	1.2
habitats	4.7	0.5	distribution of organisms	4.0	1.0
ecosystems	4.7	0.6	interdependence between organisms	4.0	0.9
competition between organisms	4.6	0.5	evolution now	3.9	0.8
natural selection	4.5	0.7	extinction in the past	3.9	0.8
environmental pollution	4.5	0.7	life cycles of organisms	3.9	1.2
pyramids of numbers	4.5	0.7	animal behaviour	3.9	1.0
adaptation	4.4	0.8	carbon cycle	3.9	1.2
extinction now	4.4	0.6	genetic mutation	3.9	1.1
pyramids of biomass	4.4	0.7	inheritance	3.9	1.0
ecological niches	4.3	0.7	evolutionary time scales	3.8	1.1
culling of animals	4.3	1.0	asexual reproduction	3.8	1.0
natural population fluctuations	4.3	1.1	genes	3.8	1.0
pyramids of energy	4.3	0.8	sexual reproduction	3.8	1.0
rarity	4.2	0.9	variation within species	3.8	0.6
energy flow	4.2	0.8	gene pools	3.8	1.0
nitrogen cycle	4.1	0.9	reintroduction/relocation of species	3.8	1.2
species	4.1	0.9	isolated populations	3.8	1.1
introduction of species	4.1	0.9	resistance to disease	3.7	0.7
variation between species	4.1	0.9	biological classification	3.6	1.2
evolution in the past	4.0	0.8	others (none of the teachers added to this list)		

Teachers also indicated which concepts they expected pupils would use when making decisions about the issues. The fact that teachers do not rate genetics highly in this regard, could partly explain the finding in section 7.1.1 that many schools teach genetics topics after conservation. Table 7.5 shows concepts that most teachers (i.e. over 50%) expected pupils would use. These expectations strongly reflected their own views on which concepts were important (in table 7.4), suggesting the teachers' belief that their pupils would draw mostly upon the concepts they had been taught.

Table 7.5
Concepts that the majority (over 50%) of science teachers expected pupils to consider while discussing conservation issues.
(Rating scale used: essential =5; not at all important =1)

Concept	Mean rating	SD	Concept	Mean rating	SD
food chains	4.9	0.4	adaptation	4.4	0.8
food webs	4.9	0.5	extinction now	4.4	0.6
populations	4.9	0.6	culling of animals	4.3	1.0
habitats	4.7	0.5	natural population fluctuations	4.3	1.1
ecosystems	4.7	0.6	rarity	4.2	0.9
competition between organisms	4.6	0.5	species	4.1	0.9
natural selection	4.5	0.7	evolution in the past	4.0	0.8
environmental pollution	4.5	0.7			

7.4 Biological concepts discussed by pupils

Table 7.6 shows that teachers were good at predicting pupils' use of concepts. If concepts raised more than once by pupils are considered, teachers' predictions of the concepts pupils would use were fairly accurate (eleven out of fifteen concepts predicted). As predicted by teachers, most groups discussed ecological concepts rather than genetics concepts. Only one group discussed concepts relating directly to genetics and inheritance. However, four concepts expected by teachers were not used by pupils, three of which - natural selection, population fluctuations and evolution - are relatively complex 'applied genetics' concepts (the other - pollution - was not particularly relevant to the two scenarios provided). It could be therefore that the teachers themselves intuitively linked these concepts to conservation, but the links had not been made explicit to pupils.

Table 7.6
Concepts used by pupils in rank order of frequency.
(Asterisks indicate the concepts that over 50% of teachers expected pupils to consider).

Concepts used by pupils	Elephants (12 groups)	Puffins (12 groups)	Total (24 groups)
culling of animals*	12	12	24
rarity*	12	12	24
species*	12	12	24
food chains*	12	12	24
relocation of species	8	11	19
habitats*	9	8	17
animal behaviour	5	12	17
populations*	7	7	14
competition*	1	12	13
extinction now*	8	1	9
ecosystems*	4	4	8
food webs*	4	2	6
sexual reproduction	3	3	6
animal physiology	4	1	5
introduced species	0	1	1
extinction in the past	0	1	1
genetic mutation	1	0	1
Inheritance	1	0	1
gene pools	1	0	1
genes	1	0	1
adaptation*	1	1	2
environmental pollution*	0	0	0
natural selection*	0	0	0
natural population fluctuations*	0	0	0
evolution in the past*	0	0	0
Total	19	17	21

7.5 Similarities between concepts used by pupils in both scenarios

Pupils mentioned twenty of the forty-five biological concepts identified by experts - eighteen while discussing the elephant issue and fifteen while discussing puffins (table 7.6).

The only concepts raised and discussed by all groups in both scenarios were 'species', 'rarity', 'culling' and 'food chains'. In both scenarios, some terms were conceptualised, but not necessarily mentioned by name. From the beginning, all pupils understood that the reason they were discussing elephants or puffins was because they were rare (or endangered), so rarity as a concept was naturally embedded in all discussions. The concept of 'species' was also implicitly used throughout all discussions in the sense that pupils recognised elephants, puffins and rabbits and distinct types of animals. Similarly, the concept of 'habitat' was often implied by referral to the place where these animals lived. Conversely some concepts were mentioned by name, but not in the established scientific sense. For example, 'natural selection' was mentioned by 4 groups, but in the sense of letting nature take its course, despite human intervention, rather than letting evolution continue naturally.

e.g. (Group 9 discussing the elephant scenario)

Pupil A: *Or we could just leave things the way they are. Just do nothing. Even though they they'd get hunted to extinction.*

Pupil B: *Yeah, that's natural selection for you.*

Food chains were alluded to in each discussion group, but food webs and more complex food relations were seldom raised. This reflects findings in other studies on feeding relationships. Brody (1994) identified the food web as a higher order concept than a food chain. Other researchers (Griffiths and Grant, 1985; Leach *et al.* 1993) found that most youngsters think in linear terms about food chains when considering balanced communities and ecosystems, and very few use the notion of interdependence or cycles of matter. When 'animal behaviour' and 'competition' were introduced into the discussions it was usually in relation to where the animals fit into the 'food chain'. However, these concepts were mentioned in all puffin discussions because the puffin groups all talked about the burrowing behaviour of puffins and rabbits as this was central to the debate. Concepts of genetics and inheritance were only raised directly by one group, in relation to elephants (group 8):

Pupil A: *...but if they're [elephants] cut off from others in a small group, then they'll start inbreeding and the gene pool with get too small, and they'll get diseases and things.*

7.6 Differences between concepts used in both scenarios

Table 7.6 also shows that there were some noticeable differences in concepts drawn on in discussion of the two scenarios. One concept was 'competition'. This was competition in the ecological sense of struggle for survival between (or within) species. All groups recognized the competition for resources between puffins and rabbits, as this was at the heart of the problem presented to them. However, competition for resources between elephants and other organisms was mentioned only once, in spite of their large size, large appetite and potential impact on the local environment. 'Competition' is a concept familiar to pupils from the human standpoint and therefore fairly easy to grasp as a scientific concept, but from these discussions it might appear that knock-on effects on other species were overlooked. Competition between elephants and people was recognized, but I did not categorize this as 'ecological' competition. Four groups considered aspects of animal physiology in the elephant discussions, mostly in relation to tusks and whether they would grow back if they were sawn off. None of the groups considered puffin physiology, although rabbit physiology was briefly alluded to in discussion about sterilising as an optional method of control.

The ultimate objective of biological conservation is to avoid extinction (discussed in section 2.1), and the concept of extinction featured in most (eight) elephant discussions, but it was only considered in one puffin discussion (group 11). This echoes findings by Greaves *et al.* (1993) that when British children of this age were asked to list endangered animals, they seldom considered British animals to be under threat, and most frequently mentioned elephants (53% of pupils). The only British animals mentioned were foxes and badgers, which are not particularly endangered species anyway.

This section provides evidence that at least some of the concepts pupils use in conservation discussions are context-dependent, and indicates the need to provide a variety of scenarios, which involve local familiar organisms and distant exotic ones, and involve direct competition between species as well as competition with human communities. This way pupils can draw on a wider range of underlying biological concepts.

7.7 School leavers' views on important concepts underpinning conservation

When pupils were surveyed again a year later (using the questionnaire in appendix 5.13), at the end of their compulsory schooling, there was still evidence that they rated ecological concepts higher than genetic concepts in conservation decision-making. Table 7.7 shows that a 'substantial' number (arbitrarily taken as over 20%) of these above average achievers in science cited nineteen (mostly ecological) concepts as 'important', and over 20% stated that the following (mostly genetics-oriented) concepts were '<u>not</u> important': adaptation, genes, gene pools and genetic mutation, variation, classification, pyramids of numbers, biomass and energy, natural population changes, evolution now, the carbon and nitrogen cycle, decomposers and energy flow (table 7.7). This clearly demonstrates that even after completing the whole science curriculum, there was still a lack of appreciation of interdependence among these concepts, and that making decisions about conservation issues relies heavily on knowledge of genetics and variation.

Table 7.7
Concepts which at least 20% of pupils i) regarded as important, ii) regarded as not important, iii) were not sure about, when making decisions about conservation of animals.

i) important

competition between organisms	isolated populations
culling of animals	life cycles of organisms
distribution of organisms	moving animals from one place to another
ecosystems	populations
environmental pollution	rarity
extinction now	resistance to disease
food chains	sexual reproduction
food webs	species
habitats	species depending on each other
introduction of species	

ii) not sure

animal physiology	extinction in the past
asexual reproduction	inheritance
environmental indicator species	natural selection
evolution in the past	variation between species
evolutionary time scales	variation within species

iii) not important

adaptation	gene pools
animal behaviour	genes
biological classification	genetic mutation
carbon cycle	natural population changes
decomposers	nitrogen cycle
ecological niches	pyramids of biomass
energy flow	pyramids of energy
evolution now	pyramids of numbers

7.8 Summary

This summary highlights the main findings described in this chapter.

The place of biological conservation in the science curriculum

Although conservation is not explicitly mentioned in the science national curriculum, all science teachers sampled indicated that they included it in their teaching programmes. Findings show a wide range of practices in relation to conservation education among the schools sampled in terms of: i) the years in which conservation is taught, ii) the time pupils spend studying living organisms first-hand, and iii) the order in which related or underpinning topics were taught. Only a minority of schools taught animal/plant conservation in conjunction with any other subjects. This diversity of approaches is likely to result in patchy responses among pupils. If some topics are taught separate from and after conservation issues, as in many of these schools, pupils will be in less able to make the links and less likely to include these topics in conservation discussions.

Experts' views on biological concepts underpinning conservation

The conservation experts consulted in the study agreed on a final list of forty-five underpinning biological concepts, and they generally preferred not to prioritise these as they were all regarded as equally important.

Science teachers' views on biological concepts

Science teachers generally agreed with the importance of these underpinning concepts, but rated 'ecological concepts' more highly than 'genetics concepts' in relation to the puffin conservation issue, and this was also reflected in their expectations of the concepts that pupils would use. The fact that teachers do not rate genetics highly in this regard, could partly explain the finding that many schools teach genetics topics after conservation.

Biological concepts discussed by pupils

Teachers also fairly accurately predicted the concepts that pupils used, perhaps reflecting their own ratings of the concepts. As expected by teachers, 'ecological concepts' were far more frequently raised than 'genetics concepts', but some genetics-based concepts expected by teachers (natural selection, population fluctuations and evolution), were not used by pupils. It could be therefore that the teachers themselves intuitively linked these concepts to conservation, but the links had not been made explicit to pupils. Pupils mentioned only twenty of the forty-five biological concepts identified by experts, and many of these appeared to be context-dependent. This indicates the need to provide pupils with a variety of scenarios so that they can draw on a wider range of underlying biological concepts - local and familiar scenarios, distant and more exotic ones, those involving direct competition between species, and those involving competition with human communities.

School leavers' views on important concepts underpinning conservation

When surveyed at the end of their compulsory schooling, there was still evidence that pupils rated ecological concepts higher than genetic concepts in conservation decision-making. Many genetics-oriented concepts were deemed 'not important' by a substantial number of pupils. This indicates that even after completing the whole science curriculum, there was still a lack of appreciation that conservation issues rely heavily on knowledge of variation and inheritance, and that all these concepts are interdependent.

The next chapter focuses on the values drawn upon by pupils during discussion about conservation issues, and compares pupils' responses with those of science teachers.

Chapter 8

Values pupils draw on in making decisions about conservation

Introduction

This chapter presents the findings relating to the third main research question:

What values do pupils draw on in making decisions about conservation?

It focuses on the values raised and drawn upon during discussion about conservation issues, and then compares pupils' responses with those of science teachers. The chapter is structured as follows:

8.1 values raised by pupils during conservation discussions;

8.2 science teachers' expectations of the values pupils would raise during conservation discussions, and a comparison with pupils' actual responses;

8.4 a summary of the findings.

8.1 Values raised by pupils during discussions

The values that pupils might use in discussion were categorized and discussed in detail in chapter 2 (see section 2.7). These are listed again below:

Anthropocentric values (centred upon humans),

- cost
- effectiveness of materials used and measures taken
- safety to humans
- value as food
- value as medicine
- value as raw materials for industry
- value through interdependence (environmental values)
- aesthetic and cultural values
- socio-political values
- altruism /future generations
- research

Biocentric values (centred upon life).

- pain and sentience approach
- right to life approach
- anthropomorphism

Theocentric values (centred upon God and religion).

These categories were used to identify values drawn upon by pupils, during their audio-taped discussions (methodology in section 5.2.10.4) and are listed in table 8.1 with the number of groups of pupils raising these values in discussion, and the values that science teachers expected pupils to draw on. While identifying values (and concepts) from the audio-tapes it became clear that they were not always mentioned explicitly, and it was important therefore not to remove the utterances from the context of the discussion as a whole. An example of this was evident from Michelle's comment early on in group 5's discussion (in appendix 9.4) when she suggested setting up a "puffin centre". At that stage in the discussion it was not obvious whether her idea was to create a wild puffin conservation centre – implying the use of biological concepts underpinning sound conservation measures – or a zoo-like refuge for puffins, suggesting a more value-laden approach in terms of keeping them as pets. It only became apparent much later on in the discussion that she was suggesting the latter. This implicitness was sometimes difficult to verify, as for example in the following excerpt from group 10's discussion about selling ivory:

Steve: *They'd have to release it slowly though otherwise they'd flood the market.*
Lindsey: *Also it would help the country's economy.*
Amy: *Then they could be off their debts.*

The value ascribed to this extract could be categorized as 'cost', i.e. based on purely economic grounds, but it is quite possible that the participants are thinking about the knock-on socio-political values, particularly as this was an above average class academically and this group contains pupils demonstrating examples of high quality argumentation (discussed in the next chapter).

When engaged in discussions both biocentric and anthropocentric values were a major consideration among pupils. Every group raised biocentric 'right to life' values in both scenarios, mostly in terms of the rights of animals – not only advocating their rights, but often questioning their rights:

Amy in group 10 (elephant scenario):

No but at the same time, the elephants were there first, it was the people who decided to make their homes...

Peter in group 1 (elephant scenario):

Right what's more valuable, an elephant's life or a human's life?

Paul and Nigel in group 11(puffin scenario):

Paul: *Well then they're* [puffins] *going to have to die out aren't they...*
Nigel: *That's not very sympathetic.*
Paul: *No but it's nature isn't it.*

These comments reflect those found by Greaves *et al.* (1993) who investigated children's views on why preventing extinction was important. They found that, apart from a tautological response that extinction would lead to fewer species, the commonest response was 'ethical', which they categorized as 'value for life'. All elephant discussions and most (9 out of 12) puffin discussions also talked about biocentric values in terms of pain or sentience. Some groups (4 in each scenario) talked in anthropomorphic terms. For example, one pupil (in group 20) discussing the effect of sterilising rabbits to control the population stated:

...but they'll [rabbits] *get all annoyed if they can't breed!*

This also emphasises the close links between values and science concepts – discussing the physiological aspects of sterilisation, while stating how the rabbits would feel if they were human.

Among anthropocentric values (i.e. values of some benefit to humans), all groups discussed the animals in an aesthetic sense, using words such as 'pretty', 'cute' and 'friendly' to support arguments for conserving them:

A girl in group 15:

You can't kill such pretty birds...

A girl in group 20 (puffin scenario):

I saw puffins in Jersey. They're really cute. They just stand there on the rocks looking at you.

A boy in group 22 (elephant scenario):

...they (elephants) like spray water at people just for fun...they're really friendly –some people have them like family pets

All but two of the groups discussed economic values such as the cost of electric fencing around farms in Africa:

Peter in group 1 (elephant scenario):

Yeah and it will cost quite a lot of money, and where will they get the electricity from?

and around puffin islands:

Maurice in group 5 (puffin scenario):

> *But James how big is the island? It might be massive and cost loads of money to fence it.*

Other values – environmental values, socio-political values, altruism and safety, were more context-dependent as shown in table 8.1, being more frequently raised in association with the elephant issue, which directly involved human interests. The difficulty of focusing on human-oriented conservation issues was highlighted by Lindsey's comment in group 10's discussion:

> *It's really easy to get confused between the human viewpoint and the elephant viewpoint.*

None of the groups raised theocentric values, and it would have been interesting to follow this up to see to what extent this was because pupils felt compelled to omit theocentric comments during a science lesson.

I did not identify the emergence of any previously unconsidered value categories as a result of the discussions.

8.2 Teachers' expectations about pupils' use of values

The values that teachers expected pupils to raise are shown in table 8.1 alongside the pupils' actual responses. Teachers accurately predicted the use of biocentric values, with 85% expecting pupils to mention 'right to life' values. However, they were less accurate at predicting the use of anthropocentric values. Most groups of pupils raised 'cost' and 'aesthetic' values, but the teachers did not generally expect their pupils to draw on anthropocentric values – with only 26% predicting aesthetic values and 11% predicting effectiveness (which could feasibly relate to cost).

Despite the encouragement in the science national curriculum for pupils to explore values (3.1.1), science teachers do not expect their pupils to bring anthropocentric values into discussions.

Table 8.1
Frequency of values used by pupils during decision-making, compared with teacher expectations.
(The rationale for categorizing these as values is discussed in section 2.7 onwards)

Values	Elephants (12 groups)	Puffins (12 groups)	% of teachers expecting these values (on puffins only)
ANTHROPOCENTRIC (useful to humans in some way)			
• **Cost** (economic value) *"...how much would it cost to find and move all of them (rabbits)?"*	12	10	3%
• **Effectiveness** *"..an electric fence won't necessarily stop a herd of elephants."*	10	4	11%
• **Safety** (to people) *"...they(*elephants*) can kill people when they're frightened."*	4	1	0%
• **Food**	4	4	0%
• **Medicine**	4	0	0%
• **Raw materials**	5	2	0%
• **Environmental values/ interdependence**	6	0	0%
• **Aesthetic/ enjoyment/ cultural values** *"cute"*, *"pretty"*, *"friendly"*	12	12	26%
• **Socio-political values**	6	0	0%
• **Altruism/ future generations** *"The people need to eat even if it means killing some elephants."*	11	0	0%
• **Research**	0	0	0%
BIOCENTRIC (of intrinsic value to organisms other than people)			
• **Pain and sentience**	12	9	40%
• **Right to life** *"...you can't say a puffin has more right to live than a rabbit."*	12	12	85%
• **Anthropomorphism** *"...but they'll (*rabbits*) get all annoyed if they can't breed!"*	4	4	18%
THEOCENTRIC (values centred upon God and religion)	0	0	0%

8.3 Summary

Values raised by pupils during discussions

When engaged in decision-making discussions about conservation, pupils draw on biocentric and anthropocentric values. Dominant among the biocentric values were comments about the 'right to life' and 'pain and sentience', and a third of the puffin and elephant groups raised anthropomorphic views. Among anthropocentric values all groups discussed the animals in terms of 'aesthetic' values, and most groups discussed cost-effectiveness relating to the problems and possible solutions.

The use of biocentric values was not noticeably context-dependent, but groups discussing elephants drew on more anthropocentric values (e.g. environmental values, socio-political values, and altruism) than those discussing puffins. This was to be expected as the elephant scenario directly involved human interests.

The absence of environmental/ interdependence values raised in the puffin discussions (and only half the elephant discussions) is a matter for concern. Pupils need to be aware of the possible knock-on effects that losing a single species might have on an ecosystem.

Teachers' expectations about pupils' use of values

Teachers accurately predicted the use of biocentric values among pupils, but a key finding here is that despite the encouragement in the science national curriculum for pupils to explore values (3.1.1), science teachers do not expect their pupils to bring anthropocentric values into discussions.

Two major points for further consideration (discussed in chapter 10) emerge from the findings in chapters 7 and 8: i) the use and integration of essential biological concepts underpinning conservation management; and ii) a conception of conservation education which explicitly includes science and values, and does not ignore the complexity of environmental decision-making. The nature of this complexity in peer-group discussions is explored in the next chapter.

Chapter 9

Features indicating high quality peer-group discussions about conservation

Introduction

This chapter presents findings relating to the main research question 4:
Are there recognizable features that indicate high quality peer-group discussion about conservation? i.e. features which might be identified and promoted by teachers.
The principal goals here are to i) look for changes in pupils' thinking about the conservation issues (as discussed in section 4.4.1, change in thinking has been regarded as an indication of high quality discussion), ii) to identify pupils who demonstrated high quality argumentation following the discussions, and iii) look for connections between high quality argumentation and readily identifiable factors evident in these pupils' discussions. The chapter is arranged in the following sections:

9.1 outlines some general observations on how the discussion groups engaged with the tasks and with each other. A key feature of discussions about conservation is whether any animals should be culled to protect others (discussed in section 2.1).

9.2 considers changes in thinking about culling before and after the discussion.

9.3 compares the decisions made by individuals about culling with the decision made by their group.

9.4 presents the extent to which pupils modified their decisions after discussion.

9.5 explores changes in level of personal reasoning before and after discussions to identify 'high quality' discussion groups.

9.6 looks at features present in these 'high quality' discussion groups in terms of:

9.6.1 use of concepts and values among groups

9.6.2 decisions made prior to discussion;

9.6.3 synopses of group discussions;

9.6.4 general comparison between group discussions;

9.6.5 equality of participation within groups;

9.6.6 individual roles within groups;

9.6.7 argumentation within groups;

9.6.8 proportion of time group spent on task;

9.6.9 inclusion of long utterances;

9.6.10 relevance of pupils' experiences and interests;

9.6.11 pupils' perceived usefulness of conservation discussions;

9.1 General observations on group engagement

The amount of time pupils spent off-task during the discussions was measured in each group and ranged from 4-24% (appendix 9.1). I regard this as evidence that pupils generally remained on-task and engaged during the decision-making activities. This reflects the findings in other research reports. Gayford (1993) concluded that environmental issues could be adequately reasoned by 15 year olds, and Ratcliffe (1997) reported that pupils remained fully engaged with socio-scientific issues when following a decision-making framework. The modified version of Ratcliffe's framework used in the present study (shown in appendix 5.12, and discussed in section 5.2.10.4), encouraged pupils to consider the possible solutions to the problems. In doing so, all groups identified at least three options for both scenarios: leave things as they are, remove the threat completely (e.g. protect all elephants from humans; remove all rabbits from the puffin colony), and a compromise solution.

Some of the transcripts are presented in full in appendices 9.2 - 9.6. Scrutinising these and listening carefully and repeatedly to the twenty-four audio-tapes, there was no discernable pattern of the order in which concepts and values were raised and discussed. This could have been at least in part due to the presence of the decision-making framework, which pupils felt they had to return to at various times throughout their discussion. Whereas some groups used the framework sparingly, others referred to it frequently and it would sometimes encourage them to switch from discussing values to scientific concepts. For example in group 3 discussing elephants (appendix 9.3), Andy was talking about values in terms of educating the local people:

OK so... if education is successful feed them waste harvest...

when Kathy chimed in and brought them all back to the framework where it asked them to consider the science involved:

Shall we do the other side then?

thus changing the focus of the conversation. Natalie then focused the discussion on looking at concepts:

The science we need is about the way they adapt and...

The framework was certainly used on occasion to help bring the discussion back on task:

e.g. group 1:

Off task dicussion

George:	*Anyway back to the subject, let's move on to the advantages*
Peter:	*Yeah, the advantages with an electric fence is that they can be very powerful...*

or if the conversation began to wander:

e.g. group 3:

Kathy:	*Yeah but if the people were more aware through education...*
John:	*Hmm, I know what you mean but...*
Andy:	*OK what about number 3, do we have enough information?*
Kathy:	*We need more general research about it*
John:	*Yeah*

9.2 Modification of views after discussion

Although some pupils were initially very rigid in their views, exposure to the views of others in the discussions often brought pupils to a compromise view, demonstrating perhaps the benefit of discussing the issues with peers. For example, discussing elephants in group 10 (appendix 9.5), Lindsey began with a strong view that elephants should not be killed stating:

> [people should] *not kill any more elephants, 'coz they're being hunted to extinction.*

And later:

> *Elephants are intelligent creatures. We shouldn't kill any of them.*

However, later still she began to agree that culling was acceptable in some situations in order to help the local economy:

> *I think it should happen in national parks... 'coz that's where the elephants will be...so there'll still be enough elephants there for hunters – it will be an incentive.*

Towards the end of the discussion she actually led the argument that elephants had to be culled if people's livelihood was at stake:

> *When you've got a choice of feeding your family...and saving an elephant, what are you going to do? You can't expect them to put elephants before themselves...that's the way it should be though for humans to survive.*

Indeed, Simon accuses her of changing her opinion, and Lindsey denies this by saying:

> *I'm not saying I'm against it, it's more complex than it appears.*

After the discussions most pupils modified their views in some way, by suggesting a different solution or at least electing for a combination of ideas as a solution to the problem. These figures are shown in table 9.1. As discussed in section 4.4.1, this study is searching for signs that pupils were changing their minds, in line with the views of other researchers (Toulmin,1958; Osborne *et al.*, 2001a) that a key factor in identifying a good quality argument (as part of a discussion) is the extent to which pupils change their thinking about issues.

Table 9.1
Percentage of pupils who modified their views following discussion

	Girls	Boys	Total
Rabbits	73%	79%	76%
Elephants	71%	74%	73%

9.3 Individuals' pre-test/post-test change in thinking about culling

For both scenarios, pupils provided a range of suggestions in response to the question "*What do you think should be done about this problem, why and how*?" in the pre- and post-tests and in the final questionnaire (described in section 5.2.10.4). A comparison of individual choices at these three stages may indicate the possible impact of the group discussion on their views. A fundamental choice underlying the question above is whether we should kill (cull) individual animals in order to protect other animals (see section 2.1). This aspect accounted for a substantial part of the conversation in all discussion groups. Changing one's mind about culling represents an *extreme* change of mind – and changing one's mind is a product of rational thought, which is a feature of good quality argument (as discussed in section 4.4.1).

Both before and after discussion, the majority of pupils suggested a solution other than culling (e.g. constructing fences, relocating or sterilising animals). Table 9.2 shows the percentage of boys and girls advocating culling – before and after the decision-making exercise, and almost one year later. As shown in table 6.3, most pupils viewed species extinction as an unacceptable consequence of human activities such as building roads and houses and other industrial development. However, girls are known to be more environmentally aware and active than boys, tending to express a more 'sympathetic' view, and stronger positive attitude towards conservation (Morris and Schagen, 1996).

It might follow that girls are less favourably disposed towards the killing (culling) of individual animals, although species extinction and killing individual animals are very different issues in a scientific context. The data in table 9.2 does indeed indicate that before and after the discussion, more boys than girls chose culling as an option (of both elephants and rabbits), and although more people advocated culling rabbits than elephants, the gender difference was fairly consistent for both scenarios. However, chi-square tests showed this was not a statistically significant gender difference (appendix 9.7). After the discussion, there was a marked increase in those advocating culling among both boys and girls. Chi-square tests showed that this increase was statistically significant ($p<0.05$).

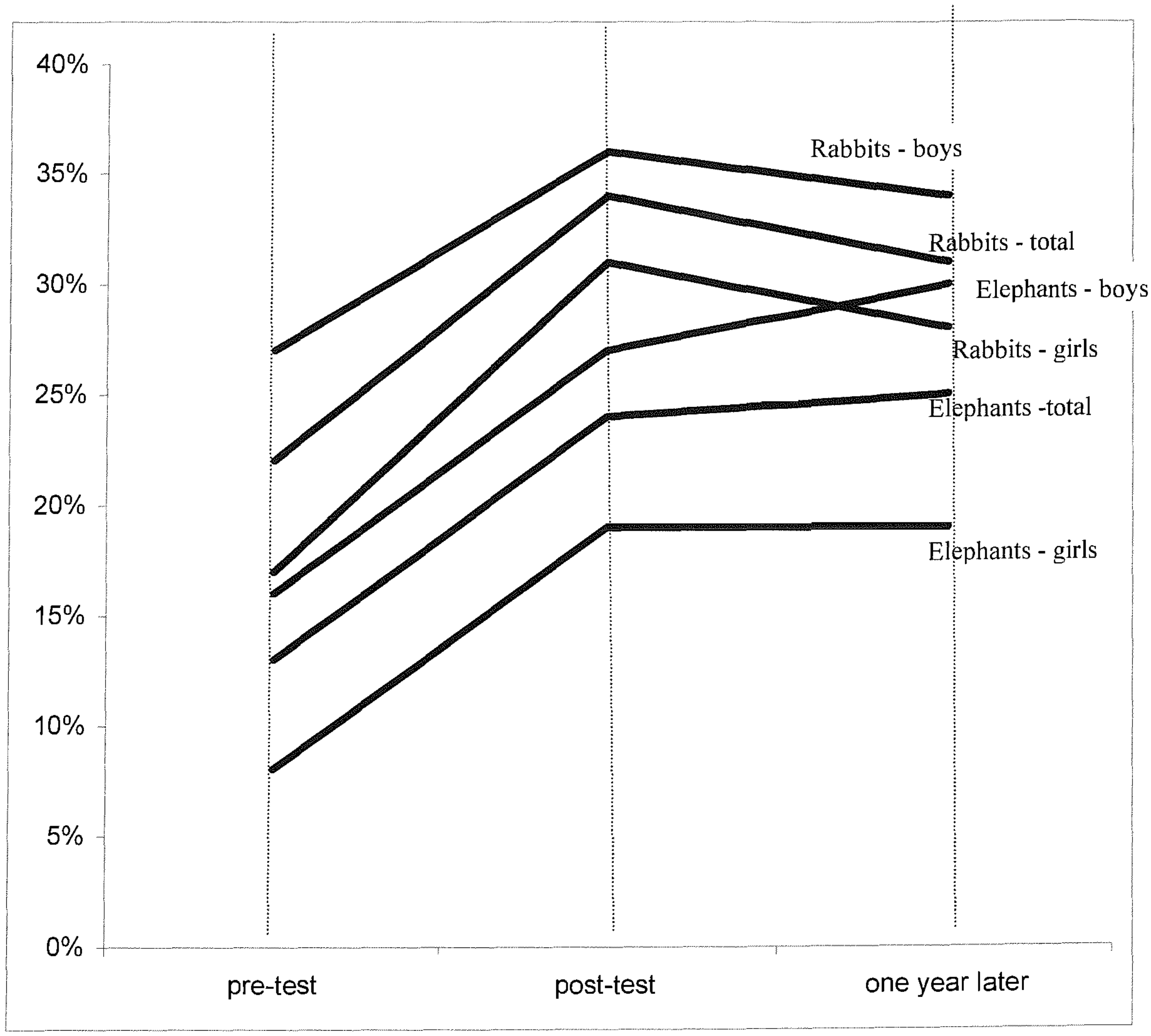
Numbers advocating culling in the final questionnaire (one year later) remained elevated (table 9.2); but with the pupils' additional wealth of experiences during the intervening year it is speculative to suggest that these discussions played a significant part in this finding.

Table 9.2
Percentage of males and females advocating culling as a solution

	Pre-test attitude			Post-test attitude			Final attitude		
	Girls	**Boys**	**Total**	**Girls**	**Boys**	**Total**	**Girls**	**Boys**	**Total**
Cull rabbits	6/35 (17%)	9/33 (27%)	16/38 (22%)	11/35 (31%)	12/33 (36%)	23/68 (34%)	9/32 (28%)	11/32 (34%)	20/64 (31%)
Cull elephants	2/26 (8%)	6/37 (16%)	8/63 (13%)	5/26 (19%)	10/37 (27%)	15/63 (24%)	5/26 (19%)	10/33 (30%)	15/59 (25%)

Figure 9.1 gives a visual impression of these attitude changes over the three stages.

Figure 9.1
Percentage of pupils advocating culling as a solution at three stages: pre- and post-discussion, and a year later.



9.4 Comparing individual decisions about culling with group decision

The following comparisons relate to responses regarding culling – the issue at the heart of these conservation scenarios. Of the twenty-four groups, five groups agreed to accept the practice of culling if absolutely necessary, five groups failed to reach a decision about culling, and the remaining fourteen groups rejected culling as an option. However, the pupils' individual responses following their discussion did not necessarily reflect their group's decision (table 9.3).

Table 9.3
Group and individuals' post-test views on culling

Groups	No. of groups	Total no. of pupils	% of pupils from these groups advocating culling in their individual responses
Groups advocating culling	5	27	48%
Groups rejecting culling	14	69	17%
Groups failing to reach a decision about culling	5	35	38%

Despite seemingly agreeing to culling as an acceptable solution within the group, less than half (48%) of the pupils in these groups rejected culling in their subsequent individual responses. Therefore a group decision does not necessarily mean that everyone in the group actually strongly supports and adheres to that decision.

9.5 Pre-test/post-test changes in level of personal reasoning

As reasoned in section 4.4.1, a change of mind is an indicator of good quality argument. However, this is not necessarily in the simplistic sense of pupils reversing their original view, but in being better able to justify their position (Osborne *et al.*, 2001a). Although the above sections suggest that the decision-making discussions resulted in a general modification of views, I now turn to analysis of the extent to which pupils justified their views to see whether pupils 'improved' their thinking about the issue as a result of discussion, in the sense of moving up to level 5 in the personal reasoning scheme shown in figure 9.2.

Figure 9.2

Hierarchical scheme for the quality of personal reasoning about biological conservation (based on principles discussed in section 5.2.10.4)

Level 1. Nonjustified arguments. Decisions that lack any supporting justification.

Level 2. Nonfunctional, partially justified arguments. There is an attempt to justify the decision, but without considering the practical nature of the decision.

Level 3 Nonfunctional, justified arguments, with no consideration of alternatives. There is an attempt to justify the decision in the form of a simple assertion supported by a single line of argument with some practical basis. There is no consideration of the comparative effectiveness of alternatives.

Level 4. Nonfunctional, justified arguments considering alternatives. There is an attempt to justify the decision, with some consideration of the comparative effectiveness of alternatives, but without explicit consideration of the function or purpose of biological conservation.

Level 5. Functional, justified arguments considering alternatives. There is an attempt to justify the decision, with explicit consideration of the function or purpose of biological conservation, and of the comparative effectiveness of alternatives.

Using this scheme it was possible to identify individuals who 'changed their thinking' and moved up to the highest level of argumentation (level 5) from a lower level following the discussions. Examples of pre and post-test written responses given by pupils are shown in appendix 9.8. At level 1, pupils merely provided a single solution:

e.g. *Put a fence round the puffin area.*

or simply stated that they didn't know what should be done:

e.g. *I don't know. I need more information.*

Level 2 comments showed an attempt at justifying the decision (including such words as 'because' or 'so that'), but without stating any practical considerations.

e.g. *Let evolution take its course because nature finds a way.*

There were a substantial number of pupils who partially justified their decisions using tautological statements.

e.g. *Deport the rabbits so that they are no longer present.*

or statements relating to biocentric values (as described in section 2.7.2)

e.g. *We shouldn't kill animals because it's wrong.*

Although these values are not necessarily regarded as less important or less worthy than anthropocentric values, the arguments did not advance any practical solution to the problem.

At level 3, there is an attempt to justify the decision - addressing the 'why' part of the question by for example advocating a solution 'in order to' achieve a specified purpose.

e.g. *We have to put the elephants in game reserves protected by people with guns <u>to</u> stop poachers getting in.*
Introduce a natural predator <u>to</u> control the rabbits

However it is only at level 4 and above that comments show consideration of the effectiveness of alternative solutions.

e.g. *Either kill the rabbits by spreading disease, which is immoral, or build ledges for puffins where the rabbits can't get to, but that will cost a lot of money.*

We've got to think about people more than animals, and ivory trade helps economy, so we should cull some elephants.

Level 5 comments include the effectiveness of alternative solutions, but also show a consideration of the function or purpose of biological conservation.

e.g. *I think that the answer is to kill some elephants humanely for their ivory which could be sold to make money for the local people. <u>This way elephants won't be made extinct</u> as some are saved and peoples well being kept. Other things could also be tried like breeding elephants in an environment where tusks aren't needed. Then you can chop them off without killing the elephants.*

<u>To stop the puffins dying out</u> we need to put a fence round them to stop the rabbits using their burrows. If the rabbits still go under the fences we might have to catch as many as possible and move them somewhere else.

Table 9.4 shows each pupil's level of response in their pre and post-test written comments. The data shows a general shift to higher-level responses in the post-test comments, with a noticeable increase in the number of pupils at levels 4 and 5. This shift was apparent across both scenarios, and it is possible that this increased score was due to most pupils being more motivated post-test and so more willing (as well as able) to write more and score higher.

Table 9.4
The general level of response in pupils' pre and post-test written comments.

	Pre-test	Post-test
Level 5	6 (5%)	17 (13%)
Level 4	12 (9%)	38 (29%)
Level 3	56 (43%)	53 (40%)
Level 2	35 (27%)	11 (8%)
Level 1	22 (17%)	12 (9%)
Total	131	131

Figure 9.3 provides a breakdown of how individual pupils' written responses changed following the discussions. Most pupils (seventy-one in all; or 54%) exhibited an increased quality of response; 53 (40%) remained at the same level, and seven (6%) dropped down a level. The data is also shown in figure 9.4 to highlight the responses of members within each peer group.

A noteworthy aspect of this finding is that 25 (almost 20%) of pupils moved from level 3 to level 4 following the discussions. The key difference here was that their post-test comments included mention of alternative solutions.

There were also some more extreme level changes. For example, Peter (in group 1) moved up two levels following the discussion - from level 3, where he offered one practical solution (erecting fences) with a supporting reason (to exclude rabbits):

Put a fence round the puffins area to stop the rabbits getting in.

to level 5, where he mentioned the function of conservation (to stop the puffins dying out), and considering the effect of relocating puffins as an alternative solution to fences:

To stop the puffins dying out we need to put a fence round them to stop the rabbits using their burrows. If the rabbits still go under the fences we might have to catch as many as possible and move them somewhere else.

At the other end of the spectrum, there were six pupils who dropped from level 2 to level 1, all of which indicated that their view remained unchanged, and they were merely repeating their view. For example, a boy in group 22 gave a pre-test partially justified solution (level 2):

> *Put the elephants in a national park where they are protected from poachers.*

followed by a post-test unjustified (level 1) solution:

> *Put the elephants in a national park.*

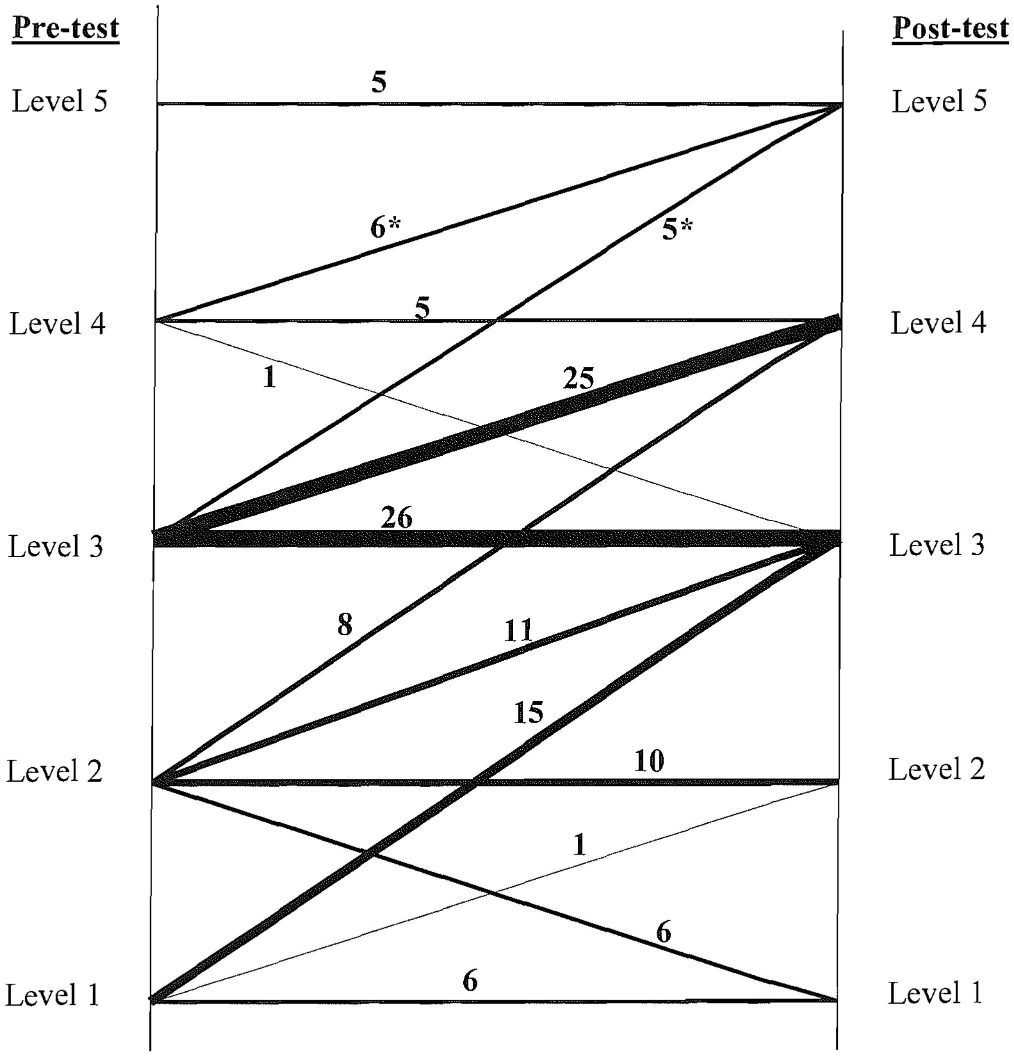
The five 'high quality' groups

As argued in section 4.4.1, changing one's mind is a product of rational thought, which is a feature of good quality argumentation (Osborne *et al.*, 2001a). It could therefore be reasoned that the group discussions of high quality were those containing pupils arguing at level 5, and more particularly (if we are searching for 'changing thinking') those containing pupils who 'changed their thinking' by moving to level 5 from a lower level. Groups containing these individuals, could then be investigated to see whether these supposedly 'high quality' discussions exhibit any readily identifiable common features. I am referring to these groups as the 'high quality' discussion groups.

Five such groups (groups 1, 3, 5, 10 and 11) were identified in this study. Between them they contained eleven pupils (asterisked in figures 9.3 and 9.5), the only ones who gave a positive change of response and reached level 5 in the post-test. Of these, six moved from level 4 to level 5, and five from level 3 to level 5. These activities of these groups were then followed more closely, as analysis of these interactions was most likely to shed light on factors contributing to quality argumentation and decision-making. The aim of the study at this point was to investigate whether these supposedly 'high quality' discussions exhibit features common to those identified in models of high quality decision-making and argumentation described in chapter 4. (These five groups are labelled as 'high quality' discussion groups in table 5.4, which summarises the data collected to support the research question.)

Figure 9.3

Overall changes in all 131 individual pupils' written responses following the decision-making discussion (line width relates directly to number of pupils)
(* indicates the eleven pupils identified as being in 'high quality' discussions as they were at level 5 after a positive change of response)



The largest rise between levels was from level 3 to level 4 (twenty-five pupils), which was essentially a move towards considering the comparative effectiveness of alternative solutions to the problem.

Lawrence in group 11 was an example of this. He began with one suggestion with some justification (level 3):

> *Poison the rabbits by putting it down their burrows, so that the puffins can use them.*

Following discussion, he suggested alternatives and attempted to compare their effectiveness (level 4):

> *You could build a fence to separate the rabbits and puffins, but that would be expensive, and rabbits might get under it. Or find another island where there aren't rabbits.*

However, he did not explicitly consider the functional part of the argument – i.e. the purpose of conserving the puffins.

Nigel, in the same group (group 11) moved from a level 3 argument:

> *Find something that kills and eats rabbits but not puffins, then the rabbits will be reduced and the puffins can expand.*

to a level 5 argument, by including some of the ideas explored in his discussion group (appendix 9.6), briefly comparing their merits, and mentioning the reason for conserving the puffins – to prevent their local extinction:

> *Build a fence across the island, to separate the puffins from rabbits, and get predators to eat the rabbits (in the winter when puffins aren't there). But if that doesn't work you might have to build a new island for the puffins to stop them dying out, even if is at great expense.*

The five 'high quality' discussion groups (groups 1, 3, 5, 10 and 11) are shown diagrammatically in figure 9.5.

Figure 9.4

Changes in all 131 individual pupils' written responses following the decision-making discussion – presented within peer groups, (groups 1, 3, 5, 10 and 11 are the 'high quality' discussion groups selected for further analysis – these are highlighted in boxes).

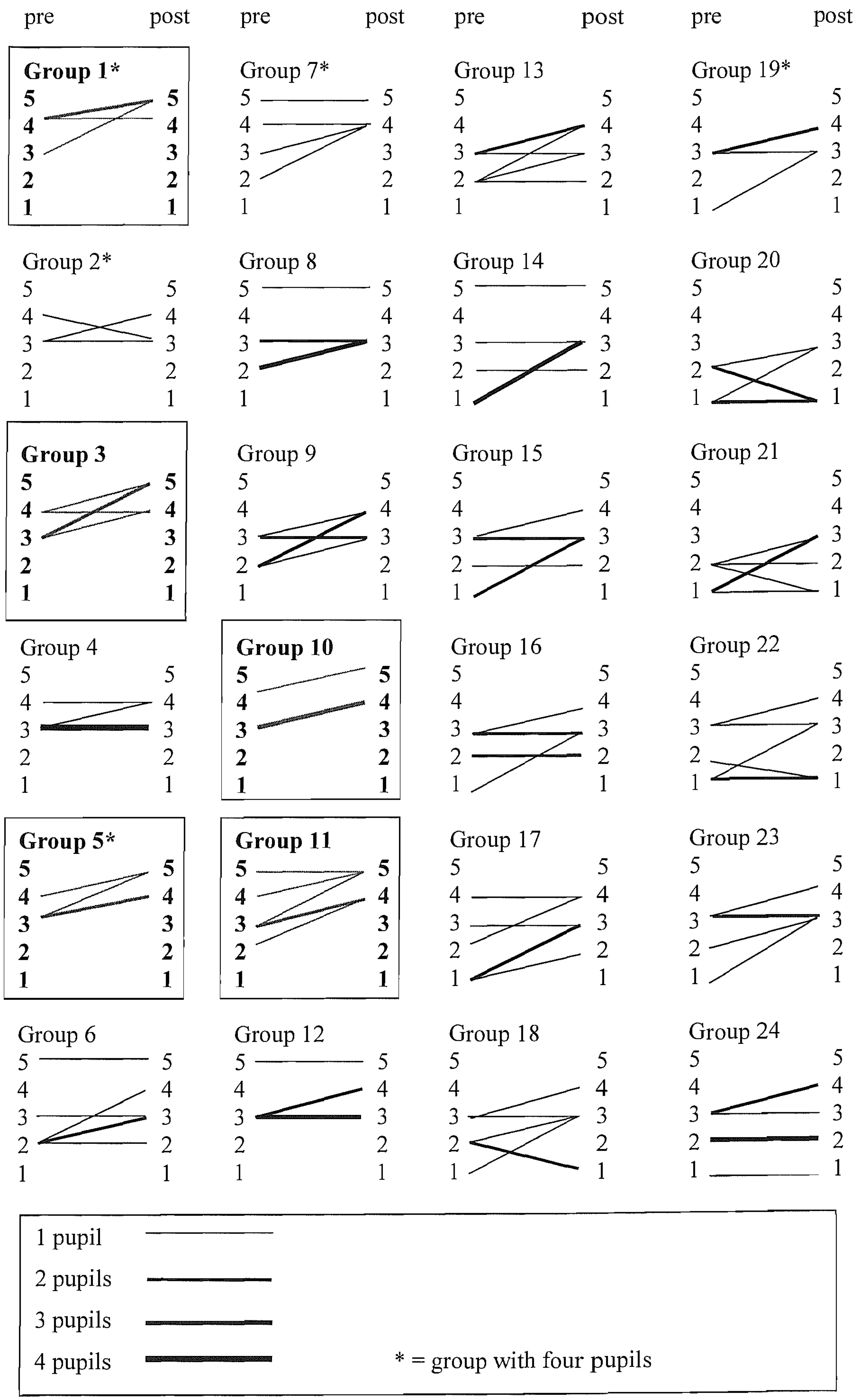
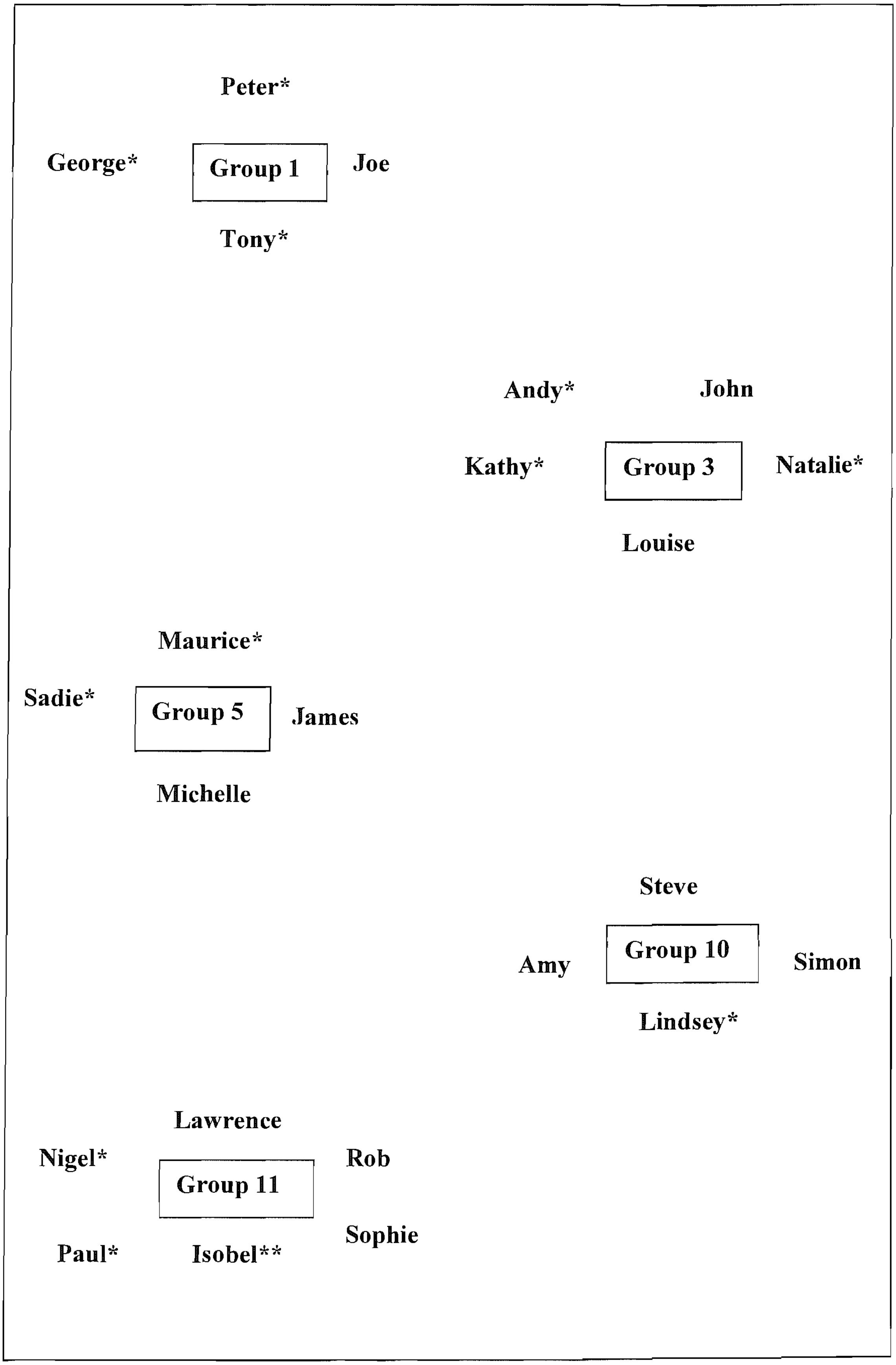


Figure 9.5
Diagrammatic representation of the five 'high quality' discussion groups containing pupils whose written responses rose to level 5 following the decision-making discussion. (These individuals are asterisked; one pupil (doubled asterisked) was level 5 at pre-test. Pseudonyms are used throughout. This does not show the actual seating arrangements, but the pupils in each group were always seated around a table.)



9.6 Features present in 'high quality' discussion groups

Having identified the five groups for further analysis, the next step was to look for factors evident in these discussions, which can be readily identified and nurtured by classroom teachers. Data collated from questionnaires (pre-test in appendix 5.10, post-test in appendix 5.11 and decision-making guide in appendix 5.12) for each of these pupils is presented in appendix 9.9.

9.6.1 Use of concepts and values among groups

The concepts and values raised by the five groups are shown alongside the original transcripts in appendix 9.10. They are shown in comparison with the results for all twenty-four groups in table 9.5. (These figures are shown as percentages to make comparison easier. However, I accept that the sample of five high-quality groups is so small that percentages have limited meaning). The data indicate that there were no conspicuous differences between the two groups, i.e. the high quality discussion groups did not draw on more or different concepts or values than the cohort as a whole.

Table 9.5
Comparison of concepts and values raised by all (24) groups and by the five 'high quality discussion groups (numbers in percentages)

Concepts			**Values**		
	All Groups (%)	**High quality groups (%)**		**All Groups (%)**	**High quality groups (%)**
culling of animals	100	100	**Anthropocentric**		
rarity	100	100	cost	92	100
species	100	100	effectiveness	58	100
food chains	100	100	safety (to people)	21	40
relocation of species	79	60	food	33	40
habitats	71	60	medicine	17	0
animal behaviour	71	100	raw materials	29	60
populations	58	40	environmental	25	60
competition	54	40	aesthetic/cultural	100	100
extinction now	38	40	socio-political	25	60
ecosystems	33	20	altruism/future generati	46	60
food webs	25	20			
sexual reproduction	25	40			
animal physiology	21	20	**Biocentric**		
introduced species	4	20	pain/ sentience	88	80
extinction in the past	4	0	right to life	100	100
genetic mutation	4	0	anthropomorphism	33	20
inheritance	4	0			
gene pools	4	20			
genes	4	0			
adaptation	8	40			

9.6.2 Decisions made prior to the discussion

A common feature among all five groups was that they all contained at least one 'level 4' pupil prior to the discussions. One pupil (Isobel in group 11) was level 5 pre and post-test. One pupil (also in group 11) began at level 2, and all the rest began at level 3 or above. The absence of level 2 or 1 pupils in the high-quality groups might suggest that discussion alone is seldom, if ever, sufficient to raise pupils responses from a level 1 to level 5.

9.6.3 Synopses of group discussions

Full transcripts of the five 'high quality' group discussions are provided in Appendices 9.2 - 9.6, and these are summarised here to draw out the general features of the discussions in terms of concepts and values drawn upon, and other immediately apparent behavioural features. Pupils who moved up to level 5 are highlighted below in capitals.

<u>Summary of Group 1 discussion</u>

Began with a grand plan by GEORGE to **transport** elephants, which was soon questioned by PETER and then TONY suggests **fences**, but GEORGE raises the social problem this would create for other people. They then all become involved in a discussion about the pros and cons of erecting **fences**, followed by **destructive nature** of elephants. Joe then takes them off task and PETER brings them back and GEORGE suggests **killing**, others then discuss this option. They then discuss operating on them and **breeding** less destructive offspring. After more off task PETER brings them back again to discuss criteria which include mention of the **local environment**, but they then concentrate again on the economics of using **fences**. Joe again takes them off task by suggesting eating elephants. PETER tries to get them on task and fails, GEORGE tries, supported by PETER and together they succeed. Further talk about economics of fences, and TONY mentions **elephant safety**. PETER suggests a **moat** instead of a fence and sticks to this mentioning it on several opportunities. TONY talks about **elephant intelligence** seen on TV but is not given the opportunity to make the connection with the present scenario. Joe then suggests they have a **vote**, and they do.

Summary of Group 3 discussion

This group discussion contains very little in terms of scientific content, but the group has a style of refining each others' ideas rather than opposing them. ANDY begins by suggesting the only solution is to **poison** the crops, but then asks others' views. John suggests separating the elephants from people, and KATHY suggests **fences**. NATALIE agrees while considering the **suffering** elephants would endure with electric fences. John mentions **cost** of fences, ANDY agrees. Louise concludes from their exchange that a fence would be suitable. KATHY suggests moving the people instead of the elephants. NATALIE and ANDY suggest the idea of giving people tranquiliser **guns**, but John explains why this is impractical. ANDY then tries to suggest a half-thought out idea, involving **diverting** them from the crops instead, and John and Louise try to support and **refine** this idea, which helps him to build the idea further. NATALIE mentions that this would **cost** a lot. ANDY suggests **relocating** them, but the conversation then lingers on encouraging the people and elephants living together somehow – keeping them as '**pets**' or feeding them away from the crops. John and KATHY are keen on the idea of **educating** the people more. Then KATHY returns to the idea of **relocation** suggesting that it wouldn't **cost** much, and it could be funded by WWF. They all agree that it's a good first step and if they come back they can try **fences**. KATHY returns to **education**, arguing that **knowledge** among locals can benefit the elephants, and others agree and return to the idea of people **feeding** the elephants, with NATALIE returning to the problem of **poverty**. John suggests feeding the elephants with any food that humans have rejected (the 'waste harvest'). Then ANDY brings them back to the task, supported by KATHY, and they use the framework to focus on **science**, KATHY says they need more **information**. NATALIE raises the need for more biological information (**uncertainty**) and mentions adaptation, then they come up with **food chains** as words but don't discuss them at all. Their final group decision is education and sharing food with elephants, suggesting relocation and fences as backup.

Summary of Group 5 discussion

They (all) begin with a discussion about whether to **move** the puffins or the rabbits. MAURICE launches straight in by challenging an idea, although it is a legitimate question about **available space**. Then they rapidly move onto the idea of reducing the size of the rabbit **population** by **culling**.. James suggests dividing the island in half with an impenetrable metal 'plate', but MAURICE objects on both **practical** and **aesthetic** grounds. Michelle suggests keeping the puffins **captive** as a means of protection. MAURICE objects to this for humane reasons, and pursues the point by **anthropomorphising** the issue asking SADIE how she would like to be in captivity. James suggests preventing **reproduction.** Michelle reverts back to her original suggestion of relocating puffins to another island and then suggests that the rabbits could be kept as **pets**. MAURICE challenges these ideas by asking probing questions and then suggests a **cage** over half the island. SADIE immediately challenges this, but without sound reasoning. They then discuss the possibility of poisoning rabbits. SADIE raises the possibility that **other species** may be poisoned too. MAURICE then calls for a **vote**, but as they still can't agree the discussion returns to the pros and cons of a **metal cage**, and this time SADIE makes an **anthropomorphic** comment by asking what it would be like for humans to be taken from their homes and **relocated**. At this point they are simply **repeating arguments** and SADIE and MAURICE decide it's appropriate to have a **vote**. However, SADIE then cuts across this activity and voices her opinion suggesting that they see if puffins can **'adapt'** elsewhere before erecting a fence. (One can assume that she was not using the word adapt in the scientific, evolutionary sense, but as meaning settling into their new surroundings). SADIE then mentions the notion of rabbits becoming **extinct**, and a conversation develops about how to dispose of rabbits. At this point Michelle who has until now made rather weak and unsubstantiated points, suggests a well backed up idea of introducing **foxes to predate** on the rabbits in winter, when the puffins have migrated. MAURICE is surprised by Michelle's idea and when he tries to take them back to his plan SADIE steps in sharply with 'No we're not doing that now'. MAURICE's response is to ask the others for their **decisions**. James then simply states the same view he started with – a big 'plate' (barrier) across the middle of the island! This was the only group of the five that did not openly follow the decision-making framework, suggesting that the framework may not be entirely necessary to progress pupils to level 5; but it is possible that a little more teacher intervention to encourage its use may have helped raise James and Michelle to a level 5 too.

Summary of Group 10 discussion

Discussion began with some relevant content knowledge input by Steve about a **television** programme he saw regarding the dilemma faced by African states whether to sell or destroy ivory seized from **poachers**. This set the scene for subsequent discussion about the **economics** of selling ivory. Then Simon suggested **breeding** elephants with big tusks which triggered a conversation about woolly **mammoths** and this led of task. LINDSEY then brings them back to the warehouse dilemma with a comment about **seeking evidence** that the ivory comes from warehouses and not freshly-killed elephants, and they agree that the trade needs to be **regulated**. LINDSEY remains adamant that elephants should not be **killed**, but Steve then points out that they can be **pests**. Amy suggests they **breed** them like **farm** animals, but LINDSEY protests that this is **inhumane**, particularly as elephants are **intelligent creatures**. Simon mentions pragmatically that the local people do **eat elephant meat**, and then returns to the question of the value of ivory, which results in more discourse about **economic value** of ivory. Steve brings them back to the **options** available. LINDSEY spells out the options and Simon raises the '**human nature'** factor (You can't stop them anyway, coz there's always going to be an illegal trade). LINDSEY introduces the notion of **national parks**. After some distantly related off task chat, Amy mentions the **suffering** elephants would have if their tusks were removed. Simon is says it isn't necessarily so, but is sympathetic. LINDSEY comes back to the **options**, and this focuses them on deciding whether tusks could be removed to assist the **economy**. Simon then introduces a new opinion that elephants need their **tusks** (as 'tools'), but Steve cuts in with the issue of **balancing the needs** of elephants with those of local people and this is discussed. At this point they agree that they are **repeating the arguments** again and need to make decisions. They return to **economics** of ivory again and the possibility that **over exploitation** will lead to **extinction**. LINDSEY suggests that there are alternatives to harvesting ivory to make a living, such as planting crops. Steve then starts a talk about **punitive measures** for poaching. LINDSEY stresses that this will cost more **money**, and Amy states that people need a **moral** opinion about the issue. LINDSEY returns once again to ivory **trading**, but they conclude by LINDSEY conceding that perhaps **people should come before elephants**. When Simon accuses her of changing her opinion, she denies it but admits that the issue is 'more **complex** than it appears'.

<u>Summary of Group 11 discussion</u>

ISOBEL begins by asking **ecological questions** about the size of the islands and how the rabbits came to be there. PAUL responds by providing his understanding of the preliminary information supplied. They continue to discuss the **ecological** aspects until Lawrence cuts in suggesting with an unjustified view that they **poison** the rabbits. NIGEL responds by saying that they need to follow the **framework** before they reach a decision, supported by *ISOBEL*. PAUL or Rob mention **guns** and NIGEL restates the options. NIGEL and *ISOBEL* mention impact of **poisoning** on the **environment** and **food chains**. PAUL then suggests **sterilisation, creating more islands** or introducing **predators**. NIGEL asks what eats rabbits and Sophie who has not contributed until now, offers foxes. Lawrence suggests 'encouraging' **fox-hunting** (somewhat provocatively). PAUL then returns to **predation**. *ISOBEL* then sums up the situation as she sees it and **instructs the group** to write down the pros and cons. Lawrence mentions **guns** again, and although *ISOBEL* tries to dismiss the idea NIGEL **mediates** by suggesting they include it as one of the options. Sophie repeats the idea of **sterilisation**. PAUL again suggests something not previously mentioned, the possibility of **leaving things as they are**. Lawrence again suggests **blowing up the burrow** and *ISOBEL* reminds him that of the **ecological** fact that puffins need the burrows too. NIGEL suggests **ferrets**, and they question what **eats** rabbits and not puffins. Rob suggests **dogs** and NIGEL suggests removing the grass (i.e. interfering with the **food chain**). NIGEL then questions why they are trying to save puffins anyway, and suggests **relocation**, but *ISOBEL* alludes to **habitat** preferences. PAUL reverts to his suggestion that the puffins might have to become **extinct** through naturally, but *ISOBEL* points out that the rabbits aren't natural (i.e. introduced by humans) and this leads to discussion about how '**natural'** can be defined, and whether **puffins are more important than rabbits**. *ISOBEL* brings them back to the framework, and they return to **sterilisation** but soon question the practicalities involved. They then move onto control of rabbits with **viruses** and problems with rabbits developing **immunity**, with PAUL mentioning this as a problem in Australia. *ISOBEL* then asks them to focus on the puffins rather than the rabbits and NIGEL again suggests **relocation**. Here, Lawrence asks if they can **catch them** all. This is the first time he has asked a question that promotes reflection. *ISOBEL* suggests a **captive breeding** programme to prevent **extinction**. PAUL then comes up with another rather profound statement about how humans will **cull** rabbits more readily than puffins. Then NIGEL mentions **fences** and *ISOBEL* refines the idea by specifying where to locate it and how, but NIGEL's not convinced it would work. This moment of uncertainty gives Lawrence the chance to **distract** them with the unhelpful idea of creating **mutant puffins** that kill rabbits, and this leads to an off-task discussion. NIGEL then returns to **fences**, and PAUL suggests **gassing** the rabbits, and again *ISOBEL* takes the idea and refines it suggesting gassing in winter when the puffins aren't present (ie considering **ecological** factors) and suggests the importance of solution which **combines a number of approaches**. Rob returns to his idea of walking dogs on the island. PAUL returns to his issue of leaving things 'natural', by saying that dog-walking was not a natural activity. Sophie then requests that they make a decision, but *ISOBEL* and NIGEL are still not agreed over the location of **fences**. Rob returns to PAUL's early idea of **creating more islands** and this time NIGEL refines the idea, with PAUL again connecting it with his knowledge of a similar project in Japan.

9.6.4 General comparison between the high-quality group discussions

I am not claiming in this study that features identified in the high-quality groups are necessarily different from those in the 'lower' groups; but this work seeks features that appear to be consistently associated with the high-quality groups. The summaries above show that all five groups discussed a mixture of science and values to varying degrees, and although some individuals began by displaying a dominating approach without involving the others, (e.g. PETER in group 1), it was noticeable that all groups rapidly settled into discussions in which there was no clearly identifiable leader, and most members contributed as a team with a degree of consensus. However, in group 5, there appeared to be some rivalry between MAURICE and SADIE, and they seemed to be vying to become dominating leaders. Sometimes one pupil would invite another to take over from them, or a new speaker would seize the initiative. As such, these groups might all be characterized as 'democratic teams' according to Gayford's (1992) categorisation of the styles of group behaviour – this is a style he identified as resulting in better understanding and motivation than the other types (4.5).

Final decisions and the main focus of the discussions varied to the extent that they did not appear to be specific indicators of quality discussions. The discussions in groups 1 (elephants) and 3 (elephants) tended to focus on <u>practical concerns</u>, with comparatively little consideration of ecological information. Group 1 spent a high proportion of time discussing fence-construction matters, whereas group 3 also focussed on the education of local people, and a feeling of uncertainty about the issues featured on occasion. Groups 5 (puffins) and 11 (puffins) concentrated more on <u>ecological considerations</u>, with some values considerations. Group 10 (elephants) focused on <u>values</u>, and were particularly <u>economics-oriented</u>, especially around the issue of the ivory trade.

With regard to the final group decision, three groups failed to reach a definite decision. Of the 'elephant' groups:

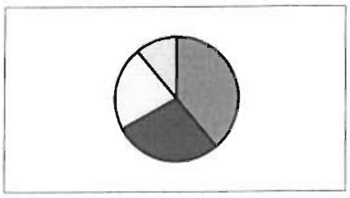
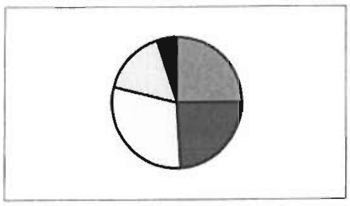
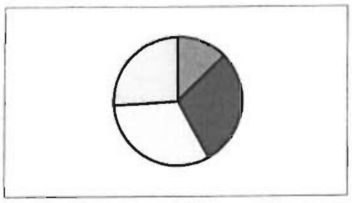
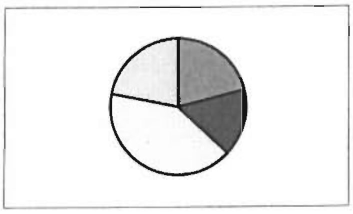
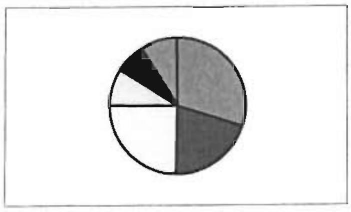
Group 1	opted not to cull but to build a fence;
Group 3	decided not to cull but to educate people, feed elephants then try relocation and fences;
Group 10	did not make a firm decision but agreed to cull if absolutely necessary.

Neither of the two 'puffin' groups came to a decision, and there was disagreement about culling, although as indicated in section 9.4, the decision itself is not necessarily important.

9.6.5 Equality of participation within groups

It also seemed apparent from the synopses above that the pupils who changed their thinking and reached level 5 tended to be those who made the largest verbal contributions to the discussions. Table 9.6 shows the equality of participation within the groups, measured as the percentage of contributions made by each group member (from the full transcripts in appendix 9.10).

Table 9.6
Equality of participation within the groups (Number of separate verbal contributions made. Pupils in capitals are those who rose to argumentation level 5; Isobel was already level 5 at pre-test)

	Pseudonym	**Number of verbal contributions made in the discussion**	**Percentage of verbal contributions made in the discussion**	**Diagrammatic representation of relative participation by each member of the group** (indicating 'reasonable' equality of participation among the pupils within the groups)
Group 1	PETER GEORGE TONY Joe	48 35 27 14	39 28 22 11	
Group 3	KATHY ANDY John NATALIE Louise	28 23 22 14 5	30 25 24 16 5	
Group 5	SADIE MAURICE Michelle James	45 41 36 19	32 29 26 13	
Group 10	LINDSEY Amy Simon Steve	44 24 23 17	41 22 21 16	
Group 11	ISOBEL NIGEL PAUL Lawrence Rob Sophie	34 28 23 10 10 8	30 25 20 9 9 7	

Although there does not appear to be any distinct pattern in terms of equality of contributions, the individuals who contribute most in each group are often the ones who have risen to level 5, suggesting a possible connection between verbal contribution and 'improved' thinking. However, Natalie in group 3 is an exception to this, and it is possible that attentive but quiet members of groups could equally move up to level 5.

9.6.6 Individual roles within groups

This section explores the roles played by individuals within the context of their group discussions. Roles of the kind identified by Hogan (1999) and Ratcliffe (1999) in section 4.5 are highlighted in bold, and some of the utterances are included to emphasise these roles.

Pupils who moved up to level 5 are highlighted below in capitals.

Group 1

GEORGE (from level 4 to 5) demonstrated his **information-vigilance** by following the decision-making framework, and this was evident from such comments as:

Anyway back to the subject, let's move on to the advantages.

and in his support of Peter's attempts to get the group back on task. He was also a **promoter of reflection** by posing questions:

What about if the ivory touches it [the electric fence]...burning the ivory; it's a valuable asset.

--

Where do you get the land from though?

GEORGE voiced his own ideas and questioned those of others, but he was also ready to **accept others' rebuttals** if it served to move the discussion along:

Tony:	*Yeah, electric fences.*
George:	*No that'd just kill 'em.*
Peter:	*No it wouldn't.*
Tony:	*No it wouldn't.*
George:	*OK.*

PETER (from level 3-5) was also **information-vigilant**:

Good, right I think we're agreed then on the options

He was the self-appointed **'leader'** of the discussion, frequently trying to bring the group back on task with chivvying phrases such as: '*come on guys*' and '*right other options*?', and ensuring that the scribe (TONY) was taking notes correctly:

So I think the most important matter here is...OK so you got that then?

He did **promote reflection**:

...right what's more valuable, an elephant's life or a human's life?

but was less prepared to adopt others' views than relinquish his own; as in the way he **stuck rigidly to his idea** of digging a ditch as a barrier. To a lesser extent he was a

contributor of content knowledge, introducing for example the ecological concept of the positive effects of trampling.

TONY (from level 4 to 5) was a **contributor of ideas**, some based on content knowledge:

...an elephant can tell what group it is by sniffing their dung...

and some simply practical ideas:

What about put all the elephants in a conservation area?

He waited for chances to voice his opinions, which were generally concise in their delivery, and his suggestions were often pivotal in moving the discussion on (e.g. introducing the ideas of fences, and conservation areas, and he was the only one to mention **elephant safety**). Unlike PETER, if TONY's ideas were not endorsed or adopted by the group, he **did not attempt to defend them** further. This was particularly evident on two occasions: when his (seemingly serious) suggestion of a 'mating scheme' created laughter in the group and ridicule from Joe; and when his thoughts about elephant intelligence were challenged by PETER for being irrelevant.

Joe (remained at level 4) generally supported GEORGE's ideas, the majority of his comments served to **distract** the group and take them off task by, for example, encouraging them to imagine: eating an elephant, operating on elephants, chasing them away with long sticks, attach an elephant to a dynamo, and putting an elephant in a box. It is difficult to draw the line between distractions that actually inhibit progress, and the kind of joking around together that forms a normal part of healthy group interaction. In this group, Joe's comments did not appear to have inhibiting effects, but neither did they contribute much to the discussion, and one can only speculate how the conversation might have proceeded without characters such as PETER to keep them on task:

Tony:	*OK which one are we going for? the fence yeah?*
Peter:	*No I wouldn't go for the fence.*
Tony:	*I would say the fence coz...*
Joe:	*I'd say we put them in a box.*
Peter:	*That's inhumane, no, the only bad thing about the fence is that it might not be strong enough, so what they could do is they could test it.*

<u>Group 3</u>

ANDY (from level 4 to 5) was **information-vigilant**, and the scribe for the group. He pulled them together and ensured they followed the decision-making framework with questions such as:

OK so where are we?

--

OK what about number 3, do we have enough information?

Another of his roles was as a **mediator of group ideas** in that he often asked for others' views and encouraged their views with a frequent supportive '*yeah*'. He did not contribute much content knowledge, and many of his suggestions were semi-thought out:

...maybe give them something they can destroy that doesn't have to be sort of...

--

What about...what about...oh I know what it was...you could have some kind of diversion that puts them off before they get to the crop.

He also had a **subordinate role as a promoter of reflection,** asking questions for others to consider:

'*OK, other than poisoning the crops, so that if they eat it they die, there's nothing really they can do is there?*'

--

'*What about relocating them?*'

John (remained at level 4) was very much a **mediator of ideas**. He politely and light-heartedly suggested why others' views were not practical:

John: *Yeah but it would take a hell of a lot of tranquilising and once you've got an unconscious elephant what the hell are you meant to do with it'* and **tactfully refined others' ideas**:

Kathy: *Is there something you could do to the people? ...like move them all away from the area?*

John: *Well not necessarily move the people, move the crops.*

Kathy: *Yeah that's what I mean.*

John **promoted reflection** by asking **questions** rather than making assertions; he was the only member overtly concerned with elephant safety, and he was **information-vigilant** by stating **uncertainty** due to lack of data:

Well you need more information about the situation really don't you.

KATHY (from level 3 to 5) demonstrated her **information-vigilance** by ensuring they followed the framework:

Shall we do the other side then?

and by expressing her **uncertainty about the information provided**:

We need more general research about it.

She also **promoted reflection** by making suggestions with a **questioning style of approach** (similar to that of John):

> *Is there something you could do to the people?...like move them all away from the area?*

and **by refining others' ideas**: she responded to John's idea of giving 'left over' parts of the crop to elephants by saying:

> *Hmm, but then you'd have to have a way of filtering out the... bad crops that you're growing wouldn't you?*

She was also keen on promoting the **education** of the local people and raised it several times, often using comparatively long utterances.

NATALIE (from level 3 to 5) **promoted reflection** not by using questions but more in a style of unfinished statements:

> *It's got to be something to do with the local people.*
> *Food would cost money and farmers couldn't afford to keep doing that...*

She was to a lesser extent a **mediator of ideas** by supporting others' comments, and **information-vigilant** by showing her concern for the **uncertainty** of underpinning information

> *Yeah, you need more information about general elephant biology...and you need more about the food chain and what elephants eat.*

Louise (remained at level 4) was relatively quiet and did not contribute much to the discussion. She displayed an **unreflective acceptance of ideas** and was **keen to complete simple tasks** in order to move on without getting involved in deeper reasoning. This attempt to reach a rapid conclusion is evident through comments such as:

'*So a fence would work.*'
'*Yeah I definitely think that's the first step.*'
'*Yeah, it's a good decision.*'

However, she did on occasion support others in helping to **refine** their ideas.

<u>Group 5</u>

James (from level 3 to 4) was rather quiet but **promoted reflection** by asking probing questions:

> *Yeah but what if the poison is still on the one side and the puffins eat the rabbit poison and they die?*

He was supportive of Michelle's ideas, but **stuck rigidly to his idea** of using a metal barrier, even when SADIE demonstrated that the notion was clearly flawed:

James: *I think you have like a great big, deep metal plate on one half of the island.*
Maurice: *But the rabbits would burrow under the plate.*
James: *No that's why I say a deep one – and high as well.*
....
....
Sadie: *Yeah, but then the puffins could fly over, so they'd go on the other side anyway.*
James: *Yes but they've got to learn eventually not to go there.*

MAURICE (from level 4 to 5) had a rather abrupt manner and had a variety of roles in the discussion. He was inclined to be the centre of attention:

OK, just listen OK?

he could also be confrontational and slightly patronising:

Maurice: *That's why it's called rabbit poison not puffin poison!*
Sadie: *What if it affects both of them?*
Maurice: *Well it doesn't! Puffins only eat fish.*

--

How would <u>you</u> honestly like to be in captivity if <u>you</u> were...

--

That is actually quite a good idea – then the foxes will hunt down the rabbits for food – but Michelle, the foxes may want to go for the puffins.

But he was nevertheless a **promoter of reflection** by challenging others with probing questions, as well as being a **contributor of some content knowledge**:

What if there's no other island?

--

What if the foxes have reproduced massively?

Despite his aggressive style, MAURICE mentions humane issues (and is against culling throughout):

They need space, you cannot keep a bird in captivity!

He is also **information-vigilant by marshalling the views** of others:

Right, we've heard Michelle's view and mine, now what's your view?

--

Who agrees with James' plan? – I agree with him – 2 v 2!

MAURICE and SADIE were noticeably antagonistic towards each other and could be regarded as **promoters of acrimony,** but it is difficult to quantify the extent of hostility, and this style of teasing and mockery actually served to move the conversation along:

Maurice:	*No you don't need to* [feed the rabbits] *they've got half an island to themselves*
Sadie:	*But they'll eat all the grass.*
Maurice:	*Grass grows!*

SADIE (from level 3 to 5) played the joint role of **contributing content knowledge** (such as when she suggested practical ideas such as reducing the rabbit population), and **promoting reflection**:

So you're only worried about the puffins and rabbits – not about all the other things on the island that you're going to poison too?

She also displayed **information-vigilance** by attempting to keep the group on task:

OK so we need to come to a decision of what we're going to do.

But she was also a **promoter of acrimony**, always ready to disagree (particularly with MAURICE, as mentioned above):

No that's a bad idea!
No we're not doing that now.

even if it was simply for the sake of disagreeing:

Michelle:	(to Maurice) *I think it's a good idea actually.*
Sadie:	*It's not a good idea Michelle.*
Michelle:	*Yes it is.*
Sadie:	*It can't be if it's Maurice's idea!*

Michelle (from level 3 to 4) plays a prominent role as a **mediator of ideas**, being prepared to support and endorse others' ideas:

Michelle:	*I think it's a good idea actually.*
Sadie:	*It's not a good idea Michelle.*
Michelle:	*Yes it is.*

She **contributed many ideas**, and as such **promoted some reflection** and was **not afraid to be rebuked**, even though her thoughts were not always fully formed:

I think we should just take the rabbits away – but not all of them.

Although she did not contribute much in the way of **content knowledge**, a notable exception to this was her well-conceived (and well-received) proposal about introducing foxes:

If you put the foxes on the island when the puffins have migrated in the winter, and then when it comes to the summer, all the rabbits will be gone, and you can take the foxes back and the puffins can live there!

<u>Group 10</u>
Simon (from level 3 to 4) **promoted of reflection** by asking pertinent questions:

Is the ivory just from those that have died?

--

Do we really need ivory?

He was **information-vigilant** in the sense of looking for information, and encouraging the group to follow the framework:

...do we have any information about each option? We need to decide what to do.

and keeping track of others' opinions:
You've changed your opinion haven't you?

He was also a **mediator of ideas**, having a fairly pragmatic approach to the issue himself (e.g. stating candidly that local people eat elephants; and that there will always be poachers), but also being sympathetic to others' views.

LINDSEY (from level 4 to 5) often **promoted reflection** with open-ended questions:

There must be some alternative way of exploiting the land...

She was **information vigilant** returning the group to the options several times, and keeping issues on the agenda, such as the regulation of the ivory trade. She was very much focused on the economics of the issue, and although she was against killing elephants at the start, she later conceded that it is acceptable if absolutely necessary.

Amy (from level 3 to 4) was not as vocal as LINDSEY, and others did not respond to her ideas so readily, but she acted as a strong **contributor of content knowledge:**

It's difficult to farm elephants though.

--

If they could reproduce the woolly mammoth...

--

With pigs they breed them specially for their meat and they could breed elephants like that.

and as a **contributor of values,** she was very concerned about elephant welfare, and our morals obligations towards them:

It's not right to remove tusks as it's painful.
Everyone always puts themselves first.
The money won't go to help the economy anyway, it will just go into the hunter's pocket.

You've got to have some kind of like moral opinion about it and stick to it.

Steve (from level 3 to 4) started the whole discussion by **contributing content knowledge** about warehouses full of ivory and this set the tone for the whole discussion which subsequently revolved around the ivory trade. His numerous contributions on this subject also served to **promote reflection**, and he showed some **information vigilance:**

So what exactly are the options available?

Group 11

ISOBEL (remained at level 5) **promoted reflection by posing probing questions**:

How do the rabbits get on the islands?

--

...how big's this island? Are we talking about a little crag off the coast?

and a **contributor of content knowledge:**

Imagine they're like the Channel Islands – I've seen puffins over there.

--

...the puffins eat the poison as well, and anything that eats the rabbits.

--

Puffins are a natural British species, rabbits aren't.

She also demonstrated **leadership** and came across strongly as an **information vigilant** pupil by encouraging the group to follow the framework:

We'll do that when we get the options done.

--

Look we're going off at a tangent here – right advantages of sterilisation?

--

OK so what's our solution? We've been through all the ways of culling rabbits.

--

Right what we're going to do is write down what we're going to do, and how we're going to do it and then we write down the advantages and disadvantages.'

And she was effective at collating others' views and **refining** them:

Isobel: *I think we should do a combination of things – that's what Captain Conservation would do!'*

--

Nigel: *We haven't talked about creating a puffin-friendly environment; make them separate like fence them in.*

Lawrence: *No coz they can fly over it.*

Isobel: *No fencing not to stop the puffins, to stop the rabbits, and make all the burrows on a certain bit of the cliff.*

--

Paul: *I think we should gas the rabbits*
Nigel: *Yeah but how do you know it's not a puffin hole?*
Isobel: *If you do it out of the breeding season…*

Sophie (from level 2 to 4) is comparatively quiet and tends to play a **supportive** role by verbally agreeing with others, rather than offering her own ideas.
However, she is discernibly **information-vigilant**, keeping others on track with both content and procedural matters:

Nigel: *…why are we trying to save the puffins anyway?*
Sophie: *Because the rabbits are stopping the puffins – there are lots of rabbits…*

--

I reckon we should now just put one of them [options] *down with reasons.*

Rob (from level 3 to 4) did not say much during the discussion and his utterances were brief. His main contribution was the **idea** of bringing dogs onto the islands, but he **did not defend** this when challenged:

Rob: *You could encourage dogs in that area*
Isobel: *So the dogs chase the rabbits*
Rob: *Yeah*
Isobel: *But they'll chase the puffins too.*
(Rob did not respond to this).

PAUL (from level 4 to 5) **promoted reflection** with comments that highlighted the complexity of the issue:

It depends how big the island is.

and also through being a major **provider of ideas**:

Make them infertile by…

--

They could make more islands; or they could get some predators there.

--

If we have some kind of smell that they didn't like.

--

I think we should gas the rabbits.

a **provider of** relevant **content knowledge:**

Yeah they did that [infect rabbits with viruses] *in Australia – they killed 99.9 percent of the rabbits and the other point one percent have taken over the whole area again.*

--

In Japan they've built an airport in the middle of the sea.

and a **provider of moralistic values (both biocentric and anthropocentric)**:

So are you saying that puffins have higher priority [than rabbits]?

--

It's strange that humans will kill the rabbits but they won't kill the puffins.

--

Or we just leave it, and let the puffins die out.

--

Paul: *Well then they're going to have to die out aren't they.*
Nigel: *That's not very sympathetic.*
Paul: *No but it's nature isn't it.*

NIGEL (from level 3 to 5) played a variety of roles in this discussion. He was occasionally

information vigilant, encouraging the group to follow the framework:

Hang on we've got to do the things of the criteria.

He **contributed some content knowledge:**

OK, poison rabbits – but they tried that didn't they in the 70s, and it just like mucked up the ecosystem.

He played a minor part in **mediating ideas**:

Put [write down] *guns, poison, infertility.*

and **refining** others' ideas:

Paul: *There are no predators for the rabbits so you just get predators.*
Nigel: *More predators, there are predators, but we just need more.*

NIGEL's major role, however, was clearly one of **promoter of reflection**, resulting from a mix of probing questions and statements:

We haven't talked about creating a puffin-friendly environment; make them separate; like fence them in.

--

Well we'll have to engineer something that eats rabbits and not puffins.

--

But that wouldn't stop the puffins getting out; and it doesn't solve the problem that there's not enough space.

--

Don't ferrets kill rabbits?

--

Why can't they find some more islands? There must be other islands.

--

So when do they [rabbits] *become natural – after 2000 years?*

--

OK what's the problem with viruses?

--

Yeah but how do you know it's not a puffin hole?

Lawrence (from level 3 to 4) did not speak very much during the discussion. All his utterances were brief, and these did not appear to contribute much to the proceedings:

I've got a clever idea; you should mutate puffins to kill rabbits.

--

Yeah; poison the rabbits.

--

Encourage fox hunting.

--

You could blow up the burrows with them in.

--

It would be easier to kill them wouldn't it?

Although these might be considered **'macho'** comments, Lawrence was actually against culling in his pre and post-discussion individual written response! As with Joe in group 1, Lawrence could have been a potential **promoter of distraction**, but this was kept in check by the other group members' enthusiasm to make progress. His most prominent role was probably that of **promoting unreflective acceptance of ideas.** Although he was the first to suggest introducing predators, there was no evidence of deeper thinking about how this might be achieved:

They could get something that eats rabbits.

The above summaries of the roles played by individuals are collated in table 9.7. There is undoubtedly some overlap among the categories, and the data are somewhat subjective since it is not entirely possible to gauge the impact a comment can have on, for example, 'promotion of reflection'. However it serves to compare the range of roles that pupils adopted during the activity in an attempt to detect factors common to all. The analysis of roles in this section shows that the role referred to by Ratcliffe (1997; 1999) as 'information-vigilant' (i.e. those who used readily accessible information to clarify the pros and cons of particular options) was evident in all groups; but not always in the same respect. There appeared to be three distinct approaches to this role as follows:

- information-vigilance by showing concern for uncertainty about the issue, or looking for information (present in two of the five groups)
- information-vigilance by marshalling others' ideas (present in three of the five groups)
- information-vigilance by following the decision-making framework (present in four of the five groups)

These were not always present in the discussions, but it is important to recognize that information-vigilance can manifest itself in several different ways. For example, a disregard for the decision-making framework (as with group 5) does not necessarily indicate a lack of information-vigilance.

Roles suggested by Hogan (1999) that promote groups' reasoning processes (see section 4.5) were also present in these high quality discussion groups - contributors to content knowledge, mediators of group interactions and ideas, and promoters of reflection. But only promoters of reflection were prominent in each group. Hogan (1999) regarded promoters of reflection as the most important role in this respect, and I have added some detail to the nature of this role by dividing it into three distinct sub-categories:

- promoter of reflection through asking thought-provoking questions
  (present in all groups)
- promoter of reflection through making thought-provoking statements
  (present in all groups)
- promoter of reflection by refining others' ideas
  (present in three of the five groups)

Again, it is useful to recognize different forms of promotion of reflection, but the form that emerged most prominently in all discussions was reflection through asking relevant probing questions of peers (as shown in table 9.7). This could thus be a technique worth encouraging among pupils to improve their skills of argumentation.

Table 9.7
Main roles played by group members during discussions
(capital letters indicate a prominent role; asterisks refer to 'high quality reasoners', i.e. those who rose to level 5 in the scheme shown in figure 9.2; Isobel** was also level 5 pre-test)

Roles	Group 1	Group 3	Group 5	Group 10	Group 11
Promoter of reflection (through questions)	GEORGE* PETER*	Andy* JOHN KATHY*	JAMES MAURICE* SADIE* Michelle	SIMON LINDSEY* Steve	ISOBEL** NIGEL*
Promoter of reflection (through statements)	George*	NATALIE*	Sadie* Michelle	Simon Lindsey* Steve	PAUL* NIGEL*

Roles	Group 1	Group 3	Group 5	Group 10	Group 11
Promoter of reflection (by refining others' ideas)	GEORGE*	KATHY* JOHN Louise			ISOBEL** Nigel*
Information-vigilance (by concern for the uncertainty/looking for information)		John Kathy* Natalie*		SIMON STEVE	
Information-vigilance (by marshalling others' ideas)		ANDY*	MAURICE* SADIE*		ISOBEL**
Information-vigilance (by following the decision-making framework)	GEORGE* PETER*	KATHY*		SIMON LINDSEY*	ISOBEL** SOPHIE Nigel*
Group leader	Peter* (initially)				
Contributor of science content knowledge	Peter* TONY*	John	SADIE* Maurice* Michelle	AMY STEVE	ISOBEL** PAUL* Nigel*
Contributor of ideas (and will defend them until they are adequately modified by others)	GEORGE*		MICHELLE		PAUL*
Contributor of ideas (and will defend them rigidly, regardless of quality of rebuttal)	PETER*		JAMES		
Contributor of ideas (but reticent to defend them on rebuttal)	TONY*				Rob
Contributor of values				AMY	PAUL*
Promoter of distraction	JOE				Lawrence
Mediator of group ideas		ANDY* JOHN Natalie*	MICHELLE	SIMON	Nigel*
Promoter of unreflective acceptance of ideas		LOUISE			LAWRENCE
Promoter of completing simple tasks		LOUISE			
Promoter of acrimony			Maurice* Sadie*		

9.6.7 Argumentation within groups

The five high-quality groups were identified as those containing pupils who reached level 5 in the hierarchical scheme for the quality of personal reasoning - presented in figure 9.2. The hierarchical model proposed by Osborne *et al.* (2001a) and Zeidler *et al.* (2003) (described in section 4.4.1, and summarised again in figure 9.6) for measuring the quality of argumentation within discussion groups, was applied to the five 'high quality' groups in this study, to see if top level group argumentation was a feature of the five high-quality discussion groups.

Figure 9.6
Hierarchical scheme indicating levels of quality of group argumentation (after Osborne *et al.* (2001a; 2004a) and Zeidler *et al.* (2003)

Level 1 Arguments
Consist of a simple claim versus a counter-claim; or a claim versus a claim.
Level 2 Arguments
Consist of claims with either data, warrants or backings but do not contain any rebuttals.
Level 3 Arguments
Consist of a series of claims or counter-claims with either data, warrants or backings with the occasional weak rebuttal.
Level 4 Arguments
Consist of a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims as well, but this is not necessary.
Level 5 Arguments
This is an extended argument with more than one rebuttal.

Appendices 9.2 – 9.6 show the full transcripts for the five groups divided into episodes of argumentation and their associated features of argument, as described in section 4.4.1. These appendices show how the utterances were analysed by categorizing parts of the conversation as specific features of argument. The features of argument were assigned, regardless of whether the statements made by pupils are true, or based on sound evidence – it is the structure of the conversation under scrutiny rather than the accuracy of the content.

Sometimes it was impossible to be sure whether comments were counter claims or actually supporting claims in an attempt to encourage the protagonist to expand on their claim. For example group 10's discussion:

Simon: *You can't stop them* [poachers] *anyway, coz there's always going to be an illegal trade, and poachers.*

Lindsey: *But it* [the ivory trade] *will decrease the likelihood of it* [slaughter] *happening*
Simon: *Maybe; otherwise it* [slaughter] *will increase – sometimes it does increase.*
Amy: *Why?*
Simon: *Because it's* [the ivory] *less available…*

Simon claimed that banning the sale of ivory might increase the slaughter of elephants. Amy asked '*Why*?' in a tone that suggested she disagreed. However, she may have been (possibly subconsciously) encouraging him to articulate his contribution more clearly.

Rebuttals are not always easy to identify. Occasionally pupils challenge their own ideas while verbalising their thoughts – a kind of 'self-rebuttal', as exemplified by Kathy's comment in group 3:

> *You could try relocating them, that would get rid of them permanently, I mean there are elephants like on the edge of safari parks, but if you get rid of them, we don't know if they'd just turn up again.*

It is important to note that it is not only the episodes of argumentation that advance the discussion; there are occasions when individuals contribute information which is not challenged, but serves to focus the group and put the issues into context. This was the case, for example, with Tony's utterance in group 1:

Tony: *Elephants are really clever right. I saw this programme right where elephants…an elephant can tell what group it is by sniffing their dung, and to know how old the dung is and to know where the other tribe are.*
George: *Like marking its territory.*

Although pupils in all groups talked collaboratively to co-constuct arguments, it would appear that rebuttals, interruptions and non-verbal interactions were a part of this dynamic process, and similar to the concept of *exploratory talk*, put forward by Mercer *et al.* (1999) (4.4.1), which in their view is indicative of effective argumentation. There were similarities in that contributions were often critical and challenging but constructive, and interruptions were often supportive rather than disruptive.
In relating the components of group argumentation to the levels of quality presented in figure 9.6, each of the five groups demonstrated high quality (level 5) group arguments of the type described by Osborne *et al.* (2001a) and Zeidler *et al.* (2003). Level 4 arguments contain a clearly identifiable rebuttal; level 5 arguments are extended arguments with more than one rebuttal. However, the occurrence of these episodes

varied considerably between groups (table 9.8). Group 3 had noticeably fewer level 4 and 5 episodes than the other groups, and their discussion was more characterized by agreement and refinement of each other's ideas. It follows that this group's arguments contained a relatively high number of 'qualifiers', as these often served to clarify conditions under which a claim can be regarded as true.

It would appear from the findings presented in table 9.8 that these groups were readily able to engage in frequent level 5 group arguments, and while this may be one indicator of quality discussion for educators to encourage among pupils, there may be other indicators of equal value. Some of these are explored in the following sections.

Table 9.8
Number of episodes of high quality arguments within groups
Data extracted from features of arguments identified in the transcripts in appendices 9.2 – 9.6

Group	Number of episodes at Level 4	Number of episodes at Level 5
1	5	3
3	1	3
5	4	7
10	6	4
11	11	4

9.6.8 Proportion of time group spent on task

The proportion of time spent off-task was measured for each of the five 'high quality' discussion groups, although this is a subjective measurement as the extent to which the off-task conversations relates to the issue varied considerably. However, the results given in table 9.9 indicate that off-task conversation did not appear to be directly related to quality of discussion. Group 1 were particularly prone to tangential conversations, often instigated by one member (Joe), but others (George and Peter) were always ready to steer them back on task, and it remained a high quality discussion.

Table 9.9
Percentage of time spent off-task by each of the five 'high quality' discussion groups.

	Group 1	Group 3	Group 5	Group 10	Group 11
Time spent off-task	21%	4%	7%	8%	9%

9.6.9 Inclusion of 'long utterances'

Mercer *et al.* (1999) identified 'long utterances' as a factor indicating high quality argumentation (as described in section 4.4.1). When working with ten year olds he arbitrarily defined these as being at least 100 characters in length when transcribed. Similarly, for the present selected groups of 15 year olds I have arbitrarily defined long utterances as at least 150 characters long when transcribed. The frequencies of occurrence of long utterances in the five selected discussions (shown in table 9.10) are variable, as are the number of individuals using them, indicating that this is not a reliable measure of high quality argument in this study. Furthermore, the longer utterances are often, but not exclusively, made by pupils who began at level 5, or reached level 5 after the discussions.

Table 9.10
Frequencies of occurrence of 'long utterances' (at least 150 characters when transcribed) in the five 'high quality' discussions. (asterisks indicate 'level 5' reasoners)

	Total number of long utterances	Number of individuals using long utterances	Pseudonyms of group members and length of utterances
Group 1	6	2	Peter* 151, 246, 182, 286, 202 Tony* 209
Group 3	9	3	Kathy* 155, 202, 203, 196, 332, 166 John 176, 150 Natalie* 154
Group 5	7	4	Maurice* 180, 187 Sadie* 245, 210, 162 Michelle 212 James 160
Group 10	8	2	Steve 303 Lindsey* 177, 210, 164, 179, 207, 182, 193
Group 11	2	1	Isobel* 341,154

9.6.10 Relevance of pupils' experiences and interests

Table 9.11 gives a comparison between interests and experiences of all pupils with those from 'high quality' discussion groups. In response to the questions in appendix 5.10, the vast majority (75%) of the 131 pupils said they were 'quite interested' in wildlife, and 17% said they were 'very interested' in wildlife. 32% of these 'wildlife enthusiasts' supported culling of rabbits and 23% supported culling of elephants. In this respect they did not differ much from the rest of the pupils in the study, so interest in wildlife did not obviously affect views on culling. 16% of pupils claimed to watch programmes or read articles about wildlife at least once a week. Five of these (4%) belonged to some kind of wildlife group, and only one pupil (in group 2) claimed to be actively taking part in conservation activities, as part of his Duke of Edinburgh Award activities.

In exploring possible connections between high quality discussions and pupils' experiences and interests, the details of the five selected 'high quality' discussion groups are also presented in table 9.11. No strong patterns were discernable, but the sample size was fairly small. 35% of the pupils (eight of the twenty-three) changed their minds from rejecting culling before the discussion to advocating it after discussion; four of these were level 5 reasoners. However, seven of these pupils (30%) were 'very interested' in wildlife, and this was a relatively high proportion compared with the 17% figure overall. All but one of these wildlife enthusiasts (i.e. six; or 26%) claimed to watch TV wildlife programmes or read wildlife articles at least once a week. Again, this is a higher proportion than the 16% across the cohort as a whole, and initial interest may therefore be a factor leading to high quality discussion, and ways of promoting interest may need to be explored. However, none of the pupils in these five groups belonged to wildlife groups or took part in conservation activities.

Table 9.11
Comparison between interests and experiences of all pupils with those from 'high quality' discussion groups (based on responses to the questionnaire in appendix 5.10)

	All pupils (n=131)	'high quality' discussion groups (n=23)
Quite interested	75%	60%
Very interested	17%	30%
Wildlife programme/ article at least once a week	16%	26%
Belong to a wildlife group	4%	0%
Take part in conservation activities	1% (1 pupil)	0%

9.6.11 Pupils' perceived usefulness of conservation discussions

Pupils appeared to find the decision-making discussions in peer-groups useful and enjoyable. Collective responses from all pupils to questions in the post-test questionnaire were as follows:

How useful do you rate this kind of discussion in helping you develop your opinion about conservation?
87% found the task 'useful' (63%) or 'very useful' (24%); 9% 'quite useful', and 4% 'not very useful'.

Do you prefer discussing conservation issues in groups like this, or thinking about it on your own?
79% registered that they preferred the group discussion approach, 9% preferred thinking alone, and 12% had no preference.

9.6.12 Pupils' memories of discussions a year later

The semi-structured interview schedule in appendix 9.11 was used as a guide to explore pupils' memories of the discussion a year later at the end of their compulsory science course. The interviews were conducted after pupils had completed the final questionnaire. It was designed to get a general idea (given the limited time available – about 10 minutes per group) of what they recalled about the issues and the decision-making process, to see what science and values they recalled drawing on, and to see how motivating the exercise was. Seven pupils were absent or had moved from the class during the intervening year. The five selected 'high quality' discussion groups did not appear to remember aspects of their discussions any better than the rest of the groups. The following is a summary of these interviews:

How did you work as a group to make the decision?

Generally the groups knew very well who the dominant characters were among them, but few remembered what their friends' actual views had been during the discussions.

What do you remember about the issues and decision-making tasks.

All groups remembered the issue they had discussed (elephants or puffins) albeit sometimes after some hesitation. After a little time all groups were able to recall at least some of the issues involved, such as whether to relocate rabbits or fence off elephants. Most of what they could remember was values-oriented, particularly in terms of animals' right to live and cost-effectiveness of proposed methods of control.

Can you remember any of the steps in the decision-making guide?

Almost none of the groups could remember any steps of the decision-making framework. The few individuals who could remember, only brought to mind weighing up pros and cons of the suggested solutions to the problems.

Can you remember any views on the subject that were different from yours?

Some individuals were able to remember some alternative views proposed during the discussion, but could seldom recall whose views these represented, and usually had trouble remembering their own points of view.

Can you remember any science that your group considered to help make the decision?

Most groups who were able to recall specific scientific concepts mentioned food relations and aspects of animal behaviour and animal physiology; but in the limited time very little else came to mind. Most of what they could remember was values-oriented.

Can you remember what decision you made?

Very few individuals remembered what decision their group had finally made, but they rapidly began to recall the alternatives they considered.

9.7 Summary

This summary highlights the main findings described in this chapter. These are not presented in order of perceived significance, as they are all potentially considered to be equally important features of high quality peer-group decision-making discussions.

General observations on group engagement

Pupils generally remained on-task during the decision-making activities. All groups suggested several possible solutions to the conservation issues. There was no discernable pattern of the order in which concepts and values were raised and discussed.

Individuals' pre-test/post-test change in thinking about culling

Both before and after discussion, the majority of pupils suggested a solution other than culling (e.g. constructing fences, relocating or sterilising animals). However, more boys than girls chose culling as an option (of both elephants and rabbits), and although more people advocated culling rabbits than elephants, the gender difference was fairly consistent for both scenarios. After the discussion, there was a marked increase in advocating culling among both boys and girls, and these elevated numbers persisted one year later.

Comparing individual decisions about culling with group decision

Of the 24 groups, 5 groups agreed to accept the practice of culling if absolutely necessary, 5 groups failed to reach a decision about culling, and the remaining 14 groups rejected culling as an option. However, the pupils' individual responses following their discussion did not necessarily reflect their group's decision, indicating that the validity of group decisions of this kind should be treated with caution, and that the process of decision-making is more meaningful than the group decision itself.

Modification of views after discussion

Although some pupils were initially very rigid in their views, exposure to the views of others demonstrated the benefit of discussing the issues with peers. After the discussions most pupils modified their views, by suggesting a different solution or at least electing for a combination of ideas as a solution to the problem.

Pre-test/post-test changes in level of argumentation

Most pupils exhibited an increased quality of argument in their responses following the discussions. The most numerous increase was from level 3 to level 4, indicating that the discussions resulted in consideration of alternative solutions, and effectively modified pupils' views on the issue. Five of the twenty-four groups were deemed 'high quality' discussion groups as they contained pupils who showed a positive change of response and reached level 5 in the argumentation scheme in the post-test.

Features present in 'high quality' discussion groups

All five groups contained at least one 'level 4' pupil prior to the discussions. They all discussed a mixture of science and values to varying degrees, and all rapidly settled into discussions without a clearly identifiable leader, with most members contributing as a team with a degree of consensus. The nature of the discussions varied, with two elephant discussions focusing on practical concerns (fence-construction, and education of local people) with comparatively little consideration of ecological information; and the other elephant group focusing on socio-political values in relation to the ivory trade. The puffin groups concentrated more on ecological considerations, with some values considerations. The final group decisions also varied. Neither of the two puffin groups came to a decision, and there was disagreement about culling. One elephant group opted not to cull but to build a fence; another decided not to cull but to educate people, feed elephants then try relocation and fences; and the other group failed to reach a firm decision but agreed to cull if absolutely necessary. The proportion of time spent off-task varied considerably.

Individual roles within the groups

Most members of each group contributed to the discussion by playing a variety of roles. At least four members of each group contributed by: promoting reflection through questions; promoting reflection through statements; information-vigilance by following the decision-making framework; contributing science content knowledge; and mediation of group ideas. Few individuals adopted roles that inhibited discussion. There did not appear to be any pattern in terms of 'long utterances 'or equality of contributions, but the individuals who contribute most in each group are often the ones who have risen to level 5.

Argumentation within the 'high quality' groups

Each of the five groups engaged in high quality, extended arguments with more than one rebuttal, although the occurrence of these episodes varied considerably between groups. One group had noticeably fewer high quality episodes than the others; their discussion being more characterized by agreement and refinement of each other's ideas, suggesting that the frequency of multiple rebuttals did not necessarily relate directly to the quality of the group argumentation.

Relevance of pupils' experiences and interests

A third of pupils in the 'high quality' discussion groups claimed to be the 'very interested' in wildlife, and this was a relatively high proportion compared with the pupils in the study overall. Most claimed to watch TV wildlife programmes or read wildlife articles at least once a week, but none belonged to wildlife groups or took part in conservation activities.

Pupils' perceived usefulness of conservation discussions

79% preferred the group discussion approach, and 87% found the task 'useful' or 'very useful'.

Pupils' memories of discussions a year later

All groups remembered the issue they had discussed, but most of what they could remember was values-oriented; the only specific scientific concepts they recalled were food relations and aspects of animal behaviour and animal physiology. Some individuals could remember alternative views proposed by others during the discussion. Almost none of the groups could remember any steps of the decision-making framework. Very few individuals remembered what decision their group had finally made.

The findings in this chapter begin to reveal features about pupils, as individuals and as members of discussion groups, which promote values considerations and decision-making skills, and which teachers can realistically identify, nurture and evaluate. Cultivating these features and appropriately integrating them with learning about scientific concepts that underpin conservation issues, will facilitate the development of teaching strategies for dealing effectively with controversial issues such as these; not just in terms of content, but in terms of how pupils are expected to engage with the issues. These aspects of pedagogy are borne in mind when discussing the outcomes of the study in the next chapter.

Chapter 10
Discussion

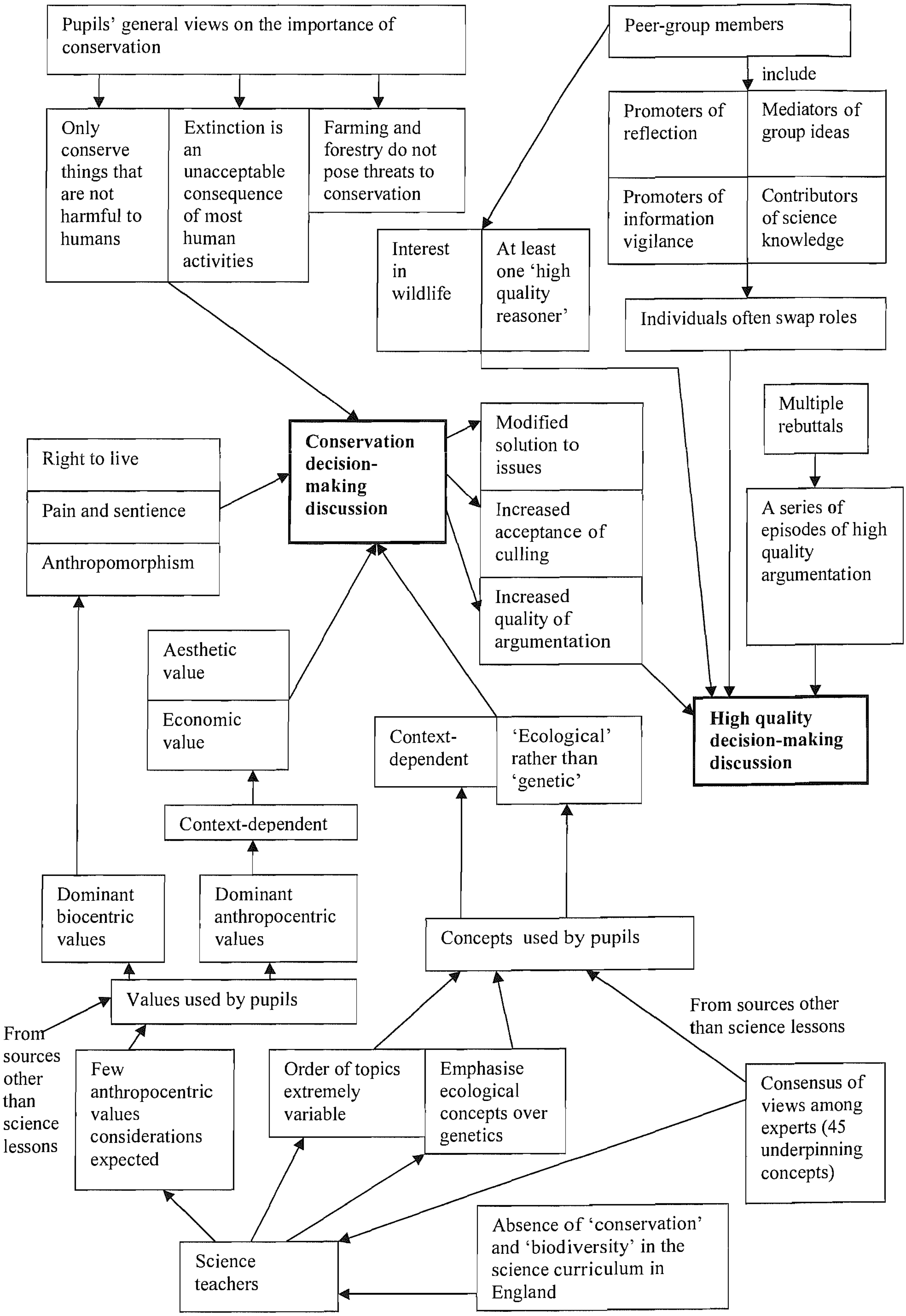
This chapter brings together the results of the study in the light of findings from each of the research questions under the following main headings:

10.1 The importance of biological conservation to pupils.
10.2 Biological concepts that pupils draw on in making decisions about conservation.
10.3 Values that pupils draw on in making decisions about conservation.
10.4 Integration of science and values
10.5 The impact of pupils' interests and experiences
10.6 General observations on peer-group group interaction
10.7 The general impact of conservation decision-making discussions
10.8 Factors common to 'high quality' discussions
10.9 Factors not common to 'high quality' discussions
10.10 Impact of discussions one year later

Introduction

The key findings of this study discussed in chapters 6, 7, 8 and 9 are presented diagrammatically in figure 10.1, and this acts as a guide to the discussion set out in this chapter. It is useful at this stage to reiterate briefly the rationale for collecting these data. This thesis is built on the premise that biological conservation is an important socio-scientific issue widely regarded as a precondition for sustainable development, and of vital significance if we are to strive for a sustainable future (section 2.1). The foundation for citizens' understanding of conservation management is laid down in formal school education, and it is therefore essential that pupils leave school with knowledge of the scientific concepts that underpin conservation issues. However, this knowledge inevitably exists within a social context, as it is people who determine its value, and people's values vary. Making judgements about conservation therefore involves a difficult compromise between many conflicting values (section 2.5), and it is equally important for pupils to develop their own values relating to the issues, while appreciating the views held by others. Such learning outcomes are necessary if they are to have the ability to make informed personal judgements about such issues, in order to fully contribute to community and societal decision-making.

Figure 10.1
Factors associated with high quality decision-making discussions about conservation issues



Researchers have promoted discussion and argumentation as an effective mechanism for achieving such outcomes in science lessons by developing social construction of knowledge (Driver *et al.*, 1994b) and encouraging pupils to articulate ideas and cope with rebuttals (Barnes, 1977; Sutton, 1992; Solomon, 1998), and good quality discussion results in participants modifying their stance on the issue by being better able to justify their position. Osborne *et al.* (2001a) believe that changing one's thinking is only possible if there are opportunities to externalise that thinking, and expose one's beliefs to scrutiny by others. This can only take place effectively by engaging pupils in some kind of discussion.

This study aims to explore features of high quality discussions, which teachers can identify and promote among their pupils. Effective science teaching depends on the provision of appropriate activities and this needs to take into account pupils' existing ideas and views (Driver *et al.*,1994b). To this end it was considered valuable to gather information about pupils' background views on the importance of conservation, prior to analysing discussions.

10.1 The importance of biological conservation to pupils.

It is common sense to suppose that youngsters will be more strongly in favour of conserving some organisms over others (e.g. mammals over insects) and that they will disapprove of building roads and factories if it leads to species extinction. The findings reported in chapter 6 provide background information about where young people might actually 'draw the line' in terms of i) how important conservation is in relation to some specific human activities, and ii) which organisms they think are worth conserving.

10.1.1 Importance in relation to human activities

Pupils' views on the importance of human activities are of fundamental significance when considering the complex issue of sustainable development (section 2.1), which is characterized by the simultaneous struggle for environmental protection and economic growth. Youngsters in this study generally did not approve of human economic activities which are perceived to threaten wildlife with extinction (6.2) which is in line with previous findings. However, there were notable exceptions to this. Only a minority of girls and boys alike would commit themselves to stating that intensive farming and commercial forestry were unacceptable (table 6.1). Interviews showed that this unexpected discrepancy stemmed from a belief that these activities were unlikely to threaten species with extinction, despite the recent media coverage of the possible environmental effects of pesticides and genetically modified crops. In Britain, 76% of the land surface is farmed, and increasingly subject to intensified agricultural methods, which result in loss of natural habitats and declines in associated birds, plants and insects (Shrubb, 2004), yet the interviews indicated that many pupils were unaware of the impact of farming on wildlife. Populations of some farmland birds are now at less than 70% of their 1970 levels (HMSO, 1999). Farming and productive forestry (which covers a further 8% of the UK), are important sustainable development issues and pupils clearly require a better appreciation of their possible environmental impact.

Gender differences

Significantly more girls than boys rejected each human activity as an acceptable threat to species extinction, giving support to other research findings that noted greater environmental awareness (Chan, 1996; Rickinson, 2001) and a more 'sympathetic' view towards conservation (Kellert, 1996; Morris and Schagen, 1996) among females. There was also a clear difference in views between the sexes over the importance of military or defence activities, with boys being more supportive. This might be a useful finding for teachers engaging pupils in discussions of this nature, as the starting point and direction of the debate may be gender-dependent.

10.1.2 Importance in relation to the kind of organism being conserved

In this study there were relatively high numbers of girls and boys who showed a positive attitude towards conserving organisms, in relation to other studies. In a study of children of a comparable age by Stanisstreet *et al.* (1993) only 46% responded positively (agreeing or strongly agreeing) to statements about conserving 'all animals', 40% to 'all plants', and 26% to 'all insects' (gender results were pooled). Corresponding percentage figures in the present study were considerably higher: 73%, 70% and 54% respectively. It may be that pupils here were more focused on the concept of conservation as a measure for countering extinction; the other study also covered a range of other issues not directly related to conservation.

However, it was clear that when pupils were asked to consider conservation of some other categories of organisms, the response was less positive, and anthropocentric views emerged reflecting a feeling of human superiority and dislike of organisms harmful to people. Disease-carriers, pathogens and parasites all received a negative attitude score from both sexes, and this may indicate where pupils mentally 'draw the line' with conservation (table 10.1), based largely on the view that we should conserve things as long as they are not threatening to us in our everyday lives (6.3.1).

Another interesting feature of this response is that many pupils appear to change their views. Although they begin with a biocentric view that all things have a right to live, further consideration reveals the more anthropocentric view. Furthermore, many who had agreed, or strongly agreed to conserving 'all living things' and 'all animals', disagreed with conserving insects and often strongly disagreed with conserving disease-carriers such as houseflies. It is well known that some youngsters, even at this age, have difficulty understanding the concept of 'animal' (Bell and Barker, 1982). Follow up interviews showed that this was certainly one reason for the discrepancy, but that the main reason for the contradictory responses was that pupils simply did not bring lower organisms to mind when considering conservation. This highlights the importance of emphasising the 'biodiversity' aspect of biological conservation in school education. The development of positive attitudes in school requires the need for opportunities to experience the environment (Morris and Schagen, 1996). Considerable diversity within and among lower organisms can be found even in the smallest and bleakest of urban school grounds, and guides are available aimed at encouraging secondary school pupils to experience common, yet frequently overlooked groups of organisms first hand. Youngsters are frequently exposed to issues about endangered mammals or birds during conservation or ecology teaching programmes. Much less attention is paid to conservation of lower species. In my experience with primary and secondary school pupils, brief discussion and decision-making exercises with pupils about conserving lesser known organisms can spark off real interest and has proved invaluable in developing children's thinking about the complexities of biodiversity conservation and its relationship with the concept of sustainable development. Particularly lively debate can ensue over issues such as the conservation of the smallpox virus, and who might host the last human tapeworm!

Gender differences

Gender differences were also noticeable over the question of what to conserve. Girls were more favourably disposed towards conserving organisms, again reflecting the sympathetic view females have towards conservation reported elsewhere (Kellert, 1996; Morris and Schagen, 1996). Girls did not simply hold stronger views than boys on conservation; an overriding difference between the sexes was that girls were more prepared to register strong support for certain aspects of conservation, whilst boys were more willing to show strong disagreement for conserving others (6.3).

There is some anecdotal evidence that girls hold stronger views than boys about science-related issues. There is little empirical support for gender-related traits of this kind in relation to environmental and conservation issues in the literature. However, Boone (1997) surveyed the general attitudes towards science of 170 eighth grade Chinese students, and found that girls selected more intense response categories (*strongly agree* or *strongly disagree*). He tentatively suggests that this could be due to 'more thoroughly developed attitudes' by girls, but equally concedes that extreme attitudes may be indicative of less mature views.

Table 10.1
'Drawing the line': a summary of the majority views of pupils in this study.

Acceptability of human activities which threaten organisms with extinction	**Acceptability of organisms becoming extinct***
Unacceptable activities Building houses Recreation/ leisure Building roads Industry Hunting	Unacceptable extinctions Living things Animals Mammals Birds Plants Insects
Acceptable activities (or uncertain) Commercial forestry Intensive farming Military/ defence (among boys only)	Acceptable extinctions Disease-carriers Pathogens Parasites
	** as discussed in section 10.1.2 these findings seem contradictory, as most pupils advocate conserving 'all living things' but not 'all parasites'; but this may suggest that after some reflection, pupils move from a biocentric to an anthropocentric viewpoint*

These findings discussed so far are useful in the present context as they may indicate pupils' general attitudinal position at the start of a discussion about conservation issues. The next section discusses the science and values the case-study pupils drew on in the decision-making discussions.

10.2 Biological concepts pupils draw on in making decisions about conservation.

The biological concepts pupils draw on in discussions will partially result from knowledge acquired outside school, but also from what they have been taught in science lessons. This knowledge exists in a social context (section 2.5) as the pupils inevitably receive a 'filtered' view of conservation which is socially constructed to an extent by conservation experts and then further by those who design the curriculum, and by their teachers who present it in the way they deem most appropriate within the constraints of the school timetable. A cursory analysis of these filters revealed the lack of emphasis on conservation as a topic in the English science curriculum (as opposed to, for example the curriculum in Wales) and consequently a potential lack of linkage with other topics and decision-making skills (section 3.1.1).

Furthermore, although science teachers generally agreed with the need to include all concepts advocated by experts (section 7.2), they regarded some concepts as more important than others, and these views will inevitably influence the way they teach conservation. They rated basic 'ecology concepts' more highly than basic 'genetics concepts' in relation to conservation issues (section 7.3), which is at odds with the emphasis on the preservation of genetic diversity as one of the main conservation objectives in The World Conservation Strategy (IUCN, 1980). Pupils also appear more likely to use these ecology concepts in decision-making discussions without prompting - genetics and inheritance was only raised by one group (group 9), in relation to elephants (section 7.5). However, teachers expected pupils to use 'higher order' concepts such as adaptation, evolution and natural selection, which require some understanding of basic genetics. Genetics is a relatively difficult topic for pupils (3.3). Teachers are aware of the topic's perceived difficulty and consequently often place it at the end of the school curriculum, after and separate from, conservation

The results from this study reveal a wide range of practice across schools in the delivery of conservation education - in terms of cross-curricular approaches, the importance of fieldwork, the number of lessons, and the order in which topics are taught (section 7.1).

A third of schools taught conservation as a topic before teaching underpinning topics such as inheritance and evolution, and almost half the schools had no set order for teaching these topics. This is likely to have some impact on pupils' ability to link concepts together. If, for example genetics and inheritance topics are taught after conservation issues, as is the case in many of these schools, pupils will be in less of a position to include these topics in conservation discussions. This suggests that there is a need to pay closer attention to the order in which concepts are taught, and it is my contention therefore that if conservation experts are stressing the importance of all forty-five underpinning biological concepts, pupils need to cover all of these in the curriculum *before* they can make informed judgements about conservation issues. This reflects the view of Lewis and Wood-Robinson (2000) who suggest that the structure of the curriculum is one explanation for students' lack of understanding of genetics, resulting in related topics being taught months or sometimes even years apart, and there is little opportunity to give a holistic view by making the relationship between these topics more explicit. This view is further supported by the results of the questionnaire given to school leavers. This identified sixteen of the essential underpinning concepts as being rejected as not important in making conservation decisions by at least 20% of the pupils (7.8).

In their discussions, pupils raised almost half of the biological concepts proposed by the conservation experts (7.6). This is a much higher rate than Ratcliffe (1997) encountered among pupils discussing socio-scientific issues, where only a third of discussions mentioned the science involved, despite being explicitly asked to discuss the scientific aspects. This may be due to the nature of the present scenarios as being obviously biological issues, and regarded as such by pupils from the outset. Some concepts were raised by all discussion groups; the commonest being food relations, but generally in simple predator-prey food chain terms, rather than mentioning higher order concepts such as the wider effects on food webs, habitats or ecosystems (section 7.6). This reflects findings in other studies on feeding relationships (Brody, 1994; Griffiths and Grant, 1985; Leach *et al.* 1993). Griffiths and Grant (1985) suggested that students' failure to use ideas about interdependency to explain relationships in complex ecosystems may partly result from the common teaching approach, which introduces the concept of a food chain as a prelude to food webs.

Other concepts appeared to be context-dependent. The two contrasting conservation scenarios were provided to explore this aspect (5.1.3). Usage depended on the extent to which certain concepts were central to the debate. For example, 'animal behaviour' and 'competition' were used more frequently in the puffin discussions than the elephant discussions because these concepts were closely tied to the burrowing behaviour of puffins and rabbits (section 7.7).

By comparing conservation experts' views with those of science teachers and pupils, it may be possible to search for any gaps in the curriculum and begin to explore areas for pedagogical development. All forty-five concepts endorsed by the experts are (at least theoretically) covered in the science national curriculum, with the possible exception of ecological niches, and culling of animals. The curriculum content therefore paves the way for effective teaching about conservation matters; but the depth of coverage of these concepts and the order in which they are taught is up to the teacher.

High-quality discussion groups did not draw on more or different concepts than the cohort as a whole (9.6.1). Thus there is no evidence here that bringing more concepts into the discussions would necessarily lead to higher quality argumentation. Although pupils raised twenty-one biological concepts in the discussions (section 7.5) these were rarely discussed in depth, and it would appear that very specific prompting is needed for pupils to relate conservation issues to the underlying scientific principles.

10.3 Values pupils draw on in making decisions about conservation.

The science teachers in this study accurately predicted pupils' use of biocentric values such as animals having a 'right to life'. However, they did not expect their pupils to bring anthropocentric values into discussions (section 8.2), despite encouragement in the science national curriculum for pupils to explore values (3.1.1).

Pupils' responses to the general questionnaire about the importance of conservation (chapter 6) indicated that as they think more deeply about conservation issues, they progress from considering biocentric values to anthropocentric values – (e.g. initially advocating conservation of all species, but then refining their view to conserving organisms as long as they are not harmful to humans; section 6.3.1). When engaged in discussions, both types of values were seen as a major consideration among pupils (section 8.1). While the biocentric values ('right to live', 'pain and sentience' and 'anthropomorphism') did not appear to be context-dependent, the use of anthropocentric values varied considerably. The dominant anthropocentric values ('aesthetic values', and 'economic values') were raised in almost all groups, but other anthropocentric values (e.g. environmental values, socio-political values, and altruism) were clearly context-dependent, being more frequently raised in association with the elephant issue (section 8.1). This is unsurprising since this scenario directly involved human interests; but it demonstrates the need to include such human-oriented issues in conservation discussions, in order to provide opportunities to include a wider range of values as well as the challenge raised by Lindsey in group 10:

> *It's really easy to get confused between the human viewpoint and the elephant viewpoint.*

Although most of these anthropocentric values might not be particularly relevant to the puffin issue, the fact that environmental/ interdependence values were not raised is a matter for further exploration. It indicates a lack of 'obviousness' among pupils that a loss of puffin or rabbit populations could have serious ramifications for other organisms connected in the food web, and for the local environment – and that we do not necessarily know the consequences. Pupils need to be aware that it is not possible to predict with certainty the effect of losing individual, even seemingly inconsequential, species within an ecosystem.

10.4 Integration of science and values

Although there is a need to expand the number of science concepts used, to add depth and balance to discussions, the inclusion of values considerations in conservation education is very important. Values and scientific ideas are closely connected in the human mind (2.5). During discussions among pupils there were a number of comments which could have multiple interpretations. For example, when a pupil argues that: *'puffins should be moved to a safer place where rabbits don't live',* is this a 'scientific' or a 'value' statement? Competition between organisms is a scientific concept; competition between animals and humans is a values issue, depending on one's biocentric-anthropocentric viewpoint.

This study shows that scientific concepts and values are both used by pupils in deciding about conservation issues, but more weight appears to be given to values. This is in line with the comments of conservation managers who criticise the scientific orientation of conservation management (e.g.Yearly, 1991; Harrison, 1993; Spellerberg, 1996). In actual conservation management decision-making, scientifically objective criteria are compromised by the multiple demands placed on the site. In both developed and developing countries, conservation management programmes are increasingly expected to fulfil cultural, educational and amenity roles (Boza, 1993). It follows that pupils should also experience this holistic, integrated approach if they are to gain a meaningful understanding of the issues. Biological conservation is often taught as a value-free scientific discipline, and this may impede learning. Brody (1994) found that scientific knowledge related to ecological crises does not increase with age, and suggests that this is because such issues are not associated with science concepts taught in the classroom. Kinsey and Wheatley (1984) found that environmental studies courses did not significantly change students' attitudes, but they were more able to defend their attitudes, using evidence based on ecological principles. We therefore might not expect conservation management education to change attitudes and behaviour, but a more clearly integrated concept may encourage 'non-experts' to draw on their values and a wider range of scientific evidence in determining their viewpoint.

High quality discussion groups did not draw on more or different concepts than the cohort as a whole (9.6.1), but pupils' use of scientific concepts and anthropocentric values was context-dependent (7.7 and 8.1 respectively). This indicates a need for them to discuss a range of conservation scenarios in order to maximise their understanding of the complexities involved.

Witherspoon (1994) identified three factors influencing environmental values: 'social values', 'rational perceptions' based on scientific evidence, and 'romantic world views' based on scepticism about scientific and economic progress. The adolescents in this study clearly demonstrate a tendency to take an emotional or 'romantic' stance over biodiversity conservation issues. For example, intensive farming is more acceptable as a threat to wildlife than hunting, and mammals are more worthy of conservation than plants. Without coherent scientific knowledge and balanced experience of biodiversity, it is difficult to avoid such heavily value-laden romantic views about biological conservation.

10.5 The impact of pupils' interests and experiences

Selection of appropriate issues will depend on the pupils' interests and experiences. Rogoff and Lave (1984:2) argued that:

"*...thinking is intricately interwoven with the context of the problem to be solved.*"

Pupils in the present study were generally interested in the topic of wildlife conservation, but members of the high quality discussion groups were noticeably more interested and also claimed to watch more TV programmes and read more articles about wildlife (section 9.6.10). Initial interest may therefore be a factor leading to high quality discussion, and ways of promoting interest may need to be explored.

Another factor worth following up is the lack of experience pupils appear to have in engaging in conservation activities. Only one pupil of the 131 claimed to be actively taking part in conservation activities. There is some research evidence that pupils' interest in environmental issues is enhanced by direct experience. Robinson and Kaleta (1999) for example, found that Polish secondary school students ranked the importance of potentially threatening environmental issues according to their personal experience rather than the topics they had covered in school.

The discussion above does not necessarily indicate a causal relationship between wildlife interest and quality of decision-making discussions but they seem connected, and if first-hand experience of conservation can promote interest (as indicated in 3.1.4) this could be a route to enhancing the quality of argument and decision-making about conservation issues.

10.6 General observations on peer-group group interaction

The great majority of pupils welcomed the discussion of these issues, and were generally supportive of small group discussions rather than considering the issues on their own (9.6.10). Pupils could reason adequately and fully engage in decision-making about conservation issues (section 9.1). However, there was no discernable pattern of the order in which concepts and values were raised and discussed, possibly due to guiding influence of the decision-making framework, encouraging them to switch from discussing values to scientific concepts.

10.7 The general impact of conservation decision-making discussions

10.7.1 Modified solutions to conservation issues

It is important to note that in this study pupils were not changing attitudes because their knowledge changed, but because they were given the opportunity to think (and talk) the issues through. I am not therefore arguing that they make 'better' decisions through discussion - but different decisions. If they had more knowledge of the underlying science and of relevant social values they would presumably make more informed decisions.

Although the decision-making discussions were no more than 40 minutes long, they had a marked impact on pupils' proposed solutions to the conservation problems. About three-quarters of girls and boys modified their proposed solutions to the conservation problem following discussion (Table 9.1). This may appear to contradict the claim of Kuhn *et al.*, (1997) that one-off discussions failed to enhance the quality of reasoning (section 4.4.1); but I agree with them that valid argumentation skills only develop through practice, and taught explicitly as part of a structured activity.
Indeed, given more time, these pupils may well have developed their views further, or perhaps even reverted back to their original opinions. However, Kuhn's findings were based on a series of much shorter (10-minute) discussions, and I believe that factors such as focus for discussion, familiarity with peers and the classroom setting, may be just as important as the time available.

10.7.2 Increased acceptance of culling

The issue of culling is at the heart of many conservation management programmes (2.1); it featured in all discussions in this study, and was used as a discussion impact indicator, i.e. to show how much pupils changed their views as a result of discussions. Changing one's mind is a feature of good quality argument recognized by Osborne *et al.* (2001a) (section 4.4.1). Both before and after discussion, the majority of pupils suggested a solution other than culling (e.g. constructing fences, relocating or sterilising animals). However, more boys than girls chose culling as an option (of both elephants and rabbits), and although more people advocated culling rabbits than elephants, the gender difference was fairly consistent for both scenarios. After the discussion, there was a marked increase (statistically significant) in advocating culling among both boys and girls, and these elevated numbers persisted one year later (section 9.3). This change in attitude supports Solomon's (1992) suggestion that group discussion can assist attitude change, and is consistent with the assertion by Zoller *et al.* (1990:33-34) that STS (Science-Technology-Society) courses can:

> "*...substantially change the viewpoints/position of senior high school students...*".

It contrasts, however, with Aikenhead's (1989) hypothesis that, in resolving conceptual conflicts, group decisions emerge from members' original choice preferences, rather than from their interactions during discussion. Aikenhead indicates the difficulty in identifying factors which contribute to viewpoint change, but in the present study the peer group friendship seemed sufficiently robust to allow disagreement without much personal conflict. There are signs in this study that discussion of the issues reduces the rigidity of views and brings pupils towards a compromise view (9.2). However, the pupils' individual post-test responses did not necessarily reflect their group's decision (section 9.4), and the validity of group decisions of this kind should thus be treated with caution. While the process of decision-making may have benefits such as modifying views as indicated in section 9.2, the group decision itself may be less informative to educators in terms of identifying learning gains among pupils.

10.7.3 Increased quality of argumentation

When referring to the group interaction among pupils in this study, in an attempt to avoid confusion of terms, I adopted the approach proposed by Newton *et al.*, (1999) in using the terms 'decision-making', 'argument' and 'discussion' interchangeably, as meaning verbal interaction focusing on the resolution of a controversy (4.2). The pupils here were involved in decision-making discussions, which were composed of a series of episodes of argumentation.

The hierarchical scheme (figure 9.2) for the quality of personal reasoning about biological conservation provided a useful instrument for identifying individuals who 'changed their thinking' by coding pre and post-test written responses. This revealed a general shift to higher-level responses following the discussions, with a noticeable increase in the number of pupils at levels 4 and 5 (9.5); indicating that these brief decision-making discussions can have an immediate, although not necessarily long-lasting, effect on pupils' ability to argue about conservation issues.

10.8 Factors common to 'high quality' discussions

Two principal instruments were used in this study for measuring the quality of argumentation (4.4.3), the hierarchical model proposed by Kuhn *et al.* (1997) was adapted to gain pre and post-test information about individuals' level of reasoning (figure 9.2), and the group argumentation model used by Osborne *et al.* (2001a)(figure 9.6) was employed to identify the quality of argument present in the decision-making discussions.

In addition to the positive outcomes of discussion outlined above (i.e. modified solutions, increased acceptance of culling, and increased quality of argumentation), this study sought to explore other factors common to the five selected high quality discussion groups – factors that might be readily identified and nurtured by classroom teachers.

As discussed above (in section 10.5) members of the five high quality groups appeared to have an elevated interest in wildlife, and the pre-test questionnaire also revealed that each of these groups contained at least one 'level 4' pupil (section 9.6.2). This suggests that when arranging groups, teachers should (if possible) consider including in each:

- wildlife enthusiasts (i.e. those knowledgeable and/or interested in wildlife)
- at least one confident (level 4 or level 5) individual reasoner (by providing a pre-test of the kind used in this study)

but this needs to be weighed against any detrimental effects created by altering the dynamics within existing peer-groups.

Most members of each group contributed to the discussion with a degree of consensus by playing a variety of roles, without a clearly identifiable leader. Sometimes one pupil would invite another to take over from them, or a new speaker would seize the initiative. As such, these groups might all be characterized as 'democratic teams' according to Gayford's (1992) categorisation of the styles of group behaviour – this is a style he identified as resulting in better understanding and motivation than the other types (section 4.5).

Principal individual roles identified across the groups were: Promoters of information vigilance, promoters of reflection, contributors of science content knowledge, and mediators of group interactions and ideas. These roles mirror those recognized by other authors. Among pupils considering socio-scientific issues, Ratcliffe (1997; 1999) identified individuals she referred to as information-vigilant (section 4.5) who used readily accessible information to clarify the advantages and disadvantages of particular options. In this study this role was evident in all groups (section 9.6.6), but not always in the same respect; three approaches appeared to be evident:

- information-vigilance by showing concern for uncertainty about the issue, or looking for information
- information-vigilance by marshalling others' ideas
- information-vigilance by following the decision-making framework

The other roles mentioned above were also suggested by Hogan (1999), as those that promote groups' reasoning processes (section 4.5). Hogan regarded promoters of reflection as the most important role in this respect, and the present study adds some detail to the nature of this role by recognizing three distinct sub-categories (section 9.6.6):

- promoter of reflection through asking thought-provoking questions
- promoter of reflection through making thought-provoking statements
- promoter of reflection by refining others' ideas

Each of the five groups engaged in high quality, extended arguments with more than one rebuttal, of the top level (level 5) type described by Osborne *et al.* (2001a). However, the occurrence of these episodes varied considerably between groups. One group had noticeably fewer high quality episodes than the others; their discussion being more characterized by concurrence and refinement of each other's ideas; the nature of the argument was often a collaborative endeavour to obtain stronger agreement. Osborne *et al.* (2001a) developed their hierarchical scheme using transcripts from discussions among 12 and13 year-olds. It may be the case that further refinement of the scheme is necessary for older pupils, whose social and literacy skills are more sophisticated.

10.9 Factors not common to 'high quality' discussions

The five groups discussed a mixture of science and values to varying degrees. The nature of the discussions varied (section 9.6.3), with some focussing on practical concerns (e.g. fence-construction), others on socio-political values (e.g. in relation to the ivory trade) and others concentrated more on ecological considerations. The final group decisions also varied; there was disagreement about culling, and three groups failed to reach a decision, which again might suggest that the process of the discussion has more value than the outcome in terms of strengthening argumentation skills. Among other factors highlighted by previous research as possible contributing factors to the quality of argumentation (section 4.4.1), the proportion of time spent off-task varied considerably, and there did not appear to be any pattern in terms of 'long utterances' or equality of contributions.

In terms of how pupils interacted and the nature of the argument in which they engaged, there was no discernable difference between genders. This contrasts with a suggestion made by Swann (1992) that whereas boys are likely to adopt a more dominant role, girls are more likely to play a supportive and exploratory role, and avoid competitive behaviour. This stereotypical behaviour was not evident in this research. There was no general pattern of equality of participation across the groups (section 9.6.5), but there were examples of boys and girls talking confidently and taking leading roles within arguments, at all levels of argumentation.
Group size is another potentially important factor. A study in a Greek secondary school for example, reported that pupils progressed significantly more in their physics reasoning after working in groups of four rather than in pairs (Alexopoulou and Driver, 1996). In my study there were high quality discussion groups of four, five and six, indicating that even groups of six can lead to increased argumentation and decision-making. However, it was noticeable that three of the six groups of four were rated high quality, and this raises the possibility that generally smaller group sizes may have been more effective. These groups were self-selected, but their size was largely determined by the space and number of tables in the science classroom.

Pupils' willingness to contribute may also be influenced by other factors which can be recognized but not easily controlled. These may include scientific knowledge, communication skills, self-esteem, pupils' worldviews (Slater, 1996), and their particular feelings and emotional condition at the time. These are aspects worthy of further research.

10.10 Impact of discussions one year later

A year after the discussions, all groups remembered the issue they had discussed, but most of what they could remember was values-oriented; the only specific scientific concepts they recalled were food relations and aspects of animal behaviour and animal physiology. Some individuals could remember alternative views proposed by others during the discussion. Few pupils could remember any steps of the decision-making framework, and few remembered what decision their group had finally made. An interesting finding was the apparent persistence of elevated numbers of boys and girls advocating culling one year later (section 9.3), although I make no claim here of long-term effect, since many other factors could contribute to this, such as age difference and any other relevant experiences during the intervening year.

10.11 Key outcomes of the study

Key outcomes of this study are listed below. They are not presented in order of significance or importance; but all contribute to an understanding of the features associated with high quality decision-making discussions, and they serve to describe the elements presented in the flow chart in figure 10.1.

- Pupils of both sexes showed a positive attitude towards conserving all organisms surveyed except disease-carriers, pathogens and parasites - a view based largely on an opinion that we should conserve things as long as they are not harmful to humans. This may indicate where they mentally 'draw the line' with the need for conservation, and thus one starting point for teaching programmes.
- Pupils generally found human activities unacceptable if they threatened species with extinction; but intensive farming and forestry were not considered deleterious suggesting that they required a better appreciation of the environmental impact of these activities.
- There were gender-related differences in views on conservation. Girls demonstrated a more 'sympathetic' view towards conservation, and registered stronger support for certain aspects of conservation, whilst boys were more willing to show strong disagreement for conserving others.
- Science teachers rated 'ecological concepts' more highly than 'genetics concepts' in relation to conservation issues. Pupils' actions in discussions, and their own ratings at the end of compulsory schooling, mirrored the teachers' ratings.

- The timing and sequencing of teaching underpinning concepts varied considerably among schools. This is likely to have some impact on pupils' ability to link concepts together.
- Some underpinning concepts are context-dependent, indicating the need to provide a variety of scenarios, so that pupils can draw on a wider range of concepts.
- Biocentric values did not appear to be context-dependent, but anthropocentric values were used more frequently in association with the human-oriented elephant issue, indicating the need to provide a variety of scenarios, so that pupils can draw on a wider range of values.
- Science teachers did not expect their pupils to bring anthropocentric values into discussions.
- The brief conservation decision-making discussions resulted in the majority of pupils modifying their solutions to the issues, a significant increase in those advocating culling as a solution, and an increase in the overall quality of personal reasoning. Such discussions, guided by a framework, but with little required teacher intervention can thus have an immediate (although not necessarily long-lasting) effect on pupils' ability to argue about conservation issues.
- In high quality discussion groups, members played four key roles (promoters of information vigilance, promoters of reflection, mediators of group ideas, and contributors of science content knowledge), and frequently swapped these roles among themselves. They also had an elevated interest in wildlife, and at least one member identified as a 'high quality reasoner'.
- High quality discussion groups engaged in extended arguments with more than one rebuttal, but the occurrence of these episodes varied considerably between groups.

10.12 Limitations of the study

All social science research has its design weaknesses and limitations, such as the inherent subjectivity of the findings and the influence the researcher has on the subjects' actions, as discussed in section 5.2.8. While I have attempted to minimise such factors, with the benefit of hindsight I am able to identify other limitations of the study in terms of: pupil involvement; exploring pupils' views by questionnaire; interpreting key factors - concepts, values and argumentation; and use of the decision-making framework.

10.12.1 Pupil involvement

Although feedback at the end of the research suggested that pupils generally enjoyed the decision-making activity (section 9.6.11), I had no sure way of ensuring they were all keen to contribute. Such willingness may be influenced by a complex of factors, which are not easily recognised or controlled, such as confidence, scientific knowledge and communication skills. Alternatively, it is possible that some may have understood the concepts and had the ability to reason at level 5 as an individual, but did not get the words down fast enough in the pre and post-test, or were without the vocabulary or verbal skills to articulate their views. This is therefore by no means the only way to gauge their level of argumentation. However, I can be satisfied that the questionnaires and discussions did at least reveal the minimum levels of argumentation among the pupils.

10.12.2 Exploring pupils' views by questionnaire

The closed questions in the background questionnaire (appendix 5.5), such as: "*We (humans) should try to conserve all insects threatened with extinction.*" may have prevented respondents from supplying answers which reflected their true feelings, and as such were leading questions, a well-known disadvantage of questionnaires (Denscombe, 1998). If the questions had been asked in reverse order (e.g. asked about conserving 'all parasites' before 'all animals') to get them focussing more closely from the start, they may have responded differently. However, the exercise as carried out, demonstrated well that their first responses were not necessarily a true indication of how they feel, and they change their minds with further time for reflection. Some inaccurate instinctive responses were revealed in the follow-up interviews; for example one pupil who initially agreed to the extinction of parasites and pathogens, then backtracked in interview, mentioning the acceptability and importance of keeping the smallpox virus safely in laboratories. It is also possible that the 'how' and 'why' tags on the pre and post-test questions may have been overlooked by some pupils, thus lowering their score on the argumentation scheme (i.e. pupils did not read the questions properly).

10.12.3 Interpreting key factors: concepts, values and argumentation.

Biological concepts identified by experts and teachers were by definition (section 2.6) fairly easily recognized; but it could be argued that my values categorization scheme would have been more reliable by asking another researcher to moderate my findings. However, through talking extensively with pupils, listening to the audio-tapes, and cross-checking this data with written reports from the discussion groups, I also have confidence in my identification of values - they are fairly clearly defined and recognizable by teachers. The same view could relate to the reliability of my argumentation schemes, but again I have confidence in the hierarchical categories through extensive rechecking of my own findings and comparison with examples of transcripts from the literature (Kuhn *et al.*, 1997; Osborne *et al.* 2001a; Zeidler *et al.*, 2003, and Osborne *et al.* 2004).

10.12.4 Use of the decision-making framework

There was some variation in the extent to which groups referred to the decision-making framework. More consistent use might have resulted from clearer instructions about the use of the framework as an important guide to keeping pupils on track rather than a standard worksheet to be completed (i.e. an essential aid to the decision-making process as opposed to the essential end product to be collected by the teacher).

10.13 Summary

The findings of this research begin to provide information about how pupils working in peer groups are able to make decisions about conservation matters, and have implications for the curriculum order of biological concepts to allow appropriate teacher intervention in managing class decision-making.

We have a long way to go if we are to encourage concern among adolescents for conservation of diversity between and within species, but discussion of the relative importance of conserving a wide range of organisms is crucial in developing an ability to make decisions about biological conservation issues. In my opinion, this ability is a prerequisite to making informed decisions about wider issues of sustainable development.

Chapter 11
Conclusions and implications

The aims of this research were to explore the views held by 15-16 year old pupils about the importance of biological conservation, and the concepts and values they draw upon during semi-supported decision-making discussions, and to attempt to identify features of high quality discussions that science teachers might recognize and nurture in their classrooms. The main research findings were discussed in chapter 10 in relation to the four research questions. The research was divided into two parts as explained in the methodology (chapter 5). The first part sought to gather baseline data from a large number of pupils' (405) about their views on the importance of conservation to see where they draw the line with the need for conservation. This provided background information, and helped interpret findings in the second part of the research, which focussed on 131 pupils and explored the nature of high quality peer-group decision-making discussions, with a view to identifying features that science teachers might be able to identify and encourage among their pupils. The discussions resulted in an overall increase in level of argumentation among the pupils, and as a result of this study I have provided (in figure 10.1) a holistic view of factors that would appear to require consideration in order to achieve high quality conservation decision-making discussions.

The findings contribute to the field of science education in two broad respects:

11.1 <u>Contribution to group discussion theory and practice</u>

- Features common to high quality discussions about conservation.
- The relative importance of decision-making processes and outcomes.
- The structure of conservation discussion lessons.

11.2 <u>Contribution to conservation education theory and practice</u>

- The purpose of conservation education.
- The nature of the conservation issues selected for study.
- Gender-related differences in relation to conservation issues.
- Teaching underpinning biological concepts: timing, order and integration.
- Integration of science and values.

The chapter ends with some consideration of recommendations for further research.

11.1 Contribution to group discussion theory and practice

The use of group argumentation and personal reasoning frameworks

This study used two kinds of hierarchical argumentation schemes to assess pupils' quality of argument: a scheme for measuring the quality of argumentation within groups proposed by Osborne *et al.* (2004a), and a modified version of the scheme put forward by Kuhn *et al.* (1997) for measuring personal reasoning. The work shows that both schemes have a place as useful and complementary assessment tools – group argumentation exploring the interactive dialogical characteristics of argumentation, and personal reasoning focusing on internalised reflective aspects.

Features common to high quality discussions about conservation

The conservation decision-making discussions in this study generally resulted in an increase in quality of argumentation among the pupils (section 10.7.3). The fourth research question sought to find factors common to the high quality discussion groups, which could be readily identified and promoted by teachers. These factors (discussed in section 10.8) are as follows:

i) Individuals played four key roles - promoters of information vigilance, promoters of reflection, mediators of group ideas and interactions, and contributors of science content knowledge - and they frequently swapped these roles among themselves. It is possible that teachers, perhaps with a little training, could readily identify these roles by circulating among the groups during discussions and listening to pupils' contributions.

ii) The groups engaged in a series of extended arguments with multiple rebuttals – i.e. level 5 in the scheme for group argumentation presented in figure 9.6. Rebuttals can be difficult to identify (section 9.6.7), but research into recognition of levels of argumentation has resulted in productive teacher-training (Osborne *et al.*, 2004a) and associated training materials (Osborne *et al.*, 2004b).

iii) At least one member of each high quality group was identified as a 'high quality reasoner' prior to the discussion. With minimal guidance, teachers could identify such pupils quite rapidly by conducting a pre-test about the issue, as performed in this study, and levelling pupils according to the scheme for personal reasoning presented in figure 9.2.

iv) Members of high quality groups had an elevated interest in wildlife. This does not necessarily represent a causal relationship between wildlife interest and quality of decision-making discussions, but they seem connected, and if first-hand experience of conservation can promote interest (as indicated in section 3.1.4) this could be a route to enhancing the quality of argument and decision-making about conservation issues. The above suggests that teachers should attempt to arrange for each group to contain wildlife enthusiasts, and at least one confident reasoner; but this needs to be weighed against any detrimental effects created by altering the dynamics within existing peer-groups.

The relative importance of group decision-making processes and outcomes

Several of the discussion groups (including some high quality groups) failed to reach a final decision over the issues, and I support the views of Aikenhead (1985) and of De Jager and Van der Loo (1990) that the quality of the decision-making process is more important than the quality of the decision itself. A further finding of note for teachers is that pupils' individual post-test responses did not necessarily reflect their group's decision (section 9.4), and the validity of group decisions of this kind should thus be treated with caution. While the process of group decision-making may have benefits such as modifying views (section 9.2) and increasing argumentation skills (section 9.5), the group decision itself may be less informative to educators in terms of identifying learning gains among pupils. Providing a decision-making framework, which encourages pupils to note down their views as they progress through the discussion, can reinforce the required skills and assist teachers in reviewing pupils' engagement with the process Ratcliffe (1996).

The structure of conservation discussion lessons

There are of course many approaches to decision-making, such as dramatic interpretations, story-telling, and critical reading and writing activities, each of which encourages the development of particular skills. Role-play remains one of the most popular approaches used in the teaching of controversial issues (Oulton, *et al.*, 2004). However, I concur with the view of Slater (1982) that pupils sometimes need opportunities to consider and argue their own positions on an issue rather than always being asked to adopt a role. Although in my view a whole scheme of work on the unifying theme of conservation would help consolidate pupils' understanding of science, this is not practical within the time constraints of the present curriculum. Any proposed model needs to recognize that there is a trade off between complexity and manageability. However, this study has shown that it is feasible to generate positive outcomes by discussing conservation issues in one 40-minute lesson in a realistic science classroom environment, i.e. with minimum disruption to existing timetabled activities; and I would encourage a lesson structure that includes components explored in this study, namely:

i) A brief pre-test question about the issue as a starter exercise to encourage pupils to explore their opinions and become more aware of the values underlying their choices (Slater, 1982).

ii) Group discussion using a guiding decision-making framework to keep pupils on track and to help balance the consideration of science and values (Ratcliffe, 1996); this also reduces the need for teacher intervention, freeing up time for the teacher to circulate among groups assessing progress and pointing out links between underpinning science concepts. Guidance on appropriate ground rules for collaborative discussion may be valuable in helping pupils organize their discussion; but if this is too prescriptive it may reduce spontaneity and inhibit the flow of the conversation. The presence of the teacher might also influence the nature and direction of the arguments. Naylor *et al.* (2001) suggest that argumentation is more likely to be effective in small groups than teacher-led whole class discussion, and teachers may be able to promote effective argumentation if they are more aware of some of their own influence on the nature of discussions (section 5.2.8).

iii) A brief post-test question about the issue of the kind used in this study (perhaps as homework), that would enable pupils to reflect on their views, and appreciate the value of group discussion, while providing assessment opportunities for the teacher, using the personal reasoning scheme proposed in this study.

11.2 Contribution to conservation education theory and practice

The purpose of conservation education

The findings in this study show that although most pupils exhibited an increased quality of personal reasoning following the discussions (section 9.5), relatively few (eleven) reached the highest level in the hierarchical scheme – by demonstrating an attempt to justify the decision, with explicit consideration of the function or purpose of biological conservation, and of the comparative effectiveness of alternatives. Although many of us have an intuitive understanding of the term conservation education, it is difficult to define in a few words, largely due to the complexity of underpinning concepts and values. I view conservation as a unifying 'super-concept' providing opportunities for pupils to draw on their existing knowledge of biological concepts and appreciate how they interrelate. I have argued throughout this work that an understanding of conservation issues requires knowledge of a wide range of underlying and interlinking values and biological concepts. However, given that the term 'conservation' does not appear explicitly in the science national curriculum for England (section 3.1.1) it is difficult to define learning outcomes for conservation education. There are parallels here with well-documented problems over defining the learning outcomes of environmental education; whether it should be education *about*, *in/through* or *for* the environment – an ongoing debate of over thirty years (Schools' Council, 1974; Fien, 1993; Palmer, 1998). The same question can be applied to conservation education: is the end product education *about* conservation (knowledge-based), education *in/through* conservation (fieldwork-oriented, thus also including certain practical skills), or education *for* conservation (active participation in resolving conservation issues, thus including values and other transferable skills)? The latter would be seen as a more holistic and higher order approach, which incorporates the other two. In practice however the question is academic, as the present study has shown (in section 7.8), many school leavers do not even achieve the basic (knowledge-based) learning outcomes. Pupils gain an understanding of almost all the underlying concepts of conservation education, but do not acquire the ability to link them together to form an overall picture of conservation issues.

The nature of the conservation issues selected for study

When pupils focus on the concept of conservation as a measure for countering extinction, they generally demonstrate positive attitudes towards conserving organisms, especially intelligent or visually attractive animals (section 6.3; Stanisstreet *et al.*, 1993), so they are motivated by the subject matter. However, this enthusiasm declines when the issue concentrates on less familiar organisms (such as the waxcap mushrooms in section 5.1.2), and they exhibit negative attitudes to organisms harmful to humans (such as disease-carriers, pathogens and parasites). Furthermore, without prompting, pupils rarely bring lower organisms to mind when considering conservation, and this highlights the importance of emphasising the 'biodiversity' aspect of biological conservation in school education. In my view, this suggests a need for designing a teaching programme which includes issues primarily relating to the more motivating intelligent or attractive organisms, but one that also stresses: a) their reliance on specific lower organisms (with seemingly inconsequential effects), and b) our lack of certainty about the environmental impact of losing any genetic resources (section 2.1).

This study has shown that human-oriented conservation settings (such as the elephant scenario) elicit more anthropocentric values from pupils (section 8.1), and could thus serve to help pupils appreciate the social construction of conservation management practices (section 2.1). There may be a concern that values considerations might dominate discussions about such issues at the expense of the underpinning science, and this is where guidance such as a decision-making framework becomes invaluable in keeping participants on track and engaged with the science (section 9.1).

The impact of humans on the environment is a well-established attainment target in the science curriculum, and lends itself to the inclusion of conservation issues. Findings in this study indicate benefits of using case studies of conservation decision-making, which incorporate social and personal values as well as the underlying science. Particularly useful are human-oriented scenarios to draw out a range of anthropocentric values, preferably based on widespread human activities which pupils do not readily regard as in conflict with biological conservation, such as intensive farming and commercial forestry (section 10.1.1).

Gender-related differences in relation to conservation issues

There is some evidence that females demonstrate a more 'sympathetic' view towards conservation (section 10.1.1; Kellert, 1996; Morris and Schagen, 1996) and this was supported here by girls being more favourably disposed towards conserving organisms (section 6.3), and exhibiting a greater rejection of human activities as an acceptable threat to species extinction (section 6.2). Another notable difference was that girls were more prepared to register strong support for certain aspects of conservation, whilst boys were more willing to show strong disagreement for conserving others (section 6.3). Boys were more supportive of military or defence activities (section 6.2). These might be useful findings for teachers engaging pupils in discussions of this nature, as the starting point and direction of the debate may be gender-dependent.

Teaching underpinning biological concepts: timing, order and integration

Conservation experts agreed on forty-five essential biological concepts underpinning conservation education, and it is thus my belief that pupils need to cover all of these in the curriculum *before* they can make informed judgements about conservation issues. This study has shown that the timing and order of concepts, and amount of outdoor fieldwork varies greatly among schools (section 7.1), and this is also likely to have some impact on pupils' ability to link concepts together. Schools therefore need to agree consistency in practice within (and preferably between) schools in terms of cross-curricular approaches, the importance of fieldwork, the number of lessons, and the order in which topics are taught.

The deliberately 'spiral' nature of the science curriculum means that conservation-related topics can be introduced at earlier key stages and developed more fully at key stage 4. As older pupils are therefore already familiar with the topics, they can focus on values considerations and links between concepts, rather than increased breadth of knowledge. I would therefore like to encourage a model which builds on pupils' experience with conservation-related topics in earlier key stages, but also places conservation at the end of the curriculum, enabling pupils to make meaningful links between the underpinning concepts.

The science curriculum in England (unlike that in Wales) does not mention conservation explicitly, reducing opportunities for linkage with other topics and decision-making skills (section 3.1.1). The teachers here rated ecology concepts more highly than genetics concepts in relation to conservation (section 7.3), which is at odds with the main objectives in the World Conservation Strategy (IUCN, 1980). Teaching genetics prior to considering conservation issues, and explicitly indicating the appropriateness of drawing upon genetics, evolution, ecology and the other essential concepts would be a useful foundation for conservation education.

Integration of science and values

Although there is a need to integrate science concepts used to add depth and balance to discussions, the inclusion of values considerations in conservation education is also very important. Values and scientific ideas are closely connected in the human mind (section 2.5). For example, competition between organisms is a scientific concept; competition between animals and humans is a values issue, depending on one's biocentric-anthropocentric viewpoint. Biological conservation is often taught as a value-free scientific discipline, and this may impede learning. Real conservation management programmes are increasingly expected to fulfil social and amenity roles (section 10.4), and scientifically objective criteria are compromised by the multiple demands placed on the site (Boza, 1993). Pupils in the present study often drew upon anthropocentric values in deciding about conservation issues, but teachers did not expect this (section 8.2), despite encouragement in the science national curriculum for pupils to explore values (section 3.1.1). The challenge to curriculum developers is to develop models integrating science and values, which explicitly demonstrate the reasoning behind the integration to teachers and pupils. Another challenge is to help science teachers to value and justify discussions about conservation within the constraints of the school curriculum and timetable. The current version of the science national curriculum for England (QCA, 1999a) is concept-dominated, and the separation of the text about concepts and values may hinder and even deter teachers from including socio-scientific discussions in their schemes of work.

11.3 Recommendations for further research

The findings from this study suggest several directions for further research.
Many researchers have expressed the benefits of providing pupils with first-hand experience of conservation issues, with the inclusion of fieldwork (as discussed in section 3.1.4). It is an approach categorized by Fien *et al.* (2001) as 'non-formal' as it generally occurs through other organizations aiming to encourage practices that protect biodiversity. It would be useful to investigate ways of helping schools develop this approach in raising pupils' awareness of the issues and possibly strengthening their conservation decision-making skills. In the present study, members of the high-quality discussion groups were noticeably more interested in wildlife than the cohort as a whole, and initial interest may therefore be a factor leading to high quality discussion (9.6.10). There may be some merit therefore in exploring ways of promoting such interest.

Another aspect worthy of further research is the design of more sophisticated valid and reliable techniques for assessing decision-making about conservation - formatively and summatively - which provide suitable weighting to content versus social and ethical issues components (Aikenhead, 2000; Osborne and Ratcliffe, 2002), and appropriate feedback on progress to inform learning (Conner, 2004). This involves determining what is desirable, and what is possible. Evaluating learning outcomes of conservation education programmes is notoriously difficult (Bogner, 1999; Rickinson, 2001), and science educators may gain from research that draws across different disciplines to establish a shared theoretical foundation.

It would also be useful to examine the possibility of refining the hierarchical group argumentation scheme described by Osborne *et al.* (2001a) and used in this study (figure 9.6). Each of the five high-quality discussion groups engaged in top-level argumentation (level 5), but these pupils had little difficulty reaching this level. Osborne and his colleagues developed their scheme using transcripts from discussions among 12 and 13 year-olds and there may be a need to develop a scheme for older pupils (and maybe even for adults), whose social and literacy skills are more sophisticated. Osborne *et al.* (2001b) note that the challenge is to provide teachers and pupils with tools that help them build on emerging forms of argumentation to develop more sophisticated forms of scientific discourse.

Finally, it would be of interest and value to investigate how much guidance teachers would require to:
i) use the five-level quality of personal reasoning scheme (in figure 9.2); and
ii) recognize the key roles associated with high quality conservation discussions, i.e. promoters of information vigilance, promoters of reflection, mediators of group ideas and interactions, and contributors of science content knowledge.
There could also be considerable value in presenting the pupils themselves with the group argumentation and personal reasoning schemes, to help them develop an explicit understanding of what features are considered to characterize high quality argumentation.

11.4 Conclusion

This study has attempted to explore pupils' knowledge and views about conservation issues. The findings suggest possible directions for curriculum development and further research. The challenge is to help teachers appreciate the merits of discussions about conservation as a unifying component of the science curriculum, facilitate delivery, and draw on interdisciplinary research to establish a valid and reliable mechanism for identifying and evaluating appropriate learning outcomes.

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APPENDICES

(The first number of each appendix refers to the chapter number in which it is cited.)

Appendix 2.1
The value and importance of biological conservation.
A summary the 1995 UNEP Global Biodiversity Assessment Project.
Source: The World Resources Institute, 10 G Street, NE (Suite 800), Washington, DC 20002 (http://www.wri.org/wri/biodiv/gba-unpr.html [accessed 23 February 2005)

The United Nations Environment Programme (UNEP) formally set up the Global Biodiversity Assessment Project in May 1993, with funding from the Global Environment Facility. Over 1500 scientists worldwide participated in the project, and in November 1995 UNEP produced the most comprehensive analysis of the science of biological diversity ever attempted, in a report entitled *Global Biodiversity Assessment* (UNEP, 1995). This was an independent, critical peer-reviewed, scientific analysis of all the current issues, theories and views regarding biodiversity, viewed from a global perspective. It detailed an emerging consensus about current trends in biodiversity, about ways to approach the problem, and about possible solutions. Apart from its statistical assessment, the report also covers strategies to protect biodiversity. The traditional approach to protecting biodiversity emphasized the separation of ecosystems, species, and genetic resources from human activity through the creation of protected areas, prohibitions on harvesting endangered species, and the preservation of germ plasm in seed banks or cryogenic storage facilities. Scientists now think that it is impossible to shield all genes, species, and ecosystems from human influence. Instead, preservation efforts must include a blend of strategies, including programmmes to save species by creating controlled environments and policies to manage natural environments in ways that minimize adverse impacts on biodiversity.

In the case of agriculture, for example, a growing number of scientists are emphasizing the need for protecting genetic crop resources and agro-ecosystems in their natural settings. This approach allows for the traditional, dynamic adaptation of plants to the environment. Similarly, there is a new recognition of the need for more integrated approaches to conservation, including looking at entire ecosystems rather than just some protected areas within those ecosystems. The Assessment concludes that the Earth's biological resources are under serious threat. The damage being done today -largely as a result of human activities - will limit the range of options that people will have in the future. In addition, little progress has been made in establishing the scientific foundations needed for devising effective policies for conserving and benefiting from biological diversity and its components.

In contrast to the climate change and ozone treaties, the biodiversity treaty was not preceded by a comprehensive scientific assessment. This is partly because the field of biological diversity is so complex, and partly because biodiversity researchers and observation systems are much more decentralized and location specific. The Convention on Biological Diversity clearly recognizes that there is a lack of knowledge regarding the conservation and sustainable use of biodiversity and that there is an urgent need to develop this knowledge.

The Assessment does not attempt to provide an up-to-date inventory of ecosystems and species or an analysis of international policies and measures. It focuses instead on assessing the scientific understanding of biodiversity's various components -- ecosystems, species, and genes -- and on identifying gaps in the knowledge base that should be targeted for future research. In other words, it is a snapshot of the current state of the biodiversity sciences and of the subject as perceived by the world's scientific community.

While great advances have been made in recent years, the Assessment demonstrates that scientists still have only a very incomplete understanding of the Earth's biological diversity. In contrast to many other sciences, there is still a great range of opinion even on certain basic theoretical issues. Gaps in data are enormous, and estimates can sometimes differ by orders of magnitude.

UNEP Executive Director Elizabeth Dowdeswell stated in the report that "Enormous holes exist in our knowledge of ecosystem diversity. We urgently need a much better understanding of ecosystem dynamics. For example, how big must a nature reserve be to effectively preserve species diversity? We just do not know. The fact is that most national reserve systems are based on historical accident rather than a scientific analysis of how they should be structured to best preserve biodiversity."
Scientific understanding of how species evolve and function, and how genetic diversity is distributed within populations, also has a long way to go. Another area requiring more research is the knowledge base of indigenous peoples' knowledge that is rapidly disappearing as traditional societies become displaced from their lands.
The Assessment finds that ecosystems of all kinds are under pressure world-wide. Coastal and lowland areas, wetlands, native grasslands, and many types of forests and woodlands have been particularly affected or destroyed. For example, in the early to mid-1980s, humid tropical forests were losing nearly 25 million acres annually, or just under 1 per cent globally; dry tropical forests may have lost even more area. Of the 232,000 square miles of coral reefs in the world, about 10 percent have already been eroded beyond recovery.

The report estimates that the total number of species on Earth is 13 to 14 million, of which only 13 per cent, (about 1.75 million) have been scientifically described. It also notes that the number of species that have been recorded as threatened with extinction - about 26,000 plants and 5,400 animals - is far from the real total. The status of most of the 1.75 million described species - let alone the many millions of undescribed species - has never been fully assessed. Flowering plants and vertebrate animals have recently become extinct at a rate estimated to be 50 to 100 times the average expected natural rate. The report goes beyond evaluating the problem to analyzing various options for ensuring that biodiversity is conserved and used sustainably. It concludes that biodiversity management must go far beyond simply establishing isolated nature reserves or setting up agricultural seed banks. Instead, it must be fully integrated into all aspects of landscape management, including agriculture, socio-economics, and other relevant fields.

An analysis of the economic values of biodiversity finds that biological resources are used inefficiently and inequitably. The root causes of the loss of biodiversity are embedded in the way human societies use resources and in changes in human attitudes to nature. Policies could be adopted that would confront users with the full social costs of their actions while enabling investors in conservation to reap the benefits.

Appendix 3.1

Specific learning outcomes for Education for Sustainable Development (ESD) at the end of Key Stage 4 (relating to the 'seven key concepts for sustainable development'). [from DETR (1999) *Sustainable Development Education Panel: First Annual Report 1998*. Norwich: The Stationery Office. pp.40-42]

(I have underlined some of the main features that relate to this study for emphasis – e.g. aspects of science, biological conservation, interaction and decision-making.)

By the end of KS4 Pupils should:

1 Interdependence

- Be aware of the role of advertising, product innovation and popular culture in promoting different lifestyles and be able to critically consider choices and alternatives in the context of defining needs and wants;
- Evaluate the benefits and drawbacks of the application of scientific and technological developments for individuals, communities and environments in relation to sustainable development;
- Understand the tension between sustainable development based on local production and consumption and the globalization of trade and finance;

2 Citizenship and stewardship

- Understand and value the goal of sustainability and the collective decision-making processes required to achieve it;
- Be prepared to work with others in partnership to resolve sustainable development issues;
- Understand how values and beliefs influence behaviour and lifestyles, and how some behaviour and lifestyles are more sustainable than others;
- Understand the rights and responsibilities that are emerging as necessary to achieving a sustainable society, and how they apply to themselves and other groups in the community and wider society;

3 Needs and rights of future generations

- Appreciate that the quality of life of future generations is endangered or enhanced by actions taken now;
- Understand that basic needs for a large part of the world's population presently go unmet;
- Be able to analyse the impact of their actions and lifestyle on the environment and society and understand that restraint in the use of natural resources is necessary to ensure quality of life in the future;

4 Diversity

- Have an understanding of the paradox of increased consumer choice and communication and loss of cultural, economic and biological diversity through globalization and advances in technology;
- Be able to reflect critically on and engage in debates and decisions on political, technological and economical changes which impinge on diversity and sustainability such as the uses of biotechnology;

5 Quality of life, equity and justice

- Have a clear understanding of the role individuals can play in contributing to greater social justice and equity, and be willing to participate in this process;
- Understand why social justice is an essential part of sustainable development;
- Understand disparities in development, inequalities within and between societies, and the range and complexity of factors that contribute to the quality of life in different places;

6 Sustainable change

- Be able to question decisions, practices and processes which affect sustainable development issues and investigate alternatives;
- Know how different sectors of society in the UK and elsewhere, including business, government, local authorities, NGOs and community groups are responding to the challenge of sustainable development including Local agenda 21 work;
- Be able to discuss alternative forms of scientific, technological, economic, political and social futures in the light of sustainability;

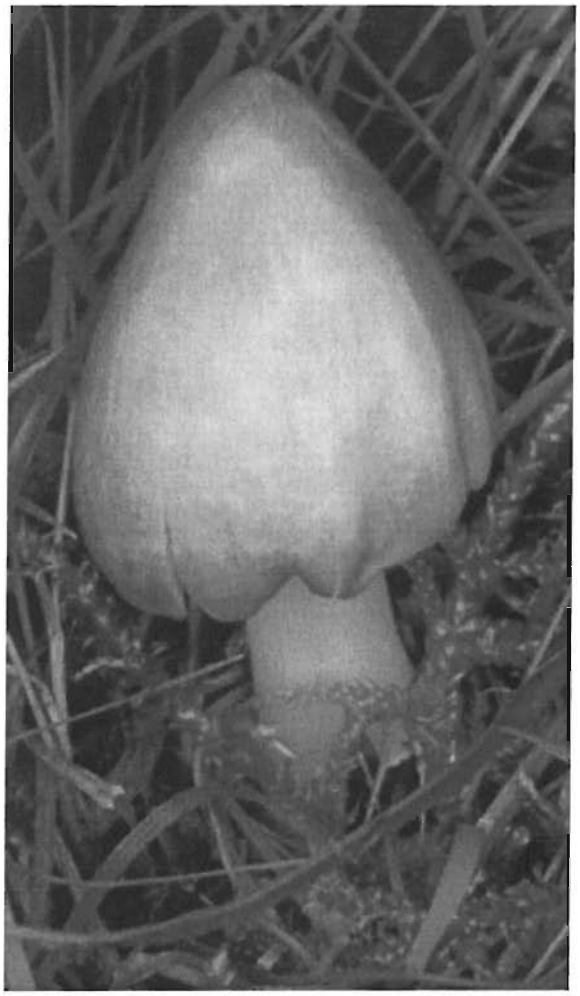
7 Uncertainty, and precaution in action

- Be able to think critically, systemically and creatively about sustainable development issues, solutions and alternatives, through study of examples;
- Understand that there are a range of possible pathways to more sustainable lifestyles and be willing participants in efforts to realise more sustainable futures through lifelong learning and informed action;
- Understand the value and use if the precautionary principle in personal, social, economic, scientific and technological decision-making in the light of uncertainty.

Appendix 5.1

The picture stimuli used for conservation scenarios.
(these were presented to the pupils as colour photographs)

Pink waxcap mushroom
Hygrocybe calyptriformis
Source: http://www.bioimages.org.uk/



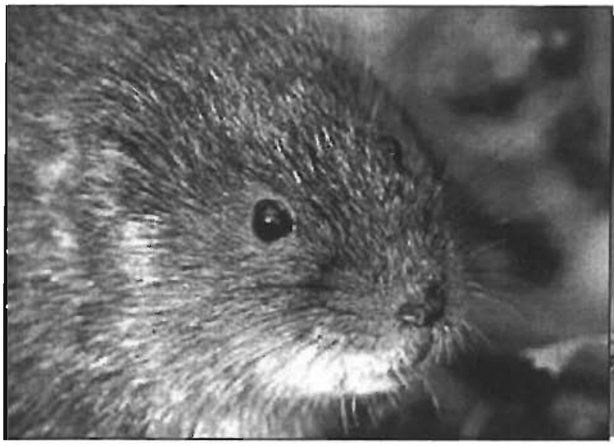
The African Elephant
Loxodonta Africana
Source: World Wide Fund for Nature, UK

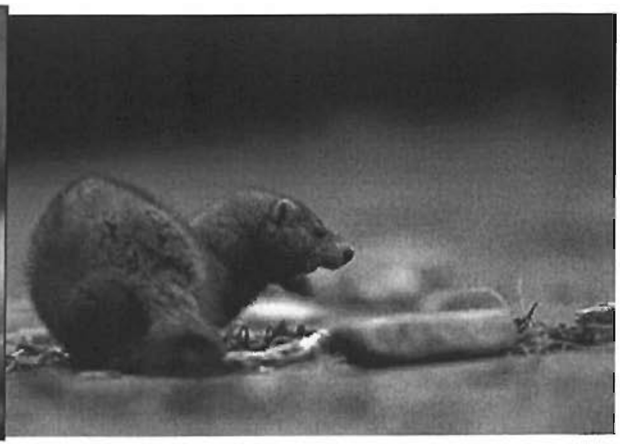
Puffin
Fratercula arctica
Source: Royal Society for the Protection of Birds

Rabbit
Oryctolagus cuniculus
Source: http://news.bbc.co.uk

Water vole
Arvicola terrestris
Source: http://news.bbc.co.uk

Mink
Mustela vison
Source: http://news.bbc.co.uk





Appendix 5.2

Written briefs for each conservation scenario – read to pupils

Introductions to the four conservation scenarios trialled with pupils. These were given to the pupils to read to set the scene, just prior to the discussions.

African elephants

The African elephant is an endangered animal, although their numbers are recovering again since the ban on ivory trading, and strict action against poaching.
However, elephants are naturally very destructive animals, and can inflict serious damage on crops and property, easily destroying a field of crops in one evening - eating some and trampling the rest. They can also cause injury or even death to human life.
This has resulted in growing conflict between elephants and local people.
What should be done about the problem, how and why?

Puffins and rabbits

Puffins are endangered seabirds which live in colonies on cliffs and islands around the coast of Britain. They don't nest on the rocks, but in burrows in the soil.
Many of these islands also have increasing rabbit populations, which also need to make burrows in the soil.
The rabbit numbers are expanding at the expense of the puffins - when the puffins return to the islands on migration each spring, there is less space for them to breed.
What should be done about the problem, how and why?

Water voles and mink

The water vole was once a common sight along our river banks, but its numbers have decreased significantly in recent years. An 'animal rights' group recently broke into a fur farm in the New Forest and released thousands of mink from their cages. A spokesperson for the group said that these beautiful animals deserved their freedom. Mink are from North America and are bred on farms in this country for their thick, soft fur. Mink are carnivores, and conservationists are concerned that they will attack water voles, which are already rare in the New Forest.
What should be done about the problem, how and why?

Pink Waxcaps

The Pink Waxcap mushroom is an endangered species, only found in a few places in Britain, including the New Forest. It is about 10 cm tall with a very attractive pointed bright pink cap, and a pinkish stem. Pink waxcaps grow in the same grassy places as other rare plants such as orchids – places which have never been ploughed, or fertilised by domestic animals. The problem is that the orchids need grassy places which are only cut once a year, but waxcaps only grow in grass that is kept very short by constant cutting or grazing by animals.
What should be done about the problem, how and why?

Appendix 5.3

Decision-making framework used with pupils in the preliminary study
(adapted from Ratcliffe, 1997)

1. OPTIONS
List the possible solutions to the problem.

2. CRITERIA
List the **important** things to consider when you look at each possible solution.

3. INFORMATION
What science information do you need to help solve this problem?

4. SURVEY
What are the good things about each option? (think about your criteria)
What are the bad things about each option? (think about your criteria)

5. CHOICE
What should be done about the problem? How?

Appendix 5.4

Some background of schools taking part in this study
(information from Local Education Authority webpages and Ofsted reports)

	School 1	**School 2**	**School 3**	**School 4**
Type of school	Comprehensive	Comprehensive	Comprehensive	Comprehensive
School category	Community	Foundation	Community	Community
Age range of pupils	11 to 16	11 to 18 years	11 to 16	11 - 16
Gender of pupils	Mixed	Mixed	Mixed	Mixed
Number on roll	1,437	1350	1070	1311
15/16 year olds	277	209	209	258
Education Authority	Southampton	Hampshire	Hampshire	Hampshire
Location	Southampton city	Southampton suburbs	Southampton suburbs	Rural Hampshire

Appendix 5.5

Questionnaire on the importance of biological conservation

Year 10/11

This is not a test! It is a questionnaire to find out what people think about animals and plants that are dying out and becoming extinct.
It is intended to last no more than 15 minutes.
There are no right or wrong answers – just indicate what YOU feel.

Please tick: Female ☐ Male ☐

Section 1
Environmental protection is often in conflict with economic development.
Do you think the following human activities are OK if they threaten an intelligent or beautiful species with extinction? (please tick)

Human activities	**YES**	**NO**	**UNCERTAIN**
Commercial forestry			
Intensive farming			
Military or defence activities			
Recreation or leisure activities			
Building houses			
Building roads			
Industrial activities			
Hunting			

Please turn over

Section 2
Please tick to show how much you agree or disagree with the following statements.

We (humans) should try to:

	I strongly agree	**I agree**	**I am uncertain**	**I disagree**	**I strongly disagree**
Conserve all threatened habitats					
Conserve all living things threatened with extinction					
Conserve all animals threatened with extinction					
Conserve all mammals threatened with extinction					
Conserve all birds threatened with extinction					
Conserve all plants threatened with extinction					
Conserve all insects threatened with extinction					
Conserve all disease-carrying species threatened with extinction (such as flies and mosquitoes)					
Conserve all deadly bacteria and viruses threatened with extinction					
Conserve all human parasites threatened with extinction (such as fleas, ticks and tapeworms)					

If you disagreed or strongly disagreed with any of these, please say why:

Appendix 5.6

Pupils completing the final version of the questionnaire about the importance of biological conservation (405 pupils in total; 216 girls and 189 boys)

	girls	boys	total
School 1	54	34	88
School 2	41	52	93
School 3	63	60	123
School 4	58	43	101
Total	216	189	405

Appendix 5.7

Provisional list of biological concepts underpinning biological conservation issues, given to 'experts'.

Which of these biological concepts do you consider 'essential' for 16 year-old school leavers to study in order to make decisions about biological conservation issues?

Are there other concepts that should be added to the list?
(items in bold are those added to my original list by the experts)

species
habitat
ecosystem
feeding relationships (food chains, food webs, pyramids of numbers/ biomass/ energy)
pollution (e.g. accumulation of toxins in food chains)
competition (for resources, predation)
interdependence (symbiotic relationships, etc.)
natural selection (Darwinian theory v Lamarkian)
distribution and abundance of organisms (in terms of adaptation, competition and predation)
evolution (resulting from variation and selection **and time - evolution now)**
extinction **(past and present - causes other than variation and selection)**
energy transfer through an ecosystem
decomposers (and cycling of C and N)
'ecological niches'
biodiversity (number and variety of organisms)
behaviour - life cycles / life histories of organisms
biogeography - 'isolated populations'
variation within spp. and between spp. (arises from genetic and environmental causes)
inheritance
sexual reproduction - (a source of genetic variation)
asexual reproduction (produces clones, i.e. not a good source of genetic variation)
genes (genotype, phenotype)
mutation (a source of genetic variation)
gene pools
disease **(as a consequence of little genetic variation)**
classification (into major taxonomic groups)
adaptation (to survive environmental changes)

Appendix 5.8

'Experts' in biological conservation consulted about 'essential' concepts underpinning education for biological conservation

1. Senior Lecturer, Biodiversity Division, School of Biological Sciences, University of Southampton
2. Lecturer, Biodiversity Division, School of Biological Sciences, University of Southampton
3. Senior Conservation Officer, Conservation Dept., Gwent Forestry Services
4. Ecologist, Poole Council, Dorset
5. Conservation Officer, Rye House RSPB Reserve, Hertfordshire
6. Head of Environmental Resource Management, Plant Conservation Department, Natural History Museum, Shinjuku, Tokyo, Japan
7. Professor of Biogeography, Head of Biology Department, Yokohama National University, Japan
8. Conservation Officer, Victoria Ranger Services, Australia
9. Senior Conservation Officer, English Nature, Peterborough, UK
10. Conservation biologist, U.S. Fish and Wildlife Service, U.S.A.
11. Professor of Plant Ecology, Department of Plant Biology, Aberdeen University
12. Conservation Officer, Iowa Conservation Education Council, U. S. A.

Appendix 5.9

Questionnaire given to science teachers about concepts and values underpinning biological conservation

The science underpinning biological conservation

Which of the following **do you think** are important for 15-16 year olds to understand and use to make decisions about biological conservation?

	essential	←———		———→	not at all important
species					
habitats					
ecosystems					
populations					
isolated populations					
population fluctuations					
food chains					
food webs					
pyramids of numbers					
pyramids of biomass					
pyramids of energy					
environmental pollution					
competition between organisms					
'co-operation' between organisms					
natural selection					
adaptation					
distribution of organisms					
abundance of organisms					
evolution in the past					
evolution now					
extinction in the past					
extinction now					
geological time scales					
introduced species					
controlled culling of animals					
energy transfer through an ecosystem					
decomposers					
ecological niches					
nitrogen cycle					
carbon cycle					
life cycles of organisms					
plant and animal behaviour					
variation between species					
variation within species					
inheritance					
sexual reproduction					
asexual reproduction					
genes					
genetic mutation					
gene pools					
resistance to disease					
classification of organisms					
major taxonomic groups					
identification of locally common organisms					
others?					

- What is your subject specialism? (i.e. *biology, chemistry, physics,* etc.):

- Which sciences do you teach at GCSE level? (please circle)

Biology Chemistry Physics others?

- Supposing pupils (15/16 year olds) are given the following scenario:

"Puffins are endangered seabirds which live in colonies around the coast of Britain, often on remote islands in the sea. They don't nest on the rocks, but in burrows in the soil above the islands. Many of these islands also have growing rabbit populations which also need burrow space in the soil. The rabbit numbers are expanding at the expense of the puffins. When the puffins return to the islands on migration each spring, there is less space for them to breed.

What should be done?"

What factors (in terms of scientific concepts and values) do you think these pupils will discuss and use if asked to make decisions about this conservation issue?

Appendix 5.10

'Pre-test' questionnaire given to pupils prior to peer-group interaction

(The picture stimuli and written briefs are the same as in appendices 5.1 and 5.2 respectively)

This is not a test!
It is a questionnaire to find out what people think about conservation. It is intended to last no more than 15 minutes.
There are no right or wrong answers – just indicate what YOU feel.

All your answers will remain completely confidential.

Name_____________________________

Please read this first:

Puffins
Puffins are endangered seabirds which live in colonies around the coast of Britain, often on remote islands in the sea. They don't nest on the rocks, but in burrows in the soil above the islands. Many of these islands also have growing rabbit populations which also need burrow space in the soil. The rabbit numbers are expanding at the expense of the puffins. When the puffins return to the islands on migration each spring, there is less space for them to breed.

1. What do you think should be done about this problem, why and how?

PLEASE TURN OVER

2. How interested are you in wildlife? (please tick one)

Very interested	Quite interested	Not interested

3. How often do you watch programmes, or read articles about wildlife? (please tick one)

At least once a week	At least once a month	At least once a year	Never

4. Do you belong to any wildlife groups? If so, which ones?

5. How often do you take part in conservation activities?

Appendix 5.11

'Post-test' questionnaire given to pupils after peer-group interaction

This is not a test!
There are no right or wrong answers – just indicate what YOU feel.

All your answers will remain completely confidential.

Name______________________________

1. What do you think should be done about the puffin problem, why and how?

PLEASE TURN OVER

2. Do you prefer discussing conservation issues in groups like this, or thinking about it on your own? (please tick)

Prefer group discussion	Prefer thinking on my own	No preference

3. How useful do you rate this kind of discussion in helping you develop your opinion about conservation? (please tick)

Very useful	Useful	Quite useful	Not very useful

Appendix 5.12
Final version of the decision-making framework given to pupils.

Please read this first:

Puffin conservation. Puffins are endangered seabirds which live in colonies on cliffs and islands around the coast of Britain. They don't nest on the rocks, but in burrows in the soil.
Many of these islands also have increasing rabbit populations, which also need to make burrows in the soil.
The rabbit numbers are expanding at the expense of the puffins - when the puffins return to the islands on migration each spring, there is less space for them to breed.

What should be done about the problem? Use the guide below to help you decide.

DECISION-MAKING GUIDE

Group: A B C D E F G H I J (please circle)

Follow these steps and note down the answers to the questions as you go.

1. OPTIONS
What are options?
(Discuss the possible solutions to the problem and list them in the first column of the table overleaf.)

2. CRITERIA
How are you going to choose between these options?
(Discuss the **important** things to consider when you look at each option, and add them to the table.)

3. INFORMATION
Do you have enough information about each option?
What science is involved in this problem?

What extra scientific information do you need to help you make the decision?

4. ADVANTAGES/ DISADVANTAGES
Discuss the advantages and disadvantages of each option, and add them to the table.

5. CHOICE
Which option does your group choose?

6. REVIEW
What do you think of the decision you have made?
How could you improve the way you made the decision?

OPTIONS (possible solutions) *[as many as you think of]*	CRITERIA (important things to consider)	ADVANTAGES	DISADVANTAGES

Appendix 5.13
Final questionnaire given to pupils a year after peer-group interaction

This is not a test!
It is intended to last no more than 15 minutes.
There are no right or wrong answers – just indicate what YOU feel.

All your answers will remain completely confidential.

Name________________________________

Please read this first to remind yourself of the problem:

Puffins
Puffins are endangered seabirds which live in colonies around the coast of Britain, often on remote islands in the sea. They don't nest on the rocks, but in burrows in the soil above the islands. Many of these islands also have growing rabbit populations which also need burrow space in the soil. The rabbit numbers are expanding at the expense of the puffins. When the puffins return to the islands on migration each spring, there is less space for them to breed.

1. What do you think should be done about this problem, why, and how?

2. Which of these areas of science are important to consider when making decisions about conserving animals? (please tick)

	Yes	No	Not sure
food chains			
food webs			
populations			
habitats			
ecosystems			
competition between animals			
natural selection			
environmental pollution			
pyramids of numbers			
adaptation			
extinction			
pyramids of biomass			
ecological niches			
culling of animals			
natural population changes			
pyramids of energy			
rarity			
energy flow			
nitrogen cycle			
species			
introduction of species			
variation between species			
evolution			
environmental indicator species			
how different animals function			
decomposers			
distribution of animals			
interdependence between animals			
evolution			
extinction			
life cycles of animals			
animal behaviour			
carbon cycle			
genetic mutation			
human skeleton			
evolutionary time scales			
asexual reproduction			
genes			
sexual reproduction			
variation within species			
gene pools			
moving animals from place to place			
isolated populations			
resistance to disease			
classification of animals			
inheritance			

Appendix 5.14

Semi-structured interview schedule, a year after the decision-making task
(10-15 mins/ group)

To explore memories of the tasks (to see what they recall about the issues and the decision-making process; to see what science and values they recall drawing on; to see how motivating the exercise was)

1. **Tell me how you worked as a group to make the decision** (was there anyone who did most of the talking, or was especially bossy about their views?; who made the decisions in the group?; who's best at science?)
2. **Tell me what you remember about the issues and decision-making tasks.**
3. **Can you remember any of the steps in the decision-making guide?**
4. **Can you remember any views on the subject that were different from yours?**
5. **Can you remember any science that your group considered to help make the decision?**
6. **Can you remember what decision you made? (if you did!)**

Appendix 6.1

Pupils completing the final version of the questionnaire about the importance of biological conservation in relation to economic activities (405 pupils in total; 216 girls and 189 boys)

Activity: Commercial forestry	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	10	10	20	19	7	26	24	18	42
School 2	9	11	20	16	11	27	16	30	46
School 3	11	10	21	23	11	34	29	39	68
School 4	7	9	16	21	9	30	30	25	55
Total	37	40	77	79	38	117	99	112	211

Activity: Intensive farming	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	6	6	12	22	10	32	26	18	44
School 2	7	15	22	17	14	31	17	23	40
School 3	11	13	24	25	13	38	27	34	61
School 4	10	11	21	23	12	35	25	20	45
Total	34	45	79	87	49	136	95	95	190

Activity: Military/ defence	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	2	9	11	38	11	49	14	14	28
School 2	0	21	21	29	19	48	10	14	24
School 3	3	19	22	42	21	63	18	20	38
School 4	2	12	14	37	14	51	19	17	36
Total	7	61	68	146	65	211	61	65	126

Activity: Recreation/ leisure	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	4	9	13	39	22	61	11	3	14
School 2	2	11	13	29	33	62	10	8	18
School 3	2	11	13	42	36	78	19	13	32
School 4	2	9	11	41	28	69	15	6	21
Total	10	40	50	151	119	270	55	30	85

Activity: Building houses	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	3	7	10	36	19	55	15	8	23
School 2	2	9	11	20	21	41	19	22	41
School 3	2	11	13	41	34	75	20	15	35
School 4	2	6	8	35	22	57	21	15	36
Total	9	33	42	132	96	228	75	60	135

Activity: Building roads	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	2	7	9	42	17	59	10	10	20
School 2	2	11	13	30	27	57	9	14	23
School 3	2	13	15	48	29	77	13	18	31
School 4	2	10	12	44	22	66	12	11	23
Total	8	41	49	164	95	259	44	53	97

Activity: Industry	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	0	5	5	44	23	67	10	6	16
School 2	0	7	7	34	36	70	7	9	16
School 3	1	8	9	50	39	89	12	13	25
School 4	1	7	8	48	29	77	9	7	16
Total	2	27	29	176	127	303	38	35	73

Activity: Hunting	Yes			No			Uncertain		
	Girls	Boys	All	Girls	Boys	All	Girls	Boys	All
School 1	0	3	3	48	27	75	6	4	10
School 2	0	5	5	36	42	78	5	5	10
School 3	0	5	5	55	48	103	8	7	15
School 4	0	4	4	52	34	86	6	5	11
Total	0	17	17	191	151	342	25	21	46

<u>Pupils completing the final version of the questionnaire about the importance of conserving habitats and a range of organisms</u> (405 pupils in total; 216 girls and 189 boys) (g= girls; b = boys)

Habitats

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**
1	35	11	46	11	15	26	5	8	13	3	0	3	0	0	0	54	34	88
2	21	12	33	14	28	42	3	12	15	3	0	3	0	0	0	41	52	93
3	32	16	48	22	29	51	4	13	17	5	1	6	0	1	1	63	60	123
4	30	12	42	19	20	39	6	10	16	3	1	4	0	0	0	58	43	101
Total	118	51	169	66	92	158	18	43	61	14	2	16	0	1	1	216	189	405

Living things

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**	**g**	**b**	**all**
1	32	8	40	17	15	32	5	9	14	0	1	1	0	1	1	54	34	88
2	17	12	29	13	27	40	4	13	17	6	0	6	1	0	1	41	52	93
3	32	14	46	20	30	50	6	12	18	5	1	6	0	3	3	63	60	123
4	29	11	40	19	18	37	5	11	16	5	2	7	0	1	1	58	43	101
Total	110	45	155	69	90	159	20	45	65	16	4	20	1	5	6	216	189	405

Animals

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	24	8	32	20	14	34	6	10	16	4	1	5	0	1	1	54	34	88
2	18	20	38	15	21	36	5	9	14	2	2	4	1	0	1	41	52	93
3	28	14	42	21	28	49	8	12	20	4	3	7	2	3	5	63	60	123
4	26	6	32	21	18	39	7	17	24	4	2	6	0	0	0	58	43	101
Total	96	48	144	77	81	158	26	48	74	14	8	22	3	4	7	216	189	405

Mammals

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	24	15	39	25	9	34	3	9	12	2	0	2	0	1	1	54	34	88
2	18	15	33	14	21	35	7	16	23	1	0	1	1	0	1	41	52	93
3	28	12	40	22	24	46	11	19	30	2	5	7	0	0	0	63	60	123
4	30	13	43	26	17	43	0	13	13	1	0	1	1	0	1	58	43	101
Total	100	55	155	87	71	158	21	57	78	6	5	11	2	1	3	216	189	405

Birds

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	22	9	31	27	13	40	4	10	14	1	2	3	0	0	0	54	34	88
2	16	14	30	15	19	34	8	16	24	1	2	3	1	1	2	41	52	93
3	25	20	45	19	22	41	13	18	31	6	0	6	0	0	0	63	60	123
4	25	8	33	14	17	31	12	14	26	6	3	9	1	1	2	58	43	101
Total	88	51	139	75	71	146	37	58	95	14	7	21	2	2	4	216	189	405

Plants

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	12	8	20	30	13	43	8	12	20	4	1	5	0	0	0	54	34	88
2	13	12	25	21	19	40	4	19	23	3	2	5	0	0	0	41	52	93
3	14	8	22	40	29	69	9	23	32	0	0	0	0	0	0	63	60	123
4	18	15	33	25	9	34	11	17	28	4	2	6	0	0	0	58	43	101
Total	57	43	100	116	70	186	32	71	103	11	5	16	0	0	0	216	189	405

Insects

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	8	3	11	27	8	35	13	16	29	5	7	12	1	0	1	54	34	88
2	9	9	18	17	12	29	10	24	34	4	7	11	1	0	1	41	52	93
3	13	11	24	29	13	42	15	30	45	6	6	12	0	0	0	63	60	123
4	15	11	26	25	9	34	14	20	34	4	3	7	0	0	0	58	43	101
Total	45	34	79	98	42	140	52	90	142	19	23	42	2	0	2	216	189	405

Disease carriers

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	1	3	4	6	1	7	27	14	41	10	4	14	10	12	22	54	34	88
2	1	5	6	5	2	7	20	21	41	7	7	14	8	17	25	41	52	93
3	0	3	3	9	4	13	31	25	56	11	8	19	12	20	32	63	60	123
4	1	4	5	4	0	4	31	20	51	11	5	16	11	14	25	58	43	101
Total	3	15	18	24	7	31	109	80	189	39	24	63	41	63	104	216	189	405

Pathogens

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	2	4	6	6	8	14	17	0	17	15	6	21	14	16	30	54	34	88
2	1	7	8	5	15	20	17	4	21	10	6	16	8	20	28	41	52	93
3	2	8	10	3	14	17	28	5	33	16	8	24	14	25	39	63	60	123
4	3	7	10	4	11	15	27	4	31	15	6	21	10	14	24	59	42	101
Total	8	26	34	18	48	66	89	13	102	56	26	82	46	75	121	216	189	405

Parasites

School	Strongly agree			Agree			Uncertain			Disagree			Strongly disagree			Total		
	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all	g	b	all
1	1	3	4	2	1	3	23	9	32	16	12	28	12	9	21	54	34	88
2	1	5	6	2	2	4	13	8	21	14	21	35	11	16	27	41	52	93
3	1	5	6	3	2	5	30	18	48	16	20	36	13	15	28	63	60	123
4	1	4	5	3	1	4	24	11	35	17	15	32	13	12	25	58	43	101
Total	4	17	21	10	6	16	90	46	136	63	68	131	49	52	101	216	189	405

Appendix 6.2

Detailed working of chi-square (χ^2) test of independence to compare pupils' response patterns from each of the four schools.

The chi-square test of independence (Hinton, 1999) compares observed with expected patterns of frequencies to see if they are different from each other (independent or not). The observed values (O) are shown below for each category listed in the questionnaire. These are followed by the expected values (E), which are the values expected if there is no difference between the groups (i.e. the numbers expected when the null hypothesis is true).

The expected value of each cell = $\frac{\text{row total x column total}}{\text{overall total}}$

For example, for the first cell in the 'commercial forestry' table below:

The expected frequency (E) = $\frac{88 \times 83}{405} = 18.0$

Activity: Commercial forestry

Observed frequencies (girls and boys combined)	**Yes**	**No**	**Uncertain**	**Total**
School 1	20	26	42	88
School 2	20	27	46	93
School 3	21	34	68	123
School 4	16	30	55	101
Total	77	117	211	405

Expected frequencies (girls and boys combined)	**Yes**	**No**	**Uncertain**	**Total**
School 1	16.7	25.4	45.9	88
School 2	17.7	26.9	48.4	93
School 3	23.4	35.5	64.1	123
School 4	19.2	29.2	52.6	101
Total	77	117	211	405

$$\chi^2 = \sum\left(\frac{(O-E)^2}{E}\right)$$

$$\chi^2 = \frac{(20.0-16.7)^2}{16.7} + \frac{(26.0-25.4)^2}{25.4} + \frac{(42.0-45.9)^2}{45.9} + \frac{(20.0-17.7)^2}{17.7} + \frac{(27.0-26.9)^2}{26.9}$$

$$+ \frac{(46.0 - 48.4)^2}{48.4} + \frac{(21.0 - 23.4)^2}{23.4} + \frac{(34.0 - 35.5)^2}{35.5} + \frac{(68.0 - 64.1)^2}{64.1}$$

$$+ \frac{(16.0 - 19.2)}{19.2} + \frac{(30.0 - 29.2)}{29.2} + \frac{(55.0 - 52.6)}{52.6}$$

$$= 0.65 + 0.01 + 0.33 + 0.30 + 0.03 + 0.12 + 0.25 + 0.06 + 0.24 + 0.53 + 0.02 + 0.11$$

$$= 2.65$$

[degrees of freedom (*df*) = (number of rows –1)(number of columns –1) = 3x2 = 6]

From χ^2 tables (Hinton, 1999: 314) the table value at p=0.05 level of significance and 6*df* is 12.59. The calculated value must be larger or equal to the table value for significance. This calculated value of 2.65 is smaller than the table value so the null hypothesis can be accepted at the p=0.05 level of significance. There is thus no significant difference in the patterns of responses of the four schools to commercial forestry.

Activity: Intensive farming

Observed frequencies (girls and boys combined)	**Yes**	**No**	**Uncertain**	**Total**
School 1	12	32	44	88
School 2	22	31	40	93
School 3	24	38	61	123
School 4	21	35	45	101
Total	79	136	190	405

Expected frequencies (girls and boys combined)	**Yes**	**No**	**Uncertain**	**Total**
School 1	17.2	29.6	41.2	88
School 2	18.1	31.2	43.6	93
School 3	24.0	41.3	57.7	123
School 4	19.7	33.9	47.4	101
Total	79	136	190	405

χ^2 = 4.19 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Activity: Military/ defence

Observed frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	11	49	28	88
School 2	21	48	24	93
School 3	22	63	38	123
School 4	14	51	36	101
Total	68	211	126	405

Expected frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	14.8	45.8	27.4	88
School 2	15.6	48.5	28.9	93
School 3	20.6	64.1	38.3	123
School 4	17.0	52.6	31.4	101
Total	68	211	126	405

χ^2 = 6.22 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Activity: Recreation/ leisure

Observed frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	13	61	14	88
School 2	13	62	18	93
School 3	13	78	32	123
School 4	11	69	21	101
Total	50	270	85	405

Expected frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	10.9	48.7	18.5	88
School 2	11.5	62.0	19.5	93
School 3	15.2	82.0	25.8	123
School 4	10.9	67.3	21.2	101
Total	50	270	85	405

χ^2 = 6.98 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Activity: Building houses

Observed frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	10	55	23	88
School 2	11	41	41	93
School 3	13	75	35	123
School 4	8	57	36	101
Total	42	228	135	405

Expected frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	9.1	49.5	29.4	88
School 2	9.6	52.4	31.0	93
School 3	12.8	69.2	41.0	123
School 4	10.5	56.9	33.6	101
Total	42	228	135	405

χ^2 = 9.88 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Activity: Building roads

Observed frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	9	59	20	88
School 2	13	57	23	93
School 3	15	77	31	123
School 4	12	66	23	101
Total	49	259	97	405

Expected frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	10.6	56.3	21.1	88
School 2	11.3	59.5	22.2	93
School 3	14.9	78.7	29.4	123
School 4	12.2	64.5	24.3	101
Total	49	259	97	405

χ^2 = 2.72 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance

Activity: Industry

Observed frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	5	67	16	88
School 2	7	70	16	93
School 3	9	89	25	123
School 4	8	77	16	101
Total	29	303	73	405

Expected frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	6.3	65.8	15.9	88
School 2	6.7	69.6	16.7	93
School 3	8.8	92.0	22.2	123
School 4	7.2	75.6	18.2	101
Total	29	303	73	405

χ^2 = 1.17 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance

Activity: Hunting

Observed frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	3	75	10	88
School 2	5	78	10	93
School 3	5	103	15	123
School 4	4	86	11	101
Total	17	342	46	405

Expected frequencies (girls and boys combined)	Yes	No	Uncertain	Total
School 1	3.7	74.3	10.0	88
School 2	3.9	78.5	10.6	93
School 3	5.2	103.9	13.9	123
School 4	4.2	85.3	11.5	101
Total	17	342	46	405

χ^2 = 1.14 (with 6 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Habitats

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	46	26	13	3	0	88
School 2	33	42	15	3	0	93
School 3	48	51	17	6	1	123
School 4	42	39	16	4	0	101
Total	169	158	61	16	1	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	36.7	34.3	13.3	3.5	0.2	88
School 2	38.8	36.3	14.0	3.7	0.2	93
School 3	51.3	47.9	18.5	4.9	0.4	123
School 4	42.2	39.5	15.2	3.9	0.2	101
Total	169	158	61	16	1	405

χ^2 = 4.2 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Living things

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	40	32	14	1	1	88
School 2	29	40	17	6	1	93
School 3	46	50	18	6	3	123
School 4	40	37	16	7	1	101
Total	155	159	65	20	6	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	33.6	34.7	14.1	4.3	1.3	88
School 2	35.6	36.5	14.9	4.6	1.4	93
School 3	47.2	48.2	19.7	6.1	1.8	123
School 4	38.6	39.6	16.3	5.0	1.5	101
Total	155	159	65	20	6	405

χ^2 = 5.7 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Animals

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	32	34	16	5	1	88
School 2	38	36	14	4	1	93
School 3	42	49	20	7	5	123
School 4	32	39	24	6	0	101
Total	144	158	74	22	7	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	31.3	34.4	16.1	4.7	1.5	88
School 2	33.1	36.3	17.0	5.0	1.6	93
School 3	43.7	47.9	22.5	6.8	2.1	123
School 4	35.9	39.4	18.4	5.5	1.8	101
Total	144	158	74	22	7	405

χ^2 = 4.1 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Mammals

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	39	34	12	2	1	88
School 2	33	35	23	1	1	93
School 3	40	46	30	7	0	123
School 4	43	43	13	1	1	101
Total	155	158	78	11	3	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	33.7	34.3	16.9	2.5	0.6	88
School 2	35.6	36.3	17.9	2.5	0.7	93
School 3	47.1	48.0	23.7	3.3	0.9	123
School 4	38.6	39.4	19.5	2.7	0.8	101
Total	155	158	78	11	3	405

χ^2 = 15.1 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Birds

Observed frequencies (girls and boys combined)	**Strongly agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**	**Total**
School 1	31	40	14	3	0	88
School 2	30	34	24	3	2	93
School 3	45	41	31	6	0	123
School 4	33	31	26	9	0	101
Total	139	146	95	21	4	405

Expected frequencies (girls and boys combined)	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**	**Total**
School 1	30.2	31.7	20.6	4.6	0.9	88
School 2	31.9	33.6	21.8	4.8	0.9	93
School 3	42.2	44.3	28.9	6.4	1.2	123
School 4	34.7	36.4	23.7	5.2	1.0	101
Total	139	146	95	21	4	405

χ^2 = 12.3 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Plants

Observed frequencies (girls and boys combined)	**Strongly agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**	**Total**
School 1	20	43	20	5	0	88
School 2	25	40	23	5	0	93
School 3	22	69	32	0	0	123
School 4	33	34	28	6	0	101
Total	100	186	103	16	0	405

Expected frequencies (girls and boys combined)	**Strongly Agree**	**Agree**	**Uncertain**	**Disagree**	**Strongly disagree**	**Total**
School 1	21.7	40.4	22.4	3.5	0	88
School 2	23.0	42.7	23.7	3.6	0	93
School 3	30.4	56.5	31.2	4.9	0	123
School 4	24.9	46.4	25.7	4.0	0	101
Total	100	186	103	16	0	405

χ^2 = 19.4 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Insects

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	11	35	29	12	1	88
School 2	18	29	34	11	1	93
School 3	24	42	45	12	0	123
School 4	26	34	34	7	0	101
Total	79	140	142	42	2	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	17.2	30.4	30.9	9.1	0.4	88
School 2	18.1	32.2	32.6	9.6	0.5	93
School 3	24.0	42.5	43.1	12.8	0.6	123
School 4	19.7	34.9	35.4	10.5	0.5	101
Total	79	140	142	42	2	405

χ^2 = 10.8 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Disease carriers

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	4	7	41	14	22	88
School 2	6	7	41	14	25	93
School 3	3	13	56	19	32	123
School 4	5	4	51	16	25	101
Total	18	31	189	63	104	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	3.9	6.7	41.1	13.7	22.6	88
School 2	4.1	7.1	43.4	14.5	23.9	93
School 3	5.5	9.4	57.4	19.1	31.6	123
School 4	4.5	7.8	47.1	15.7	25.9	101
Total	18	31	189	63	104	405

χ^2 = 6.9 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Pathogens

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	6	14	17	21	30	88
School 2	8	20	21	16	28	93
School 3	10	17	33	24	39	123
School 4	10	15	31	21	24	101
Total	34	66	102	82	121	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	7.4	14.3	22.2	17.8	26.3	88
School 2	7.8	15.2	23.4	18.8	27.8	93
School 3	10.3	20.0	31.0	25.0	36.7	123
School 4	8.5	16.5	25.4	20.4	30.2	101
Total	34	66	102	82	121	405

χ^2 = 8.7 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Parasites

Observed frequencies (girls and boys combined)	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	4	3	32	28	21	88
School 2	6	4	21	35	27	93
School 3	6	5	48	36	28	123
School 4	5	4	35	32	25	101
Total	21	16	136	131	101	405

Expected frequencies (girls and boys combined)	Strongly Agree	Agree	Uncertain	Disagree	Strongly disagree	Total
School 1	4.6	3.5	29.5	28.5	21.9	88
School 2	4.8	3.7	31.2	30.1	23.2	93
School 3	6.4	4.8	41.3	39.8	30.7	123
School 4	5.2	4	34	32.6	25.2	101
Total	21	16	136	131	101	405

χ^2 = 8.0 (with 12 degrees of freedom); not a significant difference at the p=0.05 level of significance.

Appendix 6.3

Chi-square (χ^2) comparisons between the numbers of girls and boys who rejected each human activity as an acceptable threat to species extinction. (Numbers are taken from the raw data in appendix 6.1).

Detail of the calculation for commercial forestry is shown below as an example:

Commercial forestry	**Girls**	**Boys**	**Total**
Observed (O)	79	38	(117)
Expected (E)	117/2 = 58.5	117/2 = 58.5	(117)
O – E	20.5	-20.5	(0)
$(O - E)^2/E$	420.25/58.5 = 7.19	420.25/58.5 = 7.19	

χ^2 = 7.19 + 7.19 = 14.38 with one degree of freedom, corresponding to a probability of $p < 0.01$ (Hinton, 1999: 314). The deviation from expectation is therefore very significant.

Activity	**Girls**	**Boys**	χ^2 with one degree of freedom	Significance of difference between girls and boys
Commercial forestry	79	38	14.38	$p < 0.01$ (**very significant**)
Intensive farming	87	49	10.60	$p < 0.01$ (**very significant**)
Military/ defence	146	65	31.10	$p < 0.01$ (**very significant**)
Recreation/ leisure	151	119	3.79	$p > 0.05$ (not significant)
Building houses	132	96	5.68	$p < 0.05$ (**significant**)
Building roads	164	95	9.19	$p < 0.01$ (**very significant**)
Industry	176	127	3.96	$p < 0.05$ (**significant**)
Hunting	191	151	4.68	$p < 0.05$ (**significant**)

Appendix 6.4

Pupils' responses to the question about how strongly they agree with conserving habitats and a given selection of organisms (*We (humans) should try to conserve: all mammals* [etc.] *threatened with extinction*).

405 pupils in total; 216 girls and 189 boys. Numbers are given as percentages. (G = girls; B = boys).

Category	% Strongly Agree			% Agree			% Uncertain			% Disagree			% Strongly disagree		
	G	B	All	G	B	All	G	B	All	G	B	All	G	B	All
Habitats	55	27	41	30	49	39	8	23	16	7	1	4	0	0	0
Living things	51	24	38	32	47	39	9	26	18	8	3	5	0	0	0
Animals	44	25	35	34	43	39	15	25	20	6	4	5	1	2	1
Mammals	46	29	38	40	38	39	10	30	20	4	3	3	0	0	0
Birds	41	27	33	35	38	35	18	30	23	6	4	8	0	1	1
Plants	26	23	24	54	37	46	15	37	26	5	3	4	0	0	0
Insects	21	18	19	46	22	34	24	48	36	9	12	11	0	0	0
Disease-carriers	2	8	6	11	4	7	50	42	46	18	13	15	19	33	26
Pathogens	4	14	9	8	25	17	41	8	24	26	14	20	21	39	30
Parasites	2	9	5	4	3	4	42	24	33	29	36	33	23	28	25

Appendix 7.1

Summary of responses to questionnaire given to experienced science teachers (n=23)

Teaching about animal and plant conservation at KS3 &KS4

1. In which year(s) do your pupils learn about

a) environmental conservation

Year	No. of responses
All years	4
7, 10, and 11	5
11 only	4
7, 9, and 10	1
9 and 10	2
8 and 10	2
8 and 9	3
8 only	2

b) animal/plant conservation

Year 8

Year	No. of responses
All years	4
7, 10, and 11	6
11 only	2
8 and 11	2
9 and 10	2
10 only	5
8 and 10	2

2. How much time do your pupils spend studying animals/plants in the field at

a) KS3?

6-7 lessons	3
2-3 lessons/year	8
2 lessons/year (depending on the weather)	7
1 lesson/year (depending on the teacher)	1
Very little, if any	4

b) KS4?

One day	**4**
4 lessons	**2**
2-3 lessons	**7**
One lesson/ two years (depending on teacher)	**2**
Very little, if any	**8**

3. Is animal/plant conservation taught in conjunction with any other subjects e.g. geography, PSHE, citizenship, etc? (please specify)

No	**15**
PSE sometimes	**4**
Geography	**2**
Citizenship	**1**
Joint field trip to Lepe Beach with geography	**1**

4. If possible, please show the order in which these topics are usually taught at KS4:

	No. of times a topic was ranked at this number						
Topic	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Cell activity	5			6	3		
Variation		6		4	4		
Inheritance			5	2		7	
Evolution				3	1		10
Adaptation and competition	10		2		2		
Energy and nutrient transfer	8	2	1	3			
Animal/plant conservation		7			1	6	
Environmental conservation			8		2		4
No set order 9							

Appendix 9.1

Percentage of time spent off-task by each of the 24 discussion groups (highlighted figures relate to 'high quality' discussion groups)

Group	**1**	2	**3**	4	**5**	6	7	8	9	**10**	**11**	12	13	14	15	16	17	18	19	20	21	22	23	24
% of time	**21**	16	**4**	9	**7**	13	8	10	24	**8**	**9**	20	8	4	7	9	5	11	15	19	8	9	20	17

Mean time off-task = 11.7%

Appendix 9.2
Transcript of Group 1 discussion with features of argument
(Peter, George, Tony, Joe) The text in square brackets [ ] is an explanation for the way utterances have been categorised. Counter claims listed in this appendix are generally implied, since pupils in actual conversation rarely repeat the original claim.

Argument episode	Conversation		Features of argument
1.	George:	Personally, my, like the best idea I reckon is to get a big crate and stuff and go and pick up the elephant and…	Implied claim (we could put it in a crate)
	Peter:	Yeah but how would you be able to pick up a 5 million ton elephants?	Weak rebuttal (implied counter claim + data)
	Joe:	It's possible	
	George:	Yeah it's possible, I've seen it done on the…	
	Joe:	*Blue Peter*!	
	George:	Yeah…no the *Really Wild Show*…no I have seen it though	Implied claim + data
	Peter:	Why would you want to do that though?	
2.	Tony:	Yeah just put fences around your fields	Implied claim [fences are the solution]
	George:	But then where will they go?	Weak rebuttal (implied counter claim [fences are not the solution] + data)
	Tony:	Where will they go?	Warrant
	George:	Yeah we're just making it someone else's problem, you're not resolving it	
	Off task about the tape recorder (mostly Joe)		
3.	Tony:	No right they could just put fences up round the fields	Implied claim [fences are the solution]
	George:	Anyway, important things to consider – elephants could smash fences	Rebuttal (implied counter claim [fences are not the solution] + data)
	Peter:	Yeah so we could electrify it	Qualifier [fences are the solution if they are electrified]
	Tony:	Yeah electric fences	Rebuttal of qualifier
	George:	No that'd just kill 'em	

	Peter: Tony: George:	No it wouldn't No it wouldn't OK	
4.	Peter: Tony: Peter: George:	It'd just stop 'em, then they They wouldn't hit it again so it's like… They'd just be very wounded and there'd be a slight smell of elephant skin What about if the ivory touches it…burning the ivory, it's a valuable asset	Claim [electric fences would contain elephants] Data [because one touch would deter them] Rebuttal (counter claim + data [the ivory could get damaged] + warrant [ivory is valuable])
5. Conclusion	Tony: Peter: George: Tony:	What about put all the elephants in a conservation area? If we were to do that it'd make… Where do you get the land from though? Dunno	Claim [a conservation area is the solution] Rebuttal (implied counter claim [it would not work] + data [there is not enough land]
6.	Peter: are Tony: Peter: George: Peter: Tony: Joe: Off task	They say that the elephants like ruining property right? Yeah? Well they might actually be doing some bits good because, when you like trample on earth it's sometimes puts air into it which makes it more 'nutrious' Yeah but it says its very destructive, not more nutrious Yeah but they aren't always destructive Yeah but either way they don't like it They don't go to war do they?	Implied claim [elephants are useful] + data [they trample earth] + warrant [trampling improves the soil] Rebuttal (implied counter claim [elephants are not useful] + data [they are destructive] Qualifier Rebuttal of qualifier
7.	Peter: other George:	Hey come on guys, right options, other options Um, kill the elephants, that's got to be an option	Claim [culling is an option]

	Joe: Yeah shoot the elephants Peter: Yeah it's got to be an option Tony: Allow the farmers to shoot the elephants George: And then sell the ivory to make money Peter: Yeah we could just cull them coz we've got see what good they do to the planet	Data [culling provides ivory] + warrant [farmers can make money by selling ivory]
	Tony: Or you could put them in a mating scheme, get the baby, and as the baby grows, pick it up and take it away and put it in a different country (laughter) Joe: Or you could operate on them and remove the bit of their brain which makes them destructive Peter: Yeah just remove their brain, like in *Lord of the Rings*, there you go (laughter) Peter: Right other options George: The people could move, somewhere where the elephants aren't Joe: You could chase them away with long sticks Off task Peter: So I think the most important matter here is…OK so you got that then? Tony: Yeah Peter: Good, right I think we're agreed then on the options Off task Peter: Right, criteria	
8.	Peter: Elephants could break the fence George: Yeah and it may be too powerful for them Peter: And it's money, that like they	Implied claim [fences are not the solution] + data [they can break fences] Warrant [elephants are powerful animals] Data

	don't have in Africa George: It doesn't actually say where this is, it could be Liverpool or somewhere Tony: Yeah, it does, African elephant Peter: It does say African elephants but it doesn't actually say where George: So I think it's all depending on the environment that the elephants actually living in Off task	
9.	Peter: OK erecting the fences that might cost quite a bit, and then to keep them erected	Implied claim [fences are not the solution] + data [fences are expensive]
	George: It's all going to cost money	Rebuttal (counter claim [fences are an adequate solution] + data [all solutions will be expensive]
	Peter: Yeah money is the main factor, we want the best one, but the cheapest Off task	Warrant [cost is the main factor]
	Joe: You could stop world hunger – kill an elephant Peter: Yeah imagine how much meat there is on an elephant, have you ever eaten an elephant? Tony: And the skin could be used for houses Joe: If they started doing it there'd be no hunger in Africa would there? Peter: Has anyone in the world eaten an elephant? Joe: They've got the biggest animals in the world and they're not eating them – that's why they're hungry George: No they're not the biggest animals Peter: Yeah that's the sperm whale George: They're the biggest animals on land Off task	

	Peter: OK, no we've got to keep on the point right. Tony: Yeah George: Yeah Off task	
10.	George: Anyway back to the subject, let's move on to the advantages	
	Peter: Yeah, the advantages with an electric fence is that they can be very powerful…they don't have to be made out of a very strong metal because the electric pulse can like keep them away, so you can make it out of something cheap, like aluminium, and…	Implied claim [electric fences are a good solution] + data [they can be made of cheap materials] + warrant [electric fences do not need to be strong]
	Tony: What's the disadvantage of putting up a fence? Peter: The disadvantage is…well	
	Tony: It can hurt elephants	Rebuttal (implied counter claim + data)
	Peter: Yeah and it will cost quite a lot of money, and where will they get the electricity from?	Rebuttal (implied counter claim + data [they do not have enough money] + warrant [electricity is expensive]
	George: And also the labour, people don't know how to put up fences	Rebuttal (implied counter claim + data [locals cannot erect electric fences] + warrant [locals do not have the appropriate skills]
	Peter: No (agreeing) and if the electric pulse was to go down right, then they'd be screwed coz…	Rebuttal (implied counter claim + data [there's a risk of power cuts]
	George: Yeah but the thing is right, if they get hit once by the electric fence, they're not going to do it again are they	Rebuttal (implied claim + data [elephants will not escape] + warrant [one encounter with the fence deters elephants permanently]
	Off task George: If they get hit once by the electric fence, they're not going to go there again are they?	

	Peter:	Yeah, but the thing is that they might like get entangled in it and electrocute themselves…or if there's like a hailstorm or a rainstorm…don't laugh…it could like screw them up a bit	Rebuttal (implied counter claim + data [they may be electrocuted] + warrant [electrocution is unacceptable] + qualifier [electrocution is possible in some adverse weather conditions]
	Joe:	Attach the elephant to a dynamo…(off task banter)	
	Peter:	Right let's get back to it	
	Tony:	Yeah	
	Peter:	Right what's more valuable, an elephant's life or a human's life?	
	Off task		
	George:	Anyway, let's get back to this	
11.	Peter:	Yeah, well we've done it …right, I would say the best…the most cost-effective thing is…I would actually say is fences because…if the people were to move away, that'd cost loads and they like might not be able to get a place…but the fences they could check them every night couldn't they	Claim [fences are the solution] + data [they are the most cost-effective solution] + warrant [locals do not have much money]
	George:	There could be casualties within the group	Weak rebuttal (counter claim + data [electric fences can injure elephants]
12.	Peter:	Hey! Hey! Are elephants scared of water?	
	George:	No coz they go into water to wash and drink	
	Peter:	Well what I was going to say yeah? Elephants can't jump can they..	Data [elephants cannot jump]
	George:	Ah so you could dig a trench that they can't jump across	Claim [a trench is the solution]
	Off task		
13.	Peter:	The problem with the fence is that when they've eaten everything in the fence boundary, then they won't have anything to eat for a while, so whereas normally	Implied claim [enclosure is not the solution] + data [the enclosure will not support enough food] + warrant [when elephants deplete food

		they'd move on they won't be able to move on…	supplies they move to another area]
	George:	Yeah but what if it was like a thousand million acres	Weak rebuttal (implied counter claim [a very big enclosure is the solution] + data [there is sufficient space to provide enough food]
	Peter:	Well then where are the people going to live	Rebuttal (implied claim [a big enclosure is not the solution] + data [there is insufficient space for people]
	Off task		
14.	Tony:	OK which one are we going for? the fence yeah?	
	Peter:	No I wouldn't go for the fence	Claim
	Tony:	I would say the fence coz…	Counter claim
	Joe:	I'd say we put them in a box	
	Peter:	That's inhumane, no, the only bad thing about the fence is that it might not be strong enough, so what they could do is they could test it	Data
15.	Tony:	Put 3 fences all in a row	Implied claim [the solution is to erect 3 fences]
	George:	Too much money	Rebuttal (counter claim + data)
	Joe:	Build a big wall	
16.	Peter:	Or what they could do is put barbed wire around it, and run an electric current through that couldn't they?	Claim
	Off task		
17.	Tony:	Which one are we choosing then? The fence?	
	Peter:	Fences, are we going to have them tall, or are we going to have like spikes on them?	
	George:	They need to be well tall so they can't climb over	Claim [high fences are solution] + data [elephants cannot climb high fences]
18.	Peter:	I think a moat would be quite good coz then we could have an irrigation thing	Claim + data [a ditch is a barrier and a source of water]
	Teacher intervention		
	Peter:	OK the moat would actually	Claim + data [a ditch is a

	double up as an irrigation system Off task	barrier and a source of water]
	Tony: Elephants are really clever right. I saw this programme right where elephants…an elephant can tell what group it is by sniffing their dung, and to know how old the dung is and to know where the other tribe are. George: Like marking its territory	Data
19.	Peter: But is this scientifically related? So are we going for the moat or the fences? I'd say the moat would actually be better.	Claim
	Joe: Let's have a vote Tony: I'm well up for that, I'll vote for anything George: We could have a moat then… Peter: Scientific information that we need is to find out if elephants float (laughter)…no coz if they float they can swim across the moat can't they. Joe: I reckon we should have a vote on how elephants float in a moat (laughter) Off task Peter: So are we agreeing on the fence and not the moat?	
20..	Tony: Yeah the fence is better…they might be able to swim Tony: What do we think of the decision? George: Some of them (the other choices) are inhumane	Implied claim (a fence is better than a ditch) + data (elephants can swim across a ditch) Implied claim [a fence is the best solution] + data [all other options are inhumane]

Appendix 9.3
Transcript of Group 3 discussion with features of argument
(Andy, John, Kathy, Natalie, Louise) The text in square brackets [ ] is an explanation for the way utterances have been categorised. Counter claims listed in this appendix are generally implied, since pupils in actual conversation rarely repeat the original claim.

Argument episode	Conversation		Features of argument
1.	Andy:	OK, other than poisoning the crops, so that if they eat it they die, there's nothing really they can do is there?	Claim
	John:	Unless you separate the elephants from the people, I know that sounds weird…	Counter claim
	Kathy:	I thought of that, but then you'd end up with this big fence, I mean if you think about it for elephants, it'd have to be a hell of a strong or a big fence.	Rebuttal (counter claim + data [erecting a strong fence] + warrant [elephant- proof fences must be strong]
	Natalie:	I know this sounds a bit hard, but if they were electrocuted, then they don't necessarily die, but they realise that if they go any further, they're gonna…	Rebuttal (claim + data)
	Andy:	OK, strong enough wall or fence	
	John:	It's probably going to be expensive	Weak rebuttal (counter claim + data [expensive])
	Andy:	Yeah	
	Kathy:	It'd have to be quite strong	Qualifier
	John:	And keep them away from the grass	
	Andy:	Yeah	
	Louise:	So a fence would work	Claim
	John:	But it'd have to be something like concrete	Qualifier
2.	Kathy:	Is there something you could do to the people?…like move them all away from the area?	Claim
	John:	Well not necessarily move the people, move the crops	Counter claim

	Kathy:	Yeah that's what I mean	
3.	John: Natalie: Andy: Natalie: John:	How could you make it safe so that the elephants wouldn't go to it? You could give the people guns And tranquiliser darts… That's right. Yeah but it would take a hell of a lot of tranquilising and once you've got an unconscious elephant what the hell are you meant to do with it?	 Claim Qualifier Rebuttal (counter claim + data [a lot of tranquiliser] + data [difficult to move an elephant]
4.	Andy: Louise: John: Louise: Andy:	What about….what about…oh I know what it was…you could have some kind of diversion that puts them off before they get to the crop Yeah Maybe give them something they can destroy that doesn't have to be sort of… Like their favourite food or something. Yeah maybe they should have a big bale of hay with like food in it – so they can destroy the hay and eat the food	Claim + data Claim + data [diversion] Warrant [food is a diversion] Backing [elephants like eating hay]
5.	John:	It's important to have something that doesn't hurt the elephant	Claim
6.	Natalie: Kathy: Natalie:	Food would cost money and farmers couldn't afford to keep doing that… You'd have to keep adding to it Yeah	Claim + data
7.	Andy: John: Andy: John: Andy:	What about relocating them? Yeah, it's all right if you can pinpoint them, but if it's sort of random elephants But it must be somewhere where they won't cause trouble Yeah Advantages are that it would be a permanent solution to the	Claim Weak rebuttal (counter claim + data) Claim + data [permanent solution] + warrant

		problem, and after they've been relocated it costs nothing, after the initial you know	permanent solutions are cheap]
8.	Natalie: John: Kathy:	It's got to be something to do with the local people. Education Yeah education	Claim Claim
9.	Natalie: Kathy: Natalie: John:	Get them to keep them like pets…and it might encourage them to grow trees and stuff that the elephants might eat Yeah keep this food away from the crops Yeah, have a separate area for the elephants to go But I don't know how they'd do it	Claim + data [locals grow can trees] + warrant [elephants eat trees] Counter claim + data
10.	Andy: Kathy: John: Kathy: John:	Somehow they have to live alongside each other In harmony! But the elephants are the ones posing the problem aren't they, so… Yeah but if the people were more aware through education… Hmm, I know what you mean but…	Claim Counter claim + data Claim + data Counter claim + data
	Andy: Kathy: John:	OK what about number 3, do we have enough information? We need more general research about it Yeah	
11.	Kathy: Andy: Kathy: Andy: Kathy:	You could try relocating them, that would get rid of them permanently, I mean there are elephants like on the edge of safari parks, but if you get rid of them, we don't know if they'd just turn up again. Yeah There's no guarantee that it would work, but That could be the first step. Yeah you'd probably try that one first…because it doesn't cost very much, and it's not	Claim [relocate elephants]+ data [they will not return] + self-rebuttal! (data [they might return!]) Qualifier Claim + data [relocating is cheap] + warrant [low-cost solutions are

		difficult to set up…and then if that didn't work, because you haven't really lost anything if it doesn't work…	acceptable]
	Natalie:	But in Africa, can they really afford to do things like that?	Rebuttal of warrant
	Kathy:	Well it would be funded by the WWF or whatever it is	Qualifier
	Natalie:	Yeah	
	Louise:	Yeah I definitely think that's the first step, and then to relocate them if that doesn't work	
12.	John:	Then it might be worth thinking about an electric fence, or a fence around the village and someone protecting the gate	Claim
	Kathy:	I still think education is more beneficial for the elephants in the long run…if they can educate them about the elephants, about their needs and stuff, whether it's possible to compromise or whatever, I mean if you could educate them about what elephants need and why they do what they do, for them to feel that they wanted to help…	Counter claim + data
	Natalie:	And they might be a bit more sort of tolerant when they do actually…	Data
	Kathy:	Yeah, if you know anything about them when you form your first opinion of it, if it like affects you, then you don't know any different…	
	John:	Yeah	
	Kathy:	So technically, if you educate them, they'll be far more aware, and that might make them think, oh Yeah they are endangered, so let's help them, let's give them food…	Claim [locals feed elephants]+ data [they are educated] + warrant [education raises awareness]
13.	Andy:	And maybe they could grow extra for the elephants…	Claim
	Natalie:	But they're not likely to do it themselves, because they're	Rebuttal (counter claim + data [locals are poor])

		not very rich farmers, they couldn't do it themselves whether they wanted to or not	
	Kathy:	Or maybe if they're given human food, the people would just eat it themselves…	Data
	John:	Or maybe, like this might be another point, but you know how every crop has bad bits, well maybe they could give those to the elephants – instead of growing extra food for them.	Rebuttal (qualifier)
	Kathy:	Hmm, but then you'd have to have a way of filtering out the… bad crops that you're growing wouldn't you?	Rebuttal (qualifier)
	John:	Well no, because crops go bad at different points in their growing stages, you know some are bad when you harvest them, and some are bad immediately.	Rebuttal (qualifier)
	Kathy:	Hmm, so you just have to be there at the right time.	Qualifier
	John:	It still means that they're still near the people, and anything that they don't use, like everyone has something like apple cores that they don't need.	
14.	Andy:	OK so where are we?	
	John:	Well educating the local people that will follow on feeding the elephants the waste harvest	Claim
	Andy:	OK so (writing) if education is successful feed them waste harvest.	
	Kathy:	Shall we do the other side then?	
	Natalie:	The science we need is about the way they adapt and…	
	John:	Well you need more information about the situation really don't you.	Claim
	Andy:	(writing) Is it adaptation or adaption?	
	Kathy:	Adaptation	
	All:	um…	

	Natalie:	Yeah, you need more information about general elephant biology…and you need more about the food chain and what elephants eat	
	Kathy:	So let's see what we've got (looking at the sheet)…so if that (relocate elephants on sheet) doesn't work, then we do that (relocate) or that (feed them waste food)…or we could do a combination of things	
	Andy:	(writing) Educate people	Claim
	Kathy:	Yeah, educate people first	
	Andy:	(writing) If successful,	
	Kathy:	Give waste harvest to the elephants…but you'd have to look at it long term	Claim
	Andy:	(writing) If unsuccessful	
	Kathy:	Electric fences or relocation	Claim
	Andy:	What do we think about our decision? it kind of depends on eventualities	Claim + data
	Kathy:	Yeah it depends on the farmers and other factors.	Claim + data
	Louise:	Yeah, it's a good decision	
	Kathy:	You're being very quiet Natalie	
	Off task (overhearing comments from another group)		

Appendix 9.4
Transcript of Group 5 discussion with features of argument
(Michelle, James, Sadie, Maurice) The text in square brackets [ ] is an explanation for the way utterances have been categorised. Counter claims listed in this appendix are generally implied, since pupils in actual conversation rarely repeat the original claim.

Argument episode	Conversation		Features of argument
1.	Michelle:	Why don't we try to move the puffins to another island, where they won't be disturbed and their population can get bigger??	Data + claim
	James:	Yeah that's a good idea	
	Sadie:	I say move the rabbits	Counter claim
	Maurice:	What if there's no other island?	Weak rebuttal (claim + data)
	Sadie:	Anyway, you're going to have the same problem there	Weak rebuttal (counter claim + data)
2.	Michelle:	Then you move all the rabbits onto half the islands and all the puffins onto the others.	Claim
3.	Sadie:	Cut the rabbit population down	Claim
	James:	Yeah why don't we just keep the population down?	
	Maurice:	'Coz they just keep on reproducing.	Claim + data
	James:	Just put, like a handful of them there, then it would take longer for them wouldn't it, then when they've got back to the big population again – kill them again.	Claim + data [begin with a reduced population] + warrant [they breed rapidly]
4.	Michelle:	Make a puffin centre	Claim
	Sadie:	Good idea	
	Off task		
	Maurice:	OK what do you want to do	
	James:	Not sure	
5.	Michelle:	Let's put all the puffins in captivity, so they're not eaten by the rabbits	Claim + data
	Maurice:	They're not going to be eaten by the rabbits	Weak rebuttal (counter claim)
	Sadie:	You can't keep the puffins in captivity coz they need space	Rebuttal (counter claim

		to fly.	+ data)
	Michelle:	Yeah, what you going to do with them then?	
	Sadie:	You cant keep them in captivity	Counter claim
	Michelle:	Yeah, so what we going to do?	
6.	James:	I think you have like a great big, deep metal plate on one half of the island	Claim + implied data [separate the puffins from rabbits]
	Maurice:	But the rabbits would burrow under the plate	Rebuttal (counter claim + data)
	James:	No that's why I say a deep one – and high as well	Qualifier
	Michelle:	Yeah	
	Sadie:	Yeah so..	
	Maurice:	Yeah, but then the island would look a bit dodge.	Weak rebuttal (counter claim + data)
	Sadie:	Yeah, but then the puffins could fly over, so they'd go on the other side anyway	Rebuttal (counter claim + data [puffins would fly over barrier] + warrant [puffins fly]
	James:	Yes but they've got to learn eventually not to go there.	Claim + data
7.	Sadie:	Look, I think you either have to get rid of the puffins or get rid of the rabbits	Claim
8.	Michelle:	You can breed the puffins	Claim
	Sadie:	Yeah but, where you going to breed them?	Counter claim + data
	Michelle:	In burrows	
	Sadie:	In captivity?	
	Maurice:	They need space, you cannot keep a bird in captivity!	Rebuttal (counter claim + data [puffins are wild birds] + warrant [wild birds should not be captive]
	Sadie:	Not for their whole lives, they don't stay in captivity – anyway they don't stay on this island all year.	Qualifier
	Maurice:	How would *you* honestly like to be in captivity if you were…	Rebuttal (counter claim + implied data [you would not like to be in captivity] + warrant [birds feel like us]
	Sadie:	I would not like to be in captivity – that's the point	Weak rebuttal (claim + data)
	Off task		
9.	Sadie:	OK so we need to come to a	

		decision of what we're going to do	
	James:	Separate the male and the female rabbits to stop them breeding	Claim
10.	Michelle:	(repeats the point she made earlier!) Look why don't you find an island where there are no rabbits?	Claim
	Maurice:	The situation is that there are rabbits and puffins on the same island – so what do you do?!	Weak rebuttal (counter claim+ data)
	Michelle:	And, yes and we're going to move the puffins	Claim
	Sadie:	We can't move the rabbits as it's too difficult.	Claim + data
	James:	But all the puffins might die on the way to the rabbit-free island	Counter claim + data
11.	Michelle:	I think we should just take the rabbits away – but not all of them	Claim
	Maurice:	What would you do with them?	Counter claim + data (I do not see how it can be achieved]
	Michelle:	They could become pets.	Claim + data
	Maurice:	Can I just say? How do you get pet rabbits from wild rabbits?	Counter claim + data
	James:	Yeah they're not the same	
	Maurice:	Yeah they're not the same	
	James:	Pet rabbit you have two like background pets	
12.	Sadie:	Castrate the males!	Claim
	Michelle:	Good idea!	
13.	Maurice:	Look, this is the island – you put a big cage thing over one half to keep the rabbits there	Claim + data
	Sadie:	That's keeping the rabbits in captivity	Rebuttal (claim + data)
	Maurice:	Yes it is but it also means they have half the island to walk around	Claim + data
	Sadie:	So they're in captivity, but they're still wild!	Weak rebuttal (claim + data)
	Michelle:	How can they be wild in a cage?	Weak rebuttal (claim + data)
	Maurice:	No one's going to be in there looking after them, you just	Claim + data

		give them…you just put tons of plants in there	
	Sadie:	So basically it's a giant cage in the middle of an island – that's not helping at all is it.	Counter claim
	Michelle:	I think it's a good idea actually	
	Sadie:	It's not a good idea Michelle	
	Michelle:	Yes it is	
	Sadie:	It can't be if it's Maurice's idea!	
	Maurice:	OK, just listen OK?	
14.	Michelle:	You pay someone to come and feed them?	Claim
	Maurice:	No you don't need to they've got half an island to themselves	Weak rebuttal (counter claim + data)
	Sadie:	But they'll eat all the grass	Rebuttal (claim + data)
	Maurice:	Grass grows!	Rebuttal (counter claim + data)
	Michelle:	It would have to be a couple of miles deep to stop them burrowing under	Weak rebuttal (claim + data)
	Maurice:	They're going to be dead by the time they get to the bottom of that!	
	Sadie:	They don't burrow that deep, the deepest they burrow is about 4 metres	
	Maurice:	They can't burrow straight down can they – they start at the edge and burrow gradually so they can climb back out	
	Sadie:	OK but how are going to get all the rabbits in the cage	Counter claim + data
15.	Michelle:	Just catch them and put them in	Claim
	Sadie:	But they're all burrowed down in the ground already	Counter claim + data
	Michelle:	OK You get a big digger	Claim + data
	Sadie:	Oh yeah, then you destroy the whole thing	Counter claim + data
	Maurice:	No listen – get a couple of hundred rabbits yeah? Put them on half the island. Just chuck rabbit poison on the other half of the island. If they don't want to live then that's their fault	Claim

16.	Michelle: Sadie: Michelle: Maurice: Sadie:	They need a little rabbit flap – they go in one way and not out the other A one way flap? Yeah No because a puffin might go in there Yeah like a cat flap!	Claim + data Counter claim + data
17.	James: Sadie: Maurice: Sadie: Maurice: Sadie:	Yeah but what if the poison is still on the one side and the puffins eat the rabbit poison and they die? Yeah That's why it's called rabbit poison not puffin poison! What if it affects both of them? Well it doesn't! Puffins only eat fish. So you're only worried about the puffins and rabbits – not about all the other things on the island that you're going to poison too?	Rebuttal (implied counter claim [poison is not a solution] + data) Rebuttal (claim + data) Rebuttal (counter claim + data) Rebuttal (claim + data [poison will not kill both] + warrant [rabbit poison only kills rabbits]) Weak rebuttal (counter claim + data [poison is not that specific]
18.	James: Michelle: Maurice:	I still think we should move the puffins to a rabbit-free island But they won't want to go there Who agrees with James' plan? – I agree with him – 2 v 2!	Claim Weak rebuttal (counter claim + data)
19.	Michelle: Sadie: Michelle:	No I prefer the metal cage idea. But if they're in a cage they'll get too crowded Well the old ones will die won't they – they don't live forever	Claim Rebuttal (counter claim + data) Weak rebuttal (claim + data)
20.	Maurice: James:	Have half the rabbit population – move the males and females, thereby no more procreation, which leaves an equal amount of rabbits and puffins But once the rabbits die they	Claim [separate the sexes] + data [prevent reproduction] Weak rebuttal (counter

	 Sadie: Maurice: James: Sadie: Maurice: Sadie: Michelle: Maurice:	won't be able to reproduce Yes, and then the rabbits will die and then it will just be the puffins on the island – and then you will have solved the problem – I'm sorry but how long will it take to go down every single burrow, and get them and put them in Maurice's cage?! If they don't want to be caught, they won't be will they. No but it doesn't take that long for loads of people to catch the rabbits No that's a bad idea! You get non-harmful rabbit traps It's not fair anyway – it's like taking Michelle from her house and putting her in Australia - or somewhere horrible like Antarctica. You're going to put the rabbits on a similar island somewhere else But why move the rabbits? And anyway, as *you* say – how are you going to move the rabbits?!	claim + data) Rebuttal (counter claim [catching all rabbits is not an option]) + data [this requires emptying every burrow] + warrant [you cannot empty every burrow]) Qualifier [if there are sufficient people] Counter claim Qualifier [if the traps are humane] Rebuttal (counter claim [relocating is not the solution] + data [people would not like it] + warrant [rabbits have the same feelings as people] Qualifier Weak rebuttal (repeated from above) counter claim + data [relocation requires emptying every burrow] + warrant [you cannot empty every burrow])
21.	Michelle: Sadie:	Then we move the puffins No you *can't*! They'll just fly back	Claim Rebuttal (counter claim + data + warrant [puffins can fly])
22.	Michelle:	So you need to do something to the island to make it unattractive to the puffins.	Claim
	Sadie: Maurice: Sadie:	So we need to vote Yes we need to decide Maurice? Do you think James's big metal plate down	

	Maurice:	the middle of the island is the answer? Well…	
23.	Sadie: Maurice: Off task	What you need to do is investigate whether there are other habitats around with no rabbits, and the move the puffins there and see if they will adapt there. If they don't adapt then we can put your big fence up. OK that's fine! …but if they don't, then we put the fence up and people come to the island every week and catch all the rabbits they can outside the fence – then we poison the rest	Claim
24.	Sadie: Michelle: Maurice:	Then in a couple of years we'll be going oh no the puffins are taking over and the rabbits are becoming extinct No there's millions of rabbits They're all over the place	Claim Weak rebuttal (counter claim + data)
25.	Sadie: James: Maurice: James:	Kill the rabbits on the island and then it will be a puffin sanctuary We should hunt the rabbits and then flog them off – make money How..? Have hunting parties so people pay to shoot the rabbits	Claim [create a puffin sanctuary] + data [by killing the rabbits] Claim [create puffin sanctuary] + data [by killing rabbits] + warrant [hunting is an effective way of killing rabbits] + backing [hunting attracts revenue]
26.	Michelle: Sadie: Maurice:	Release some foxes onto the island Who agrees to releasing some foxes onto the island? That is actually quite a good idea – then the foxes will hunt down the rabbits for food – but Michelle, the foxes may want to go for the puffins.	Claim Claim + data [foxes will control rabbits] Rebuttal (counter claim + data [foxes also eat

			puffins]
	Michelle:	No they wont.	Counter claim
	Maurice:	How do you know?	
	Michelle:	If you put the foxes on the island when the puffins have migrated in the winter, and then when it comes to the summer, all the rabbits will be gone, and you can take the foxes back and the puffins can live there!	Rebuttal (claim + data [will not eat the puffins] + warrant [the foxes are introduced in winter] + backing [puffins migrate in winter]
	Maurice:	What if the foxes have reproduced massively?	Weak rebuttal (counter claim + data)
	Michelle:	Well you just take them off	Rebuttal (claim + data)
	James:	Yeah how hard can a fox be to look for? It can't be that hard	Warrant [foxes are easily located]
	Michelle:	Not as hard as a rabbit	
27.	Maurice:	OK so the island is halved	
	Sadie:	No we're not doing that now	
	Maurice:	Right, we've heard Michelle's view and mine, now what's your view? (addressing Sadie)	
28.	Sadie:	Get a male and female rabbit and make them still breed on the island so that they can keep eating all the grass and keep it all balanced, but keep them controlled	Claim + data + warrant
29.	Maurice:	OK what's your idea? (addressing James)	
	James:	Island in half - plate down the middle	Claim
	Maurice:	But James how big is the island? It might be massive and cost loads of money to fence it.	Rebuttal (counter claim + data + warrant)
	Sadie:	Yeh how much money is it going to cost? and, if you put a fence up, rabbits can eat their way through it.	Rebuttal (counter claim + data)

Appendix 9.5
Transcript of Group 10 discussion with features of argument

(Simon, Steve, Lindsey, Amy) The text in square brackets [ ] is an explanation for the way utterances have been categorised. Counter claims listed in this appendix are generally implied, since pupils in actual conversation rarely repeat the original claim.

Argument episode	Conversation		Features of argument
1.	Lindsey:	OK what are we doing?	
	Steve:	I saw this programme on TV right, where they had a warehouse full of elephants' tusks they got from poachers (inaudible) …and they didn't know what to do with them coz the ivory in the tusks is worth a lot of money. So they didn't know if they should sell them or not, coz ivory is actually illegal now.	Data
	Lindsey:	Who were they? Who's warehouse was it?	
	Steve:	Some government in Africa. I think we should allow ivory in warehouses to be sold.	Claim [the solution is that ivory should be for sale]
	Lindsey:	But not kill any more elephants, 'coz they're being hunted to extinction.	Qualifier + data
	Steve:	They'd have to release it slowly though otherwise they'd flood the market	Qualifier
	Lindsey:	Also it would help the country's economy	Data
	Amy:	Then they could be off their Debts	Warrant
2.	Simon:	They could get an elephant with really big tusks and then clone it	Claim
	Amy:	Like that woolly mammoth	
	Simon:	What woolly mammoth?	
	Amy:	They found a woolly mammoth and they…(interrupted by laughter)…If they could reproduce the woolly mammoth…	Implied claim
	Off task		

3.	Lindsey:	They need to know what's from the warehouse, coz people could just say ' oh yeah, this is from the warehouse'	Claim + data
4.	Steve:	They could measure the ivory from elephants which have already been killed and then they're only allowed to sell that	Claim
5.	Lindsey: Steve:	Exactly. They need people to regulate it. Coz otherwise people are going to go out shooting elephants. But they can be a pest in some areas.	Claim + data Rebuttal (implied counter claim [shooting elephants is acceptable] + data [they are pests])
6.	Amy: Lindsey: Simon: Amy: Steve:	With pigs they breed them specially for their meat and they could breed elephants like that. But that's cruel. Elephants are intelligent creatures. We shouldn't kill any of them. African people do eat their meat. It's difficult to farm elephants though Yeh that's true	Claim [elephants could be bred] Rebuttal (counter claim[cruel] + data [elephants are intelligent]) Rebuttal (implied claim [it's OK to breed them] + data [Africans eat them]) Self counter claim! [maybe they can't be bred] + data [it's difficult]
7.	Simon: Steve: Lindsey: Simon:	Do we really need ivory? Well people pay for it don't they. Yeh that's what I'm saying – it could help the country's economy And also African people do eat the meat of elephants so it's not a complete waste.	Claim [we need ivory] + data [people pay for it]) Warrant Backing
8.	Steve: Lindsey:	So what exactly are the options available? We've got 3 options available haven't we. We've got opening the ivory trade, or half opening it – this stuff in	

	the warehouse and then option 3 is not letting any ivory be sold. Simon: You can't stop them anyway, coz there's always going to be an illegal trade, and poachers. Lindsey: But it will decrease the likelihood of it happening Simon: Maybe; otherwise it will increase – sometimes it does increase. Amy: Why? Simon: Because it's less available.	 Claim [you can't stop people killing elephants for ivory] + data Counter claim Claim Weak rebuttal (counter claim +data [there's no good reason for this claim]) Weak rebuttal (implied claim + data)
9.	Lindsey: The stuff in the warehouse will only be going to park keepers and stuff. Simon: Maybe. Is the ivory just from those that have died? Steve: I think there is a ban already, so it's not going to make any difference	Claim Claim + data
10.	Amy: The money won't go to help the economy anyway, it will just go into the hunter's pocket.	Claim + data
11.	Lindsey: I think it should happen in national parks Amy: Why national parks? Lindsey: Coz that's where the elephants will be…so there'll still be enough elephants there for hunters – it will be an incentive. (Off task)	Claim Data + warrant
12.	Amy: It's not right to remove tusks as it's painful. Simon: Yeah but it's not actually painful to remove their tusks. Amy: Yeah but haven't you seen those pictures of elephants with like their whole faces cut out? Simon: That's nasty.	Claim + data Rebuttal (implied counter claim + data) Weak rebuttal (implied counter claim)
13.	Lindsey: I think we're all basically	

		agreed that…	
	Simon:	That it should be stopped one way or another	Claim
	Lindsey:	It should be stopped, but with certain degrees	Qualifier
	Steve:	I don't agree	Counter claim [we shouldn't stop the ivory trade]
	Lindsey:	Why do you disagree Steve?	Weak rebuttal
	Steve:	I think you care too much – I think David Attenborough has brain-washed you – the money is important to the country	Implied data [ivory produces money] + warrant [money is important to the economy]
	Lindsey:	Yeah but the money isn't going to the right places – the money from poaching isn't going to improving third world economy not going blatently. It's going to go to other uses, which aren't going to be so useful.	Rebuttal of warrant
	Amy:	Yeah, and the way you're thinking, like that there's no use in elephants.	Data
14.	Lindsey:	You could take off half the tusk and it would grow back.	Claim + data
	Simon:	They use them, they're natural tools.	Rebuttal (implied counter claim + data)
	Lindsey:	But they don't always need them, it's like ingrowing toenails isn't it.	Weak rebuttal (implied claim)
15.	Steve:	The damage from elephants can be devastating.	Claim
16.	Amy:	You can't just ban elephants from going anywhere	Claim
	Lindsey:	But for some people elephants are a real problem for them – it's not fair to ask them to compromise their livelihood for the sake of some…	Rebuttal (implied counter claim [you have to ban elephants] + data [people can't compromise their livelihoods] + warrant [elephants can be pests])
	Steve:	(Inaudible)	
	Lindsey:	What were you saying about like, me caring too much Steve?	
17.	Steve:	I was just saying that elephants are a severe agricultural pest in the area.	Claim

18.	Lindsey: Simon:	How are we going to choose between these options? Coz we're going to use conservation measures	 Claim
19.	Lindsey: Simon:	It's really easy to get confused between the human viewpoint and the elephant viewpoint. Elephants don't really have a viewpoint	Claim Counter claim
20.	Amy: Lindsey: Amy: Off task	Yeah, but in 'extra scientific information'… Yeah but if we're saying like, categorically for elephants to be there, that has a bad feeling for the people they haven't got enough to support their economy but that's not really fair… No but at the same time, the elephants were there first, it was the people who decided to make their homes…	 Claim [locals don't want elephants nearby] + data [locals are already poverty-stricken] + warrant [elephants have an adverse impact on the local economy] Weak rebuttal (counter claim + data)
21.	Lindsey: Amy: Lindsey: Simon:	OK so if we take our criteria one at a time. What do we know about each option? OK let's look at the human aspect of it We've already done that Yeah we're just doing it again and again, we need… do we have any information about each option? We need to decide what to do.	
22.	Lindsey: Amy: Lindsey:	The ivory trade has a to be a big part of the economy – if you ban that you know, you're just cutting out a huge chunk of their livelihood. Which isn't really fair. Yeah but if you keep it going, the elephants will be extinct and they're not going to have anything to do anyway. Yeah but what I'm saying is that…I'm not saying	Claim [it's not fair to locals] + data [banning sale of ivory] + warrant [ivory sales are part of their livelihood] + backing [ivory is an important part of the economy] Rebuttal of warrant and backing Rebuttal (qualifier)

		that…we should keep it going.	
	Simon:	Don't forget they are going to have an effect on the environment as a whole	Data
	Amy:	Maybe they should open the ivory trade for 5 years and give it a 5 year pause.	Claim + qualifier
	Off task (inaudible)		
23.	Lindsey:	If we outlaw the ivory trade now, we can make plans for how the economy can survive – we can make some kind of arrangement – coz you can't go back once the elephants are all gone.	Claim [the solution is to make survival plans] + data [outlaw the ivory trade now] + implied warrant [banning the ivory trade saves elephants] + backing [without elephants there's no ivory]
24.	Lindsey:	There are always alternatives aren't there - if they can't carve ivory they can always carve wood	Claim + data
	Amy:	Yeah but you can't just say that…	Weak rebuttal (implied counter claim)
	Lindsey:	There must be some alternative way of exploiting the land – what about these new crops with high, you know, grain value	Claim + data
	Off task		
25.	Simon:	(commenting on banning the trade) It doesn't ruin their living	Claim
	Amy:	It's only a small proportion anyway who are living off the ivory trade	Data
	Lindsey:	You can't say if it's someone in the trade, 'oh it's a really small proportion of their income'.	Rebuttal (implied counter claim [it might ruin some lives] + data [some people might rely totally on the ivory trade]
	Amy:	No, a very small proportion of people that are actually…	Weak rebuttal (implied claim + data)
	Lindsey:	Yeah but that doesn't actually mean anything - whatever it is it's bringing more money into the economy	Weak rebuttal (implied claim + data)
26.	Steve:	They could also increase the punishment on poaching, not	Claim [the solution is to increase punishment]

		to death or anything, but they could get a few months…	
	Lindsey:	They can't have a stricter punishment coz they won't be able to deliver them.	Rebuttal (counter claim + data)
	Simon:	Why not?, but if they do catch people it will act as a deterrent to other people won't it.	Qualifier
	Lindsey:	But that's not the point though is it – the point is that economic…value…not about the fact that people are doing it when they're not supposed to…we're talking about the money that's coming into the country.	Weak rebuttal
	Simon:	But…	
	Amy:	Yeah but if you half legalise it…	Qualifier
	Lindsey:	If you're spending extra money on trying to stop people doing it by increasing the punishment, then that money can't be used elsewhere – they haven't got enough resources to do that.	Rebuttal (implied counter claim [you can't increase punishment] + data [punitive measures cost money] + warrant [the region has very little money])
	Amy:	You've got to have some kind of like moral opinion about it and stick to it	Rebuttal (claim [the solution is to increase punishment] + data [from a moral standpoint]
27.	Lindsey:	But then there's the other side of it, coz there's loads of richer countries than the countries that do the ivory trade thing…	Data [lots of countries are wealthier than Africa]
	Amy:	And we're all buying it…	Claim
	Lindsey:	And we're all buying it, yeah.	
	Steve:	We're not coz it's you can't buy ivory anymore	Rebuttal (counter claim + data)
	Lindsey:	I've got an ivory thing that I got last year	Rebuttal (claim + data)
	Steve:	What?!	
	Lindsey:	(inaudible)…sorry! – anyway that's the point. There are plenty of rich countries that aren't willing to support these other countries	
	(Off task)		

28.	Lindsey: Amy: Lindsey:	When you've got a choice of feeding your family and drinking enough water in the day, and saving an elephant, what are you going to do? You can't expect them to put elephants before themselves. Everyone always puts themselves first. That's the way it should be though for humans to survive.	Claim [the people can't put elephants first] + implied data [they are near to starving themselves] Warrant [self-preservation is natural] Backing [self-preservation is essential for survival]
29.	Simon: Lindsey: Simon: Lindsey: All: Simon: …	You've changed your opinion haven't you? No! Before you were against it I'm not saying I'm against it, it's more complex than it appears. Yeah Oh right…have you noticed how this has got a whole load more productive when there's not much time left. (Time spent completing sheet)	

Appendix 9.6
Transcript of Group 11 discussion with features of argument
(Isobel, Paul, Nigel, Rob, Lawrence, Sophie) The text in square brackets [ ] is an explanation for the way utterances have been categorised. Counter claims listed in this appendix are generally implied, since pupils in actual conversation rarely repeat the original claim.

Argument episode	Conversation		Features of argument
1.	Isobel:	OK if they live on islands, how do the rabbits get on the islands? Can't you just push them off the islands and they won't come back?	Claim [remove rabbits from the islands]
	Paul:	They've been put there already.	Counter claim [you can't remove them] + data [they were introduced]
	Isobel:	Yeah and how big's this island? Are we talking about a little crag off the coast?	
2.	Paul:	No not all of them, some live on cliffs like landbound cliffs	Claim [some live on cliffs]
	Nigel:	So they're are on the mainland too	
	Paul:	Most are on the islands, OK yeah	Qualifier
	Rob:	Just small islands	Qualifier
3.	Lawrence:	Yeah; poison the rabbits	Claim
	Nigel:	Hang on we've got to do the things of the criteria	
	Isobel:	We'll do that when we get the options done	
	Nigel:	OK	
4.	Paul: (or Rob)	Guns	Claim
5.	Nigel:	OK, poison rabbits – but they tried that didn't they in the 70s, and it just like mucked up the ecosystem	Rebuttal (counter claim [poisoning won't work] + data [already tried]
	Isobel:	Yeah the puffins eat the poison as well, and anything that eats the rabbits	Warrant
	Nigel:	Yeah anything that eats the rabbits dies too	
6.	Paul:	Make them infertile by…	Claim
	Isobel:	Jabs	Claim

	Sophie:	Yeah jabs	
7.	Paul: Lawrence: Nigel: Sophie: Lawrence: Paul: Isobel:	They could make more islands; or they could get some predators there They could get something that eats rabbits What eats rabbits? They can get a few foxes Encourage fox hunting Yeah, no! No, *discourage* fox hunting!	Claim Claim Claim Claim [fox-hunting's the solution] Counter claim [fox-hunting's not the solution]
8.	Paul: Nigel: Isobel: Sophie:	No it's simple isn't it. There are no predators for the rabbits so you just get predators More predators, there are predators, but we just need more. Not on an island though, that's why the puffins go there Yeah that's why there's the puffin colony	Claim [introduce predators] Qualifier Rebuttal (implied counter claim [predators are not the solution] + data [they'd kill the puffins too]) Warrant [predators are discouraged on puffin colonies]
9.	Isobel:	The puffins are OK on the island coz they just live on the island and eat fish and sleep on the island, but when they need to breed is when they come on land and the rabbits push them off. Right what we're going to do is write down what we're going to do, and how we're going to do it and then we write down the advantages and disadvantages.	Claim + data
10.	Lawrence: Isobel: Lawrence:	OK. Mass shooting with guns. Guns aren't allowed anymore. No but you can if you have a licence	Claim Rebuttal (implied counter claim + data) Qualifier
	Nigel: *[moved to a quieter lab]*	Put guns, poison, infertility.	

11.	Sophie: We could introduce infertility into the male rabbits	Claim
12.	Paul: Or we just leave it, and let the puffins die out (Framework procedural discussion)	Claim
13.	Lawrence: You could blow up the burrows with them in Isobel: Yeah but you need the burrows for the puffins	Claim Rebuttal (implied counter claim + data)
14.	Nigel: Don't ferrets kill rabbits? Isobel: Yeah but they probably kill puffins as well	Implied claim [ferrets are the solution] Rebuttal (implied counter claim + data)
15.	Nigel: Well we'll have to engineer something that eats rabbits and not puffins Isobel: Yeah so list the side effects, there are no side effects with guns – like diseases	Claim
16.	Sophie: Why can't they just stay where they are? Nigel: Because they need the burrows to breed in Off task	Claim Rebuttal (implied counter claim [rabbits can't stay in the burrows] + data [the puffins need the burrows]
17.	Rob: You could encourage dogs in that area Isobel: So the dogs chase the rabbits Rob: Yeah Isobel: But they'll chase the puffins too.	Data Claim Rebuttal (implied counter claim + data
18.	Paul: If we have some kind of smell that they didn't like	Claim
19.	Nigel: Or we could just get rid of all the grass in the area, then the rabbits have no food. Several : Yeah (Procedural talk)	Claim
20.	Isobel: So what else could we do? Nigel: So we're killing the rabbits so that we're saving the puffins – why are we trying to save the puffins anyway? Sophie: Because the rabbits are stopping the puffins – there are lots of rabbits...	 Claim + data

21.	Nigel: Isobel:	And what's so good about that? Why can't they find some more islands? There must be other islands No they're pretty picky. Things are pretty picky.	Claim [there must be other islands] Rebuttal (implied counter claim [there aren't other islands] + data [puffins require very specific habitat conditions])
22.	Paul: Nigel: Paul: Isobel: Paul and others: Nigel: Paul:	Well then they're going to have to die out aren't they That's not very sympathetic No but it's nature isn't it Puffins are a natural British species, rabbits aren't Yeah So when do they become natural – after 2000 years? So are you saying that puffins have higher priority? Off task	Claim Weak rebuttal (counter claim + data) Rebuttal (claim + data) Rebuttal (implied counter claim [they shouldn't be allowed to die out] + data [puffins are native species] + implied warrant [native species should be protected from extinction] Rebuttal of warrant Rebuttal of warrant + data
23.	Isobel: Rob: Nigel: Isobel: Lawrence: Nigel:	Look we're going off at a tangent here – right advantages of sterilisation? OK advantages – it's [sterilisation] very effective No it's not it's useless, coz you've got to castrate millions of rabbits No it's very effective when you catch them, and if you put nets up It would be easier to kill them wouldn't it? I mean you can imagine why it's hard to kill them all if you've got 50 thousand million warrens. Off task	 Claim Counter claim + data Rebuttal (claim + data) Data Rebuttal (counter claim + data)
24.	Nigel:	OK what's the problem with viruses?	Implied claim [viruses are the solution]

	Isobel:	The rabbits get immune	Rebuttal (counter claim + data)
	Paul:	Yeah they did that in Australia – they killed 99.9 percent of the rabbits and the other point one percent have taken over the whole area again.	Warrant [since it happened before]
	Off task		
25.	Isobel:	OK let's go onto what we can do with the puffins	
	Nigel:	Just relocate the puffins	Claim
	Lawrence:	Can we get them all?	Weak rebuttal (counter claim [maybe we can't relocate them all] + data [maybe we can't catch them all])
	Paul:	It depends how big the island is	Qualifier
	Isobel:	Imagine they're like the Channel Islands – I've seen puffins over there	
	Paul:	Yeah me too	
	Rob:	You can't move the puffins	Counter claim
	Isobel:	No you can't	
	Nigel:	Why? You can move the rabbits	Weak rebuttal
	Isobel:	You can take a breeding pair and move them to an island so you don't ever have the chance of them getting extinct, so you have a backup	Qualifier [relocate some for breeding purposes]
	Sophie:	Yeah somewhere in Scotland.	
	Off task		
26.	Isobel:	OK so what's our solution? We've been through all the ways of culling rabbits.	
	Paul:	It's strange that humans will kill the rabbits but they won't kill the puffins	
27.	Nigel:	We haven't talked about creating a puffin-friendly environment; make them separate; like fence them in	Claim [separate rabbits and puffins] + data [build a fence]
	Lawrence:	No coz they can fly over it	Rebuttal (implied counter claim + data
	Isobel:	No fencing not to stop the puffins, to stop the rabbits, and make all the burrows on a certain bit of the cliff.	Rebuttal (claim + data)

	Paul:	Yeah but rabbits aren't going to stay out	Weak rebuttal (counter claim)
	Isobel:	No you don't get my point. On the end of the cliff, like just a foot or so along the edge of the cliff. You'd have to go about a foot underground as well.	Qualifier
	Rob:	A lot more than that	Qualifier
	Isobel:	That at least; that would mean that the puffins can build on the crags, on the edge, but the rabbits couldn't get onto the crag.	Rebuttal (implied claim [separate rabbits and puffins] + implied data [build a fence] + implied warrant [rabbits can't burrow under the fence])
	Nigel:	But that wouldn't stop the puffins getting out; and it doesn't solve the problem that there's not enough space	Rebuttal (implied counter claim [this is not the solution] + data [there's not enough space])
	Lawrence:	I've got a clever idea; you should mutate puffins to kill rabbits	
	Off task		
28.	Nigel:	I think you should put down my idea about the fence, I thought that was quite a good idea.	Claim
29.	Paul:	I think we should gas the rabbits	Claim
	Nigel:	Yeah but how do you know it's not a puffin hole?	Rebuttal (implied counter claim [gassing isn't the solution] + data [it's not possible to differentiate between the burrows] + implied warrant [rabbits and puffins both live in burrows]
	Isobel:	If you do it out of the breeding season; actually I think we should do a combination of things – that's what *Captain Conservation* would do!	Rebuttal of warrant
30.	Rob:	I think that dog walking outside the breeding season would help get rid of the rabbits	Claim
	Isobel:	Yeah but how do you get out	Weak rebuttal

	to the islands? Rob: Well if you can Isobel: You could encourage dog walking in combination with fences Paul: That's not exactly natural is it. You could take all the puffins away, then kill all the rabbits, and then put the puffins back. Procedural talk	 Qualifier Qualifier Rebuttal (counter claim + data)
31.	Sophie: I reckon we should now just put one of them down with reasons Isobel: I still think fencing off the edges is the answer Nigel: Look the puffins don't want the edge, they want the middle of the place, they want the whole island	 Claim Rebuttal (counter claim + data)
32.	Rob: You could build an island I suppose Paul: That's what I said at first – it would have to be really expensive to be big enough to… Isobel: It could be done though Nigel: Yeah on a sand bank put a load of rocks on top of it, and the soil on top of the rocks, and Bob's your uncle Paul: In Japan they've built an airport in the middle of the sea Procedural talk	Claim Qualifier Data Data

Appendix 9.7
Chi-square (χ^2) comparisons between the numbers of girls and boys who advocated culling as a solution

Worked example:
Pre-test (girls v boys)

Actual nos.	For culling	Against culling	Total
Girls	8	53	61
Boys	15	55	70
Total	23	108	131

The expected frequency (E) for 'girls-for culling' is:

$$E = \frac{61 \times 23}{131} = 10.7$$

(Hinton, 1999:247)

Expected frequencies	For culling	Against culling	Total
Girls	10.7	50.3	61
Boys	12.3	57.7	70
Total	23	108	131

$$\chi^2 = \sum \left(\frac{(O - E)^2}{E} \right)$$

$$= \frac{(8 - 10.7)^2}{10.7} + \frac{(53 - 50.3)^2}{50.3} + \frac{(15 - 12.3)^2}{12.3} + \frac{(55 - 57.7)^2}{57.7}$$

$$= 0.68 + 0.15 + 0.59 + 0.12 = 1.54$$

[degrees of freedom = (rows –1)(columns-1) = 1]

χ^2 = 1.54 with one degree of freedom, corresponding to a probability of $p > 0.05$ (Hinton, 1999: 314). The deviation from expectation is therefore not significant.

Post-test (girls v boys)

χ^2 = 0.41 with one degree of freedom, corresponding to a probability of $p > 0.05$ (Hinton, 1999: 314). The deviation from expectation is therefore not significant.

Pre-test v post-test

χ^2 = 4.8 with one degree of freedom, corresponding to a probability of $p < 0.05$ (Hinton, 1999: 314). The deviation from expectation is therefore significant.

Appendix 9.8
Examples of pre and post-test written responses representing levels in the argumentation scheme in figure 5.4

Level 5

1. To stop the puffins dying out we need to put a fence round them to stop the rabbits using their burrows. If the rabbits still go under the fences we might have to catch as many as possible and move them somewhere else.
2. The elephants must be put in game parks, which are protected by fences and people with guns. Otherwise the whole species will die out. But some will have to be killed to stop the population getting too big.
3. I think the elephants should be protected completely to prevent them from becoming extinct, but obviously this decision has imperfections: economies of poorer countries will suffer from the loss of ivory trade, and any measures will be difficult to enforce.
4. I don't think we should let elephants die out, but also we can't let them keep breeding and increasing. I think it could work if some elephants are legally culled with good methods and ensuring that poaching had not occurred.
5. We didn't really decide. We don't want elephants to become extinct, but the people have rights too. We need more information on whose crops are being destroyed and if its possible to take ivory from elephants without killing them.
6. There should be fences put around property to stop the elephants destroying crops, etc. It might be expensive, but shooting them is not right. I agree that we shouldn't let elephants die out, but I feel that there will always be a black market ivory trade because people rely on it for survival.
7. To avoid elephant extinction they need to control the elephants by putting fences up around the farms. Some might have to be shot for protection of people or for selling ivory to help the local economy. I need more facts in general, about present laws, the ecosystem, and present problems.
8. It is the same decision that I had in my mind before the debate began and I am firm that I think that we should keep elephants in game parks and never kill them. I could have been open to alternative opinions but I have always believed that hunting in any form is immoral and despite arguments about benefiting the country, I still believe the same thing.
9. I think that the answer is to kill some elephants humanely for their ivory which could be sold to make money for the local people. This way elephants won't be made extinct as some are saved and peoples well being kept. Other things could also be tried like breeding elephants in an environment where tusks aren't needed. Then you can chop them off without killing the elephants.

Level 4

1. I don't know. I'm against killing animals, but the puffins need the space, so maybe killing some rabbits is the answer. I think trying to catch them or dig them out would cost too much and be nearly impossible anyway.
2. Introduce a natural predator to reduce the rabbits. If we let nature take its course the puffins would be reduced. But we should also continue to research other options in case a better solution is found.
3. We've got to think about people more than animals, and ivory trade helps economy, so we should cull some elephants.

4. I think we should kill some of the rabbits to help the puffins. But if we kill all the rabbits the island could get overgrown.
5. Either kill the rabbits by spreading disease, which is immoral, or build ledges for puffins where the rabbits can't get to, but that will cost a lot of money.
6. Fence the rabbits in because it will help the puffins and keep the rabbits alive even though it will be expensive and time consuming. If you spread disease to kill rabbits it could have side-effects on other animals.
7. Enclose them [rabbits] in a certain area. It costs a lot and takes a lot of time but it's better than spreading disease which is immoral.
8. Put ferrets on the island to kill some rabbits. I think you could kill the female rabbits so they don't have more babies, but the male rabbits may become sexually distressed.
9. Kill some of the female rabbits. If you kill them all it will reduce the food chain. If you separate the rabbits and puffins the rabbits section will be overcrowded and the puffins section will become overgrown.

Level 3

- We have to put the elephants in game reserves protected by people with guns to stop poachers getting in.
- The elephants have to be kept off farmers land by putting up big fences.
- Put a fence round the puffins area to stop the rabbits getting in.
- Introduce a natural predator to control the rabbits
- I think that some rabbits should be sterilised to slow down breeding.
- Control the rabbit population by capturing a percentage of the males.

Level 2

- Leave the elephants alone because they have a right to be there.
- Let evolution take its course because nature finds a way.
- Deport the rabbits so that they are no longer present.
- Control the rabbit population by shooting some of them each week.
- We shouldn't kill animals because it's wrong.
- I don't really know. There are so many options. But we have to reduce the number of rabbits somehow.

Level 1

- Put a fence round the puffin area
- Kill all the rabbits, it's the only logical way.
- Kill off rabbits in certain areas
- Poison the rabbits
- Sterilise the rabbits
- I don't know. I need more information

Appendix 9.9

Data collated from questionnaires (in appendices 5.10, 5.11 and 5.12) for the pupils in the five 'high quality' groups (asterisks indicate the post-test 'level 5' arguers)

Group	Name	Gender	Group decision	Personal decision (after discussion)	Pre-test view on culling	Post-test view on culling	View on culling after one year	Interest in wildlife (3 = high; 1 = low)	Frequency of looking at wildlife programmes/ articles	Belongs to wildlife groups	Taking part in conservation activities
1 elephants	George*	m	not to cull – build fences	not to cull – construct a moat/ditch	Y	Y	Y	2	Once a month	No	No
	Peter*	m		not to cull – build fences	N	Y	Y	2	Once a month	No	No
	Tony*	m		not to cull – build fences	N	N	N	3	Once a week	No	No
	Joe	m		not to cull – build fences	Y	Y	Y	1	Once a year	No	No
3 elephants	Andy*	m	not to cull - educate people, feed elephants then try relocation	not to cull – education, and fences	N	N	N	2	Once a month	No	No
	John	m		not to cull – education, relocation and fences	N	N	N	3	Once a week	No	No

	Kathy*	f	and fences	not to cull – education, relocation and fences	N	N	N	2	Once a month	No	No
	Natalie*	f		not to cull – education	N	Y	Y	2	Once a month	No	No
	Louise	f		not to cull – relocation and fences	N	N	N	2	Once a month	No	No
5 puffins	James	m	no decision - some cull some not	Cull and fences	Y	Y	Y	2	Once a month	No	No
	Maurice*	m		Don't cull but introduce foxes	N	N	N	2	Once a month	No	No
	Sadie*	f		Cull and control breeding	N	Y	Y	3	Once a week	No	No
	Michelle	f		Cull and introduce foxes	N	Y	Y	2	Once a month	No	No

Group	Name	Gender	Group decision	Personal decision	Pre-test view on culling	Post-test view on culling	View on culling after one year	Interest in wildlife (3 = high; 1 = low)	Frequency of looking at wildlife programmes/ articles	Belongs to wildlife groups	Taking part in conservation activities
10 elephants	Simon	m	cull if absolutely necessary	Cull if necessary – relocate elephants	N	Y	Y	2	Once a month	No	No
	Steve	m		Don't cull – but relocate elephants	N	N	N	3	Once a week	No	No
	Lindsey*	f		Cull if necessary. Protect elephants from poachers.	N	Y	Y	2	Once a month	No	No
	Amy	f		Cull if necessary – allow limited ivory trading	N	Y	Y	3	Once a week	No	No

11 puffins	Nigel*	m	no decision - some cull some not	Don't cull – construct a new island	N	N	N	2	Once a month	No	No
	Rob	m		Don't cull – construct a new island	N	N	N	2	Once a month	No	No
	Paul*	m		Cull rabbits– relocate rabbits	Y	Y	Y	3	Once a week	No	No
	Lawrence	m		Cull rabbits – or construct a new island	Y	N	N	1	Once a year	No	No
	Isobel*	f		Cull if necessary - fences, or a combination of approaches.	Y	Y	Y	3	Once a month	No	No
	Sophie	f		Cull if necessary – or construct a new island	N	Y	Y	2	Once a month	No	No

Appendix 9.10

Transcripts of groups 1, 3, 5, 10 and 11's discussions about puffin conservation and elephant conservation, showing concepts and values raised (IN CAPITALS) as the discussions progressed. (These are not necessarily indicated in relation to every utterance, but when they are first mentioned and when they are the main focus of the discussion).

Group 1

George: Personally, my, like the best idea I reckon is to get a big crate and stuff and go and pick up the elephant and…
Peter: Yeah but how would you be able to pick up a 5 million ton elephants? **(EFFECTIVENESS)**
Joe: It's possible.
George: Yeah it's possible, I've seen it done on the…
Joe: *Blue Peter*!
George: Yeah…no the *Really Wild Show*…no I have seen it though
Peter: Why would you want to do that though?
Tony: Yeah just put fences around your fields
George: But then where will they go?
Tony: Where will they go?
George: Yeah we're just making it someone else's problem, you're not resolving it **(ALTRUISM)**
Off task about the tape recorder (mostly Joe)
Tony: No right they could just put fences up round the fields
George: Anyway, important things to consider – elephants could smash fences **(EFFECTIVENESS)**
Peter: Yeah so we could electrify it
Tony: Yeah electric fences
George: No that'd just kill 'em **(RIGHT TO LIFE)**
Peter: No it wouldn't
Tony: No it wouldn't
George: OK
Peter: It'd just stop 'em, then they…
Tony: They wouldn't hit it again so it's like…
Peter: They'd just be very wounded and there'd be a slight smell of elephant skin **(PAIN/ SENTIENCE)**
George: What about if the ivory touches it…burning the ivory, it's a valuable asset **(COST)**
Tony: What about put all the elephants in a conservation area?
Peter: If we were to do that it'd make…
George: Where do you get the land from though? **(HABITATS)**
Tony: Dunno
Peter: They say that the elephants are like ruining property right? **(ALTRUISM)**
Tony: Yeah?
Peter: Well they might actually be doing some bits good because, when you like trample on earth it's sometimes puts air into it which makes it more 'nutrious' **(ANIMAL BEHAVIOUR/ ENVIRONMENTAL/ INTERDEPENDENCE)**

George: Yeah but it says it's very destructive, not more nutrious
Peter: Yeah but they aren't always destructive (**ANIMAL BEHAVIOUR**)
Tony: Yeah but either way they don't like it
Joe: They don't go to war do they?
Off task
Peter: Hey come on guys, right other options, other options
George: Um, kill the elephants, that's got to be an option (**CULLING**)
Joe: Yeah shoot the elephants
Peter: Yeah it's got to be an option
Tony: Allow the farmers to shoot the elephants
George: And then sell the ivory to make money (**SOCIO-POLITICAL**)
Peter: Yeah we could just cull them coz we've got see what good they do to the planet (**CULLING**)
Tony: Or you could put them in a mating scheme, get the baby, and as the baby grows, pick it up and take it away and put it in a different country
(laughter)
Joe: Or you could operate on them and remove the bit of their brain which makes them destructive
Peter: Yeah just remove their brain, like in *Lord of the Rings*, there you go
(laughter)
Peter: Right other options
George: The people could move, somewhere where the elephants aren't (**RIGHT TO LIFE**)
Joe: You could chase them away with long sticks
Off task
Peter: So I think the most important matter here is...OK so you got that then?
Tony: Yeah
Peter: Good, right I think we're agreed then on the options
Off task
Peter: Right, criteria
Peter: Elephants could break the fence (**EFFECTIVENESS**)
George: Yeah and it may be too powerful for them
Peter: And it's money, that like they don't have in Africa (**SOCIO-POLITICAL**)
George: It doesn't actually say where this is, it could be Liverpool or somewhere
Tony: Yeah, it does, African elephant (**SPECIES**)
Peter: It does say African elephants but it doesn't actually say where
George: So I think it's all depending on the environment that the elephants actually living in (**HABITAT**)
Off task
Peter: OK erecting the fences that might cost quite a bit, and then to keep them erected (**COST/ EFFECTIVENESS**)
George: It's all going to cost money
Peter: Yeah money is the main factor, we want the best one, but the cheapest
Off task (mainly Peter showing off his knowledge about hyperinflation in pre-war Germany)
Joe: You could stop world hunger – kill an elephant
Peter: Yeah imagine how much meat there is on an elephant, have you ever eaten an elephant? (**FOOD**)
Tony: And the skin could be used for houses (**RAW MATERIALS**)

Joe:	If they started doing it there'd be no hunger in Africa would there?
Peter:	Has anyone in the world eaten an elephant? **(FOOD)**
Joe:	They've got the biggest animals in the world and they're not eating them – that's why they're hungry
George:	No they're not the biggest animals
Peter:	Yeah that's the sperm whale
George:	They're the biggest animals on land
Off task	
Peter:	OK, no we've got to keep on the point right.
Tony:	Yeah
George:	Yeah
Off task	
George:	Anyway back to the subject, let's move on to the advantages
Peter:	Yeah, the advantages with an electric fence is that they can be very powerful…they don't have to be made out of a very strong metal because the electric pulse can like keep them away, so you can make it out of something cheap, like aluminium, and…**(COST/ EFFECTIVENESS)**
Tony:	What's the disadvantage of putting up a fence?
Peter:	The disadvantage is…well
Tony:	It can hurt elephants **(PAIN/ SENTIENCE)**
Peter:	Yeah and it will cost quite a lot of money and where will they get the electricity from? **(COST/ EFFECTIVENESS)**
George:	And also the labour, people don't know how to put up fences
Peter:	No (agreeing) and if the electric pulse was to go down right, then they'd be screwed coz…**(SAFETY)**
George:	Yeah but the thing is right, if they get hit once by the electric fence, they're not going to do it again are they **(ANIMAL BEHAVIOUR)**
Off task	
George:	If they get hit once by the electric fence, they're not going to go there again are they?
Peter:	Yeah, but the thing is that they might like get entangled in it and electrocute themselves…or if there's like a hailstorm or a rainstorm…don't laugh…it could like screw them up a bit **(PAIN/ SENTIENCE)**
Joe:	Attach the elephant to a dynamo…(off task banter)
Peter:	Right let's get back to it
Tony:	Yeah
Peter:	Right what's more valuable, an elephant's life or a human's life? **(ALTRUISM/ RIGHT TO LIFE)**
Off task	
George:	Anyway, let's get back to this
Peter:	Yeah, well we've done it …right, I would say the best…the most cost-effective thing is…I would actually say is fences because…if the people were to move away, that'd cost loads and they like might not be able to get a place…but the fences they could check them every night couldn't they **(COST/ EFFECTIVENESS)**
George:	There could be casualties within the group **(PAIN/ SENTIENCE)**
Peter:	Hey! Hey! Are elephants scared of water? **(ANIMAL BEHAVIOUR)**
George:	No coz they go into water to wash and drink
Peter:	Well what I was going to say yeah? Elephants can't jump can they..

George: Ah so you could dig a trench that they can't jump across

Off task

Peter: The problem with the fence is that when they've eaten everything in the fence boundary, then they won't have anything to eat for a while, so whereas normally they'd move on they won't be able to move on...(**FOOD CHAINS/ HABITATS**)

George: Yeah but what if it was like a thousand million acres

Peter: Well then where are the people going to live? (**ALTRUISM**)

Off task

Tony: OK which one are we going for? the fence yeah?

Peter: No I wouldn't go for the fence

Tony: I would say the fence coz...

Joe: I'd say we put them in a box

Peter: That's inhumane, no, the only bad thing about the fence is that it might not be strong enough, so what they could do is they could test it

Tony: Put 3 fences all in a row

George: Too much money (**COST**)

Joe: Build a big wall

Peter: Or what they could do is put barbed wire around it, and run an electric current through that couldn't they?

Off task

Tony: Which one are we choosing then? The fence?

Peter: Fences, are we going to have them tall, or are we going to have like spikes on them? (**EFFECTIVENESS**)

George: They need to be well tall so they can't climb over

Peter: I think a moat would be quite good coz then we could have an irrigation thing (**HABITAT**)

Teacher intervention

Peter: OK the moat would actually double up as an irrigation system

Off task

Tony: Elephants are really clever right. I saw this programme right where elephants...an elephant can tell what group it is by sniffing their dung, and to know how old the dung is and to know where the other tribe are (**ANIMAL BEHAVIOUR**).

George: Like marking its territory

Peter: But is this scientifically related? So are we going for the moat or the fences? I'd say the moat would actually be better (**EFFECTIVENESS**).

Joe: Let's have a vote

Tony: I'm well up for that, I'll vote for anything

George: We could have a moat then...

Peter: Scientific information that we need is to find out if elephants float (laughter)...no coz if they float they can swim across the moat can't they.

Joe: I reckon we should have a vote on how elephants float in a moat (laughter)

Off task

Peter: So are we agreeing on the fence and not the moat? (**EFFECTIVENESS**)

Tony: Yeah the fence is better...they might be able to swim (**ANIMAL BEHAVIOUR**)

Tony: What do we think of the decision?

George: Some of them (the other choices) are inhumane (**PAIN /SENTIENCE**)

Group 3

Andy:	OK, other than poisoning the crops, so that if they eat it they die, there's nothing really they can do is there? (**CULLING**)
John:	Unless you separate the elephants from the people, I know that sounds weird…
Kathy:	I thought of that, but then you'd end up with this big fence, I mean if you think about it for elephants, it'd have to be a hell of a strong or a big fence. (**EFFECTIVENESS**)
Natalie:	I know this sounds a bit hard, but if they were electrocuted, then they don't necessarily die, but they realise that if they go any further, they're gonna…(**ANIMAL BEHAVIOUR**)
Andy:	OK, strong enough wall or fence
John:	It's probably going to be expensive (**COST**)
Andy:	Yeah
Kathy:	It'd have to be quite strong
John:	And keep them away from the grass (**FOOD CHAINS**)
Andy:	Yeah
Louise:	So a fence would work
John:	But it'd have to be something like concrete
Kathy:	Is there something you could do to the people?…like move them all away from the area? (**ALTRUISM**)
John:	Well not necessarily move the people, move the crops
Kathy:	Yeah that's what I mean
John:	How could you make it safe so that the elephants wouldn't go to it?
Natalie:	You could give the people guns
Andy:	And tranquiliser darts…
Natalie:	That's right.
John:	Yeah but it would take a hell of a lot of tranquilising and once you've got an unconscious elephant what the hell are you meant to do with it?
Andy:	What about….what about…oh I know what it was…you could have some kind of diversion that puts them off before they get to the crop
Louise:	Yeah (supportive but doubtful tone)
Andy:	Maybe give them something they can destroy that doesn't have to be sort of…
Louise:	Like their favourite food or something.
Andy:	Yeah maybe they should have a big bale of hay with like food in it – so they can destroy the hay and eat the food
John:	It's important to have something that doesn't hurt the elephant (**PAIN / SENTIENCE**)
Natalie:	Food would cost money and farmers couldn't afford to keep doing that…(**COST**)
Kathy:	You'd have to keep adding to it
Natalie:	Yeah
Andy:	What about relocating them? (**RELOCATION**)
John:	Yeah, it's all right if you can pinpoint them, but if it's sort of random elephants
Andy:	But it must be somewhere where they won't cause trouble
John:	Yeah

Andy:	Advantages are that it would be a permanent solution to the problem, and after they've been relocated it costs nothing, after the initial you know
Natalie:	It's got to be something to do with the local people. **(ALTRUISM)**
John:	Education
Kathy:	Yeah education
Natalie:	Get them to keep them like pets…and it might encourage them to grow trees and stuff that the elephants might eat **(FOOD CHAINS)**
Kathy:	Yeah keep this food away from the crops
Natalie:	Yeah, have a separate area for the elephants to go **(RIGHT TO LIFE)**
John:	But I don't know how they'd do it
Andy:	Somehow they have to live alongside each other
Kathy:	In harmony!
John:	But the elephants are the ones posing the problem aren't they, so…
Kathy:	Yeah but if the people were more aware through education…
John:	Hmm, I know what you mean but…
Andy:	OK what about number 3, do we have enough information?
Kathy:	We need more general research about it
John:	Yeah
Kathy:	You could try relocating them, that would get rid of them permanently, I mean there are elephants like on the edge of safari parks, but if you get rid of them, we don't know if they'd just turn up again. **(RELOCATION)**
Andy:	Yeah
Kathy:	There's no guarantee that it would work, but…
Andy:	That could be the first step.
Kathy:	Yeah you'd probably try that one first…because it doesn't cost very much, and it's not difficult to set up…and then if that didn't work, because you haven't really lost anything if it doesn't work…**(COST/ EFFECTIVENESS)**
Natalie:	But in Africa, can they really afford to do things like that?
Kathy:	Well it would be funded by the WWF or whatever it is
Natalie:	Yeah
Louise:	Yeah I definitely think that's the first step, and then to relocate them if that doesn't work
John:	Then it might be worth thinking about an electric fence, or a fence around the village and someone protecting the gate
Kathy:	I still think education is more beneficial for the elephants in the long run…if they can educate them about the elephants, about their needs and stuff, whether it's possible to compromise or whatever, I mean if you could educate them about what elephants need and why they do what they do, for them to feel that they wanted to help…**(SOCIO-POLITICAL)**
Natalie:	And they might be a bit more sort of tolerant when they do actually…
Kathy:	Yeah, if you know anything about them when you form your first opinion of it, if it like affects you, then you don't know any different…
John:	Yeah
Kathy:	So technically, if you educate them, they'll be far more aware, and that might make them think, oh yeah they are endangered, so let's help them, let's give them food…**(RARITY)**
Andy:	And maybe they could grow extra for the elephants…

Natalie: But they're not likely to do it themselves, because they're not very rich farmers, they couldn't do it themselves whether they wanted to or not **(SOCIO-POLITICAL)**

Kathy: Or maybe if they're given human food, the people would just eat it themselves…

John: Or maybe, like this might be another point, but you know how every crop has bad bits, well maybe they could give those to the elephants – instead of growing extra food for them.

Kathy: Hmm, but then you'd have to have a way of filtering out the… bad crops that you're growing wouldn't you?

John: Well no, because crops go bad at different points in their growing stages, you know some are bad when you harvest them, and some are bad immediately.

Kathy: Hmm, so you just have to be there at the right time.

John: It still means that they're still near the people, and anything that they don't use, like everyone has something like apple cores that they don't need.

Andy: OK so where are we?

John: Well educating the local people that will follow on feeding the elephants the waste harvest

Andy: OK so (writing) if education is successful feed them waste harvest.

Kathy: Shall we do the other side then?

Natalie: The science we need is about the way they adapt and…(**ADAPTATION**)

John: Well you need more information about the situation really don't you.

Andy: (writing) Is it adaptation or adaption?

Kathy: Adaptation

All: um…

Natalie: Yeah, you need more information about general elephant biology…and you need more about the food chain and what elephants eat (**FOOD CHAINS**)

Kathy: So let's see what we've got (looking at the sheet)…so if that (relocate elephants on sheet) doesn't work, then we do that (relocate) or that (feed them waste food)…or we could do a combination of things.

Andy: (writing) Educate people

Kathy: Yeah, educate people first

Andy: (writing) If successful,

Kathy: Give waste harvest to the elephants…but you'd have to look at it long term

Andy: (writing) If unsuccessful (**EFFECTIVENESS**)

Kathy: Electric fences or relocation (**RELOCATION**)

Andy: What do we think about our decision? it kind of depends on other eventualities

Kathy: Yeah it depends on the farmers and other factors.

Louise: Yeah, it's a good decision

Kathy: You're being very quiet Natalie

Off task (overhearing comments from another group)

Group 5

Michelle: Why don't we try to move the puffins to another island, where they won't be disturbed and their population can get bigger? (**RELOCATION/ implied RARITY**)

James: Yeah that's a good idea
Sadie: I say move the rabbits
Maurice: What if there's no other island?
Sadie: Anyway, you're going to have the same problem there
Michelle: Then you move all the rabbits onto half the islands and all the puffins onto the others.
Sadie: Cut the rabbit population down (**POPULATIONS**)
James: Yeah why don't we just keep the population down?
Maurice: Coz they just keep on reproducing. (**SEXUAL REPRODUCTION**)
James: Just put, like a handful of them there, then it would take longer for them wouldn't it, then when they've got back to the big population again – kill them again. (**CULLING**)
Michelle: Make a puffin centre. (implicit **ANTHROPOMORPHISM)**
Sadie: Good idea

Off task

Maurice: OK what do you want to do
James: Not sure
Michelle: Let's put all the puffins in captivity, so they're not eaten by the rabbits (**COMPETITION**)
Maurice: They're not going to be eaten by the rabbits
Sadie: You can't keep the puffins in captivity coz they need space to fly. (**ANIMAL BEHAVIOUR**)
Michelle: Yeah, what you going to do with them then?
Sadie: You can't keep them in captivity
Michelle: Yeah, so what we going to do?
James: I think you have like a great big, deep metal plate on one half of the island
Maurice: But the rabbits would burrow under the plate (**ANIMAL BEHAVIOUR**)
James: No that's why I say a deep one – and high as well
Michelle: Yeah
Sadie: Yeah so..
Maurice: Yeah, but then the island would look a bit dodge. (**AESTHETIC**)
Sadie: Yeah, but then the puffins could fly over, so they'd go on the other side anyway
James: Yes but they've got to learn eventually not to go there. (**ANTHROPOMORPHISM**)
Sadie: Look, I think you either have to get rid of the puffins or get rid of the rabbits.
Michelle: You can breed the puffins.
Sadie: Yeah but, where you going to breed them?

Michelle: In burrows.
Sadie: In captivity?
Maurice: They need space, you cannot keep a bird in captivity! **(PAIN /SENTIENCE)**
Sadie: Not for their whole lives, they don't stay in captivity – anyway they don't stay on this island all year. **(ANIMAL BEHAVIOUR)**
Maurice: How would *you* honestly like to be in captivity if you were... **(ANTHROPOMORPHISM)**
Sadie: I would not like to be in captivity – that's the point
Off task
Sadie: OK so we need to come to a decision of what we're going to do
James: Separate the male and the female rabbits to stop them breeding
Michelle: (repeats the point she made earlier!) Look why don't you find an island where there are no rabbits?
Maurice: The situation is that there are rabbits and puffins on the same island – so what do you do?!
Michelle: And, yes and we're going to move the puffins **(RELOCATION)**
Sadie: We can't move the rabbits as it's too difficult. **(EFFECTIVENESS)**
James: But all the puffins might die on the way to the rabbit-free island
Michelle: I think we should just take the rabbits away – but not all of them
Maurice: What would you do with them?
Michelle: They could become pets. **(ANTHROPOMORPHISM)**
Maurice: Can I just say? How do you get pet rabbits from wild rabbits?
James: Yeah they're not the same
Maurice: Yeah they're not the same **(SPECIES)**
James: Pet rabbit you have two like background pets
Sadie: Castrate the males!
Michelle: Good idea!
Maurice: Look, this is the island – you put a big cage thing over one half to keep the rabbits there
Sadie: That's keeping the rabbits in captivity
Maurice: Yes it is but it also means they have half the island to walk around
Sadie: So they're in captivity, but they're still wild!
Michelle: How can they be wild in a cage?
Maurice: No one's going to be in there looking after them, you just give them...you just put tons of plants in there **(FOOD CHAINS)**
Sadie: So basically it's a giant cage in the middle of an island – that's not helping at all is it.
Michelle: I think it's a good idea actually
Sadie: It's not a good idea Michelle
Michelle: Yes it is
Sadie: It can't be if it's Maurice's idea!
Maurice: OK, just listen OK?
Michelle: You pay someone to come and feed them? **(COST/ ANTHROPOMORPHISM)**
Maurice: No you don't need to they've got half an island to themselves
Sadie: But they'll eat all the grass **(FOOD CHAINS)**
Maurice: Grass grows!
Michelle: It would have to be a couple of miles deep to stop them burrowing under
Maurice: They're going to be dead by the time they get to the bottom of that!

Sadie:	They don't burrow that deep, the deepest they burrow is about 4 metres (**ANIMAL BEHAVIOUR**)
Maurice:	They can't burrow straight down can they – they start at the edge and burrow gradually so they can climb back out (**ANIMAL BEHAVIOUR**)
Sadie:	OK but how are going to get all the rabbits in the cage
Michelle:	Just catch them and put them in
Sadie:	But they're all burrowed down in the ground already
Michelle:	OK You get a big digger
Sadie:	Oh yeah, then you destroy the whole thing
Maurice:	No listen – get a couple of hundred rabbits yeah? Put them on half the island. Just chuck rabbit poison on the other half of the island. If they don't want to live then that's their fault (**ANTHROPOMORPHISM**)
Michelle:	They need a little rabbit flap – they go in one way and not out the other
Sadie:	A one way flap?
Michelle:	Yeah
Maurice:	No because a puffin might go in there
Sadie:	Yeah like a cat flap!
James:	Yeah but what if the poison is still on the one side and the puffins eat the rabbit poison and they die? (**CULLING**)
Sadie:	Yeah
Maurice:	That's why it's called rabbit poison not puffin poison!
Sadie:	What if it affects both of them?
Maurice:	Well it doesn't! Puffins only eat fish. (**FOOD CHAINS**)
Sadie:	So you're only worried about the puffins and rabbits – not about all the other things on the island that you're going to poison too? (**RIGHT TO LIFE**)
James:	I still think we should move the puffins to a rabbit-free island (**RELOCATION**)
Michelle:	But they won't want to go there. (**ANTHROPOMORPHISM**)
Maurice:	Who agrees with James' plan? – I agree with him – 2 v 2!
Michelle:	No I prefer the metal cage idea.
Sadie:	But if they're in a cage they'll get too crowded
Michelle:	Well the old ones will die won't they – they don't live forever
Maurice:	Have half the rabbit population – move the males and females, thereby no more procreation, which leaves an equal amount of rabbits and puffins
James:	But once the rabbits die they won't be able to reproduce
Sadie:	Yes, and then the rabbits will die and then it will just be the puffins on the island – and then you will have solved the problem – I'm sorry but how long will it take to go down every single burrow, and get them and put them in Maurice's cage?! (**EFFECTIVENESS**)
Maurice:	If they don't want to be caught, they won't be will they. (**ANTHROPOMORPHISM**)
James:	No but it doesn't take that long for loads of people to catch the rabbits
Sadie:	No that's a bad idea!
Maurice:	You get non-harmful rabbit traps. (**PAIN/ SENTIENCE**)
Sadie:	It's not fair anyway – it's like taking Michelle from her house and putting her in Australia - or somewhere horrible like Antarctica. (**ANTHROPOMORPHISM**)
Michelle:	You're going to put the rabbits on a similar island somewhere else

(RELOCATION)

Maurice:	But why move the rabbits? And anyway, as *you* say – how are you going to move the rabbits?! **(RIGHT TO LIFE)**
Michelle:	Then we move the puffins.
Sadie:	No you *can't*! They'll just fly back.
Michelle:	So you need to do something to the island to make it unattractive to the puffins. (ANIMAL BEHAVIOUR)
Sadie:	So we need to vote
Maurice:	Yes we need to decide
Sadie:	Maurice? Do you think James's big metal plate down the middle of the island is the answer?
Maurice:	Well…
Sadie:	What you need to do is investigate whether there are other habitats around with no rabbits, and the move the puffins there and see if they will adapt there. If they don't adapt then we can put your big fence up. (HABITATS/ ADAPTATION)
Maurice:	OK that's fine! …but if they don't, then we put the fence up and people come to the island every week and catch all the rabbits they can outside the fence – then we poison the rest
Off task	
Sadie:	Then in a couple of years we'll be going oh no the puffins are taking over and the rabbits are becoming extinct (EXTINCTION)
Michelle:	No there's millions of rabbits
Maurice:	They're all over the place
Sadie:	Kill the rabbits on the island and then it will be a puffin sanctuary. (CULLING)
James:	We should hunt the rabbits and then flog them off – make money. **(COST/ RAW MATERIALS)**
Maurice:	How..?
James:	Have hunting parties so people pay to shoot the rabbits **(ENJOYMENT)**
Michelle:	Release some foxes onto the island
Sadie:	Who agrees to releasing some foxes onto the island?
Maurice:	That is actually quite a good idea – then the foxes will hunt down the rabbits for food – but Michelle, the foxes may want to go for the puffins. (FOOD CHAINS)
Michelle:	No they wont.
Maurice:	How do you know?
Michelle:	If you put the foxes on the island when the puffins have migrated in the winter, and then when it comes to the summer, all the rabbits will be gone, and you can take the foxes back and the puffins can live there! (ANIMAL BEHAVIOUR)
Maurice:	What if the foxes have reproduced massively?
Michelle:	Well you just take them off
James:	Yeah how hard can a fox be to look for? It can't be that hard
Michelle:	Not as hard as a rabbit
Maurice:	OK so the island is halved
Sadie:	No we're not doing that now
Maurice:	Right, we've heard Michelle's view and mine, now what's your view? (addressing Sadie)

Sadie: Get a male and female rabbit and make them still breed on the island so that they can keep eating all the grass and keep it all balanced, but keep them controlled

Maurice: OK what's your idea? (addressing James)

James: Island in half - plate down the middle

Maurice: But James how big is the island? It might be massive and cost loads of money to fence it. (**COST/ EFFECTIVENESS**)

Sadie: Yeh how much money is it going to cost? and, if you put a fence up, rabbits can eat their way through it. (**COST/ EFFECTIVENESS**)

Group 10

Lindsey: OK what are we doing?

Steve: I saw this programme on TV right, where they had a warehouse full of elephants' tusks they got from poachers (inaudible) ...and they didn't know what to do with them coz the ivory in the tusks is worth a lot of money. So they didn't know if they should sell them or not, coz ivory is actually illegal now. (**COST/ RAW MATERIALS**)

Lindsey: Who were they? Who's warehouse was it?

Steve: Some government in Africa. I think we should allow ivory in warehouses to be sold. (**COST/ RAW MATERIALS**)

Lindsey: But not kill any more elephants, 'coz they're being hunted to extinction. (**RIGHT TO LIFE/ CULLING/ RARITY/ EXTINCTION NOW**)

Steve: They'd have to release it slowly though otherwise they'd flood the market (**COST**)

Lindsey: Also it would help the country's economy (implicit **SOCIO-POLITICAL**)

Amy: Then they could be off their debts (implicit **SOCIO-POLITICAL**)

Simon: They could get an elephant with really big tusks and then clone it (**implied GENE POOLS**)

Amy: Like that woolly mammoth

Simon: What woolly mammoth?

Amy: They found a woolly mammoth and they...(interrupted by laughter)...If they could reproduce the woolly mammoth...

Off task

Lindsey: They need to know what's from the warehouse, coz people could just say ' oh yeah, this is from the warehouse' (**SOCIO-POLITICAL**)

Steve: They could measure the ivory from elephants which have already been killed and then they're only allowed to sell that (**RAW MATERIALS / SOCIO-POLITICAL**)

Lindsey: Exactly. They need people to regulate it. Coz otherwise people are going to go out shooting elephants.

Steve: But they can be a pest in some areas. (implicit **SAFETY**)

Amy: With pigs they breed them specially for their meat and they could breed elephants like that. (**FOOD**)

Lindsey: But that's cruel. Elephants are intelligent creatures.(**PAIN /SENTIENCE**)

Simon: African people do eat their meat. (**FOOD**)

Amy: It's difficult to farm elephants though (**EFFECTIVENESS**)

Steve: Yeh that's true

Simon: Do we really need ivory? (**RAW MATERIALS/ ALTRUISM**)
Steve: Well people pay for it don't they. (**COST**)
Lindsey: Yeh that's what I'm saying – it could help the country's economy (**SOCIO-POLITICAL**)
Simon: And also African people do eat the meat of elephants so it's not a complete waste. (**FOOD**)
Steve: So what exactly are the options available?
Lindsey: We've got 3 options available haven't we. We've got opening the ivory trade, or half opening it – this stuff in the warehouse and then option 3 is not letting any ivory be sold. (**RAW MATERIALS/** implicit **SOCIO-POLITICAL**)
Simon: You can't stop them anyway, coz there's always going to be an illegal trade, and poachers.
Lindsey: But it will decrease the likelihood of it happening
Simon: Maybe; otherwise it will increase – sometimes it does increase.
Amy: Why?
Simon: Because it's less available.
Lindsey: The stuff in the warehouse will only be going to park keepers and stuff.
Simon: Maybe. Is the ivory just from those that have died? (**RAW MATERIALS**)
Steve: I think there is a ban already, so it's not going to make any difference
Amy: The money won't go to help the economy anyway, it will just go into the hunter's pocket. (**SOCIO-POLITICAL**)
Lindsey: I think it should happen in national parks (**ENVIRONMENTAL**)
Amy: Why national parks?
Lindsey: Coz that's where the elephants will be…so there'll still be enough elephants there for hunters – it will be an incentive.(**ENJOYMENT**)

(Off task about cloning mammoths and oriental medicine)

Amy: It's not right to remove tusks as it's painful. (**PAIN/ SENTIENCE**)
Simon: Yeah but it's not actually painful to remove their tusks.(**ANIMAL PHYSIOLOGY**)
Amy: Yeah but haven't you seen those pictures of elephants with like their whole faces cut out?
Simon: That's nasty.
Lindsey: I think we're all basically agreed that..
Simon: That it should be stopped one way or another
Lindsey: It should be stopped, but with certain degrees
Steve: I don't agree
Lindsey: Why do you disagree Steve?
Steve: I think you care too much – I think David Attenborough has brain-washed you – the money is important to the country
Lindsey: Yeah but the money isn't going to the right places – the money from poaching isn't going to improving third world economy not going blatently. It's going to go to other uses, which aren't going to be so useful. (**SOCIO-POLITICAL**)
Amy: Yeah, and the way you're thinking, like that there's no use in elephants. (**RAW MATERIALS**)
Lindsey: You could take off half the tusk and it would grow back. (**ANIMAL PHYSIOLOGY**)
Simon: They use them, they're natural tools. (**ANIMAL BEHAVIOUR**)
Lindsey: But they don't always need them, it's like ingrowing toenails isn't it.

(ANTHROPOMORPHISM)

Steve: The damage from elephants can be devastating. **(COST) (ANIMAL BEHAVIOUR)**

Amy: You can't just ban elephants from going anywhere

Lindsey: But for some people elephants are a real problem for them – it's not fair to ask them to compromise their livelihood for the sake of some…**(SAFETY)**

Steve: (Inaudible)

Lindsey: What were you saying about like, me caring too much Steve?

Steve: I was just saying that elephants are a severe agricultural pest in the area. **(ENVIRONMENTAL/ ANIMAL BEHAVIOUR)**

Lindsey: How are we going to choose between these options?

Simon: Coz we're going to use conservation measures

Lindsey: It's really easy to get confused between the human viewpoint and the elephant viewpoint.

Simon: Elephants don't really have a viewpoint

Amy: Yeah, but in 'extra scientific information'…

Lindsey: Yeah but if we're saying like, categorically for elephants to be there, that has a bad feeling for the people they haven't got enough to support their economy but that's not really fair…**(SOCIO-POLITICAL)**

Amy: No but at the same time, the elephants were there first, it was the people who decided to make their homes…**(RIGHT TO LIFE)**

Off task

Lindsey: OK so if we take our criteria one at a time. What do we know about each option?

Amy: OK let's look at the human aspect of it

Lindsey: We've already done that

Simon: Yeah we're just doing it again and again, we need… do we have any information about each option? We need to decide what to do.

Lindsey: The ivory trade has a to be a big part of the economy – if you ban that you know, you're just cutting out a huge chunk of their livelihood. Which isn't really fair. **(RAW MATERIALS/ SOCIO-POLITICAL)**

Amy: Yeah but if you keep it going, the elephants will be extinct and they're not going to have anything to do anyway. **(ALTRUISM/ FUTURE GENERATIONS)**

Lindsey: Yeah but what I'm saying is that…I'm not saying that…we should keep it going.

Simon: Don't forget they are going to have an effect on the environment as a whole **(ENVIRONMENTAL)**

Amy: Maybe they should open the ivory trade for 5 years and give it a 5 year pause.

Off task (inaudible)

Lindsey: If we outlaw the ivory trade now, we can make plans for how the economy can survive – we can make some kind of arrangement – coz you can't go back once the elephants are all gone. **(ALTRUISM/ FUTURE GENERATIONS)**

Lindsey: There are always alternatives aren't there - if they can't carve ivory they can always carve wood **(RAW MATERIALS)**

Amy: Yeah but you can't just say that…

Lindsey: There must be some alternative way of exploiting the land – what about these new crops with high, you know, grain value (**FOOD CHAINS**)

Off task

Simon: (commenting on banning the trade) It doesn't ruin their living

Amy: It's only a small proportion anyway who are living off the ivory trade

Lindsey: You can't say if it's someone in the trade, 'oh it's a really small proportion of their income'. (**RAW MATERIALS/ SOCIO-POLITICAL**)

Amy: No, a very small proportion of people that are actually…

Lindsey: Yeah but that doesn't actually mean anything - whatever it is it's bringing more money into the economy

Steve: They could also increase the punishment on poaching, not to death or anything, but they could get a few months…

Lindsey: They can't have a stricter punishment coz they won't be able to deliver them. (**EFFECTIVENESS**)

Simon: Why not?, but if they do catch people it will act as a deterrent to other people won't it.

Lindsey: But that's not the point though is it – the point is that economic…value…not about the fact that people are doing it when they're not supposed to…we're talking about the money that's coming into the country. (**SOCIO-POLITICAL**)

Simon: But…

Amy: Yeah but if you half legalise it…

Lindsey: If you're spending extra money on trying to stop people doing it by increasing the punishment, then that money can't be used elsewhere – they haven't got enough resources to do that. (**COST/ EFFECTIVENESS**)

Amy: You've got to have some kind of like moral opinion about it and stick to it (**SOCIO-POLITICAL**)

Lindsey: But then there's the other side of it, coz there's loads of richer countries than the countries that do the ivory trade thing…

Amy: And we're all buying it…

Lindsey: And we're all buying it, yeah.

Steve: We're not coz it's you can't buy ivory anymore

Lindsey: I've got an ivory thing that I got last year

Steve: What?!

Lindsey: (inaudible)…sorry! – anyway that's the point. There are plenty of rich countries that aren't willing to support these other countries (**SOCIO-POLITICAL**)

(Off task)

Lindsey: When you've got a choice of feeding your family and drinking enough water in the day, and saving an elephant, what are you going to do? You can't expect them to put elephants before themselves. (**ALTRUISM/ FUTURE GENERATIONS**)

Amy: Everyone always puts themselves first.

Lindsey: That's the way it should be though for humans to survive.

Simon: You've changed your opinion haven't you?

Lindsey: No!

Simon: Before you were against it

Lindsey: I'm not saying I'm against it, it's more complex than it appears.
All: Yeah
Simon: Oh right…have you noticed how this has got a whole load more productive when there's not much time left.

…

(Time spent completing sheet)

Group 11

Isobel:	OK if they live on islands, how do the rabbits get on the islands? Can't you just push them off the islands and they won't come back?
Paul:	They've been put there already.
Isobel:	Yeah and how big's this island? Are we talking about a little crag off the coast? (HABITATS/ ECOSYSTEMS)
Paul:	No not all of them, some live on cliffs like landbound cliffs
Nigel:	So they are on the mainland too
Paul:	Most are on the islands, OK yeah
Rob:	Just small islands
Lawrence:	Yeah; poison the rabbits (CULLING)
Nigel:	Hang on we've got to do the things of the criteria
Isobel:	We'll do that when we get the options done
Nigel:	OK
Paul: (or Rob)	Guns
Nigel:	OK, poison rabbits – but they tried that didn't they in the 70s, and it just like mucked up the ecosystem (ECOSYSTEMS / ENVIRONMENTAL)
Isobel:	Yeah the puffins eat the poison as well, and anything that eats the rabbits (FOOD CHAINS / FOOD WEBS)
Nigel:	Yeah anything that eats the rabbits dies too
Paul:	Make them infertile by…(SEXUAL REPRODUCTION)
Isobel:	Jabs
Sophie:	Yeah jabs
Paul:	They could make more islands; or they could get some predators there (HABITATS)
Lawrence:	They could get something that eats rabbits
Nigel:	What eats rabbits? (FOOD CHAINS)
Sophie:	They can get a few foxes
Lawrence:	Encourage fox hunting (ENJOYMENT/ CULTURAL)
Paul:	Yeah, no!
Isobel:	No, *discourage* fox hunting! (ENJOYMENT/ CULTURAL)
Paul:	No it's simple isn't it. There are no predators for the rabbits so you just get predators (FOOD CHAINS)
Nigel:	More predators, there are predators, but we just need more.
Isobel:	Not on an island though, that's why the puffins go there
Sophie:	Yeah that's why there's the puffin colony
Isobel:	The puffins are OK on the island coz they just live on the island and eat fish and sleep on the island, but when they need to breed is when they come on land and the rabbits push them off (COMPETITION). Right what we're going to do is write down what we're going to do, and how we're going to do it and then we write down the advantages and disadvantages.
Lawrence:	OK. Mass shooting with guns. (CULLING)
Isobel:	Guns aren't allowed anymore.
Lawrence:	No but you can if you have a licence
Nigel:	Put guns, poison, infertility.
	[moved to a quieter lab]
Sophie:	We could introduce infertility into the male rabbits
Paul:	Or we just leave it, and let the puffins die out

Framework procedural discussion

Lawrence: You could blow up the burrows with them in
Isobel: Yeah but you need the burrows for the puffins
Nigel: Don't ferrets kill rabbits?
Isobel: Yeah but they probably kill puffins as well
Nigel: Well we'll have to engineer something that eats rabbits and not puffins **(EFFECTIVENESS)**
Isobel: Yeah so list the side effects, there are no side effects with guns – like diseases
Sophie: Why can't they just stay where they are? **(RIGHT TO LIFE)**
Nigel: Because they need the burrows to breed in

Off task

Rob: You could encourage dogs in that area
Isobel: So the dogs chase the rabbits
Rob: Yeah
Isobel: But they'll chase the puffins too.
Paul: If we have some kind of smell that they didn't like
Nigel: Or we could just get rid of all the grass in the area, then the rabbits have no food. **(FOOD CHAINS)**
Several : Yeah

Procedural talk

Isobel: So what else could we do?
Nigel: So we're killing the rabbits so that we're saving the puffins – why are we trying to save the puffins anyway? **(RIGHT TO LIFE)**
Sophie: Because the rabbits are stopping the puffins – there are lots of rabbits…**(COMPETITION/ POPULATIONS)**
Nigel: And what's so good about that? Why can't they find some more islands? There must be other islands.
Isobel: No they're pretty picky. Things are pretty picky.**(HABITAT)**
Paul: Well then they're going to have to die out aren't they
Nigel: That's not very sympathetic **(RIGHT TO LIFE)**
Paul: No but it's nature isn't it
Isobel: Puffins are a natural British species, rabbits aren't **(INTRODUCED SPECIES)**
Paul and others: Yeah
Nigel: So when do they become natural – after 2000 years?
Paul: So are you saying that puffins have higher priority? **(RIGHT TO LIFE)**

Off task

Isobel: Look we're going off at a tangent here – right advantages of sterilisation?
Rob: OK advantages – it's [sterilisation] very effective **(EFFECTIVENESS)**
Nigel: No it's not it's useless, coz you've got to castrate millions of rabbits
Isobel: No it's very effective when you catch them, and if you put nets up **(COST/ EFFECTIVENESS)**
Lawrence: It would be easier to kill them wouldn't it? **(CULLING)**
Nigel: I mean you can imagine why it's hard to kill them all if you've got 50 thousand million warrens.

Off task about *The Famous Five* story on a puffin island
(Inaudible possibly about myxomatosis)

Nigel: OK what's the problem with viruses?
Isobel: The rabbits get immune
Paul: Yeah they did that in Australia – they killed 99.9 percent of the rabbits and the other point one percent have taken over the whole area again.
Off task about rabbits and kangaroos in Australia
Isobel: OK let's go onto what we can do with the puffins
Nigel: Just relocate the puffins (**RELOCATION**)
Lawrence: Can we get them all?
Paul: It depends how big the island is
Isobel: Imagine they're like the Channel Islands – I've seen puffins over there
Paul: Yeah me too
Rob: You can't move the puffins (**EFFECTIVENESS**)
Isobel: No you can't
Nigel: Why?
Nigel: You can move the rabbits
Isobel: You can take a breeding pair and move them to an island so you don't ever have the chance of them getting extinct, so you have a backup (**RARITY**)
Sophie: Yeah somewhere in Scotland.
Off task about the temperature in Scotland
Isobel: OK so what's our solution? We've been through all the ways of culling rabbits. (**CULLING**)
Paul: It's strange that humans will kill the rabbits but they won't kill the puffins (**EFFECTIVENESS**)
Nigel: We haven't talked about creating a puffin-friendly environment; make them separate; like fence them in
Lawrence: No coz they can fly over it (**ANIMAL BEHAVIOUR**)
Isobel: No fencing not to stop the puffins, to stop the rabbits, and make all the burrows on a certain bit of the cliff.
Paul: Yeah but rabbits aren't going to stay out
Isobel: No you don't get my point. On the end of the cliff, like just a foot or so along the edge of the cliff. You'd have to go about a foot underground as well.
Rob: A lot more than that
Isobel: That at least; that would mean that the puffins can build on the crags, on the edge, but the rabbits couldn't get onto the crag (**ANIMAL BEHAVIOUR**).
Nigel: But that wouldn't stop the puffins getting out; and it doesn't solve the problem that there's not enough space
Lawrence: I've got a clever idea; you should mutate puffins to kill rabbits
Off task
Nigel: I think you should put down my idea about the fence, I thought that was quite a good idea.
Paul: I think we should gas the rabbits (**CULLING**)
Nigel: Yeah but how do you know it's not a puffin hole?
Isobel: If you do it out of the breeding season; actually I think we should do a combination of things – that's what *Captain Conservation* would do! (**ENVIRONMENTAL/ INTERDEPENDENCE**)
Rob: I think that dog walking outside the breeding season would help get rid of the rabbits

Isobel:	Yeah but how do you get out to the islands?
Rob:	Well if you can
Isobel:	You could encourage dog walking in combination with fences
Paul:	That's not exactly natural is it (**AESTHETIC**). You could take all the puffins away, then kill all the rabbits, and then put the puffins back (**CULLING**).
	Procedural talk
Sophie:	I reckon we should now just put one of them down with reasons
Isobel:	I still think fencing off the edges is the answer
Nigel:	Look the puffins don't want the edge, they want the middle of the place, they want the whole island
Rob:	You could build an island I suppose (**HABITATS**)
Paul:	That's what I said at first – it would have to be really expensive to be big enough to…(**COST**)
Isobel:	It could be done though
Nigel:	Yeah on a sand bank put a load of rocks on top of it, and the soil on top of the rocks, and Bob's your uncle
Paul:	In Japan they've built an airport in the middle of the sea
	Procedural talk

Appendix 9.11

Semi-structured interview schedule, a year after the decision-making task (10-15 mins/ group)

To explore memories of the tasks (to see what they recall about the issues and the decision-making process; to see what science and values they recall drawing on; to see how motivating the exercise was)

1. **Tell me how you worked as a group to make the decision** (was there anyone who did most of the talking, or was especially bossy about their views?; who made the decisions in the group?; who's best at science?)
2. **Tell me what you remember about the issues and decision-making tasks.**
3. **Can you remember any of the steps in the decision-making guide?**
4. **Can you remember any views on the subject that were different from yours?**
5. **Can you remember any science that your group considered to help make the decision?**
6. **Can you remember what decision you made? (if you did!)**