

Experiences drawn upon by students in post-compulsory education as they explore environmental subject matter through photography

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I confirm that the work submitted is my own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

The purpose of this thesis is to consider if and how students in post-compulsory education draw upon their compulsory science education in a particular context whilst thinking about human interactions with their environments. This has been conducted through a case study investigating experiences drawn upon by students as they explore environmental subject matter with potential links to sustainable development and content addressed in National Curriculum science. Data for the case study were collected during and after a practical task in which students aged 16-18 years explored an environmental theme through photography. The photography project presented a practical context in which individuals might potentially draw upon any number of experiences in relation to subjects explored. Qualitative analysis of four individual case studies forms the basis of findings and discussion that detail how these students acted in this particular situation. The outcomes of the study will add to the literature examining the student experience of environmental education where there is an emphasis on compulsory science education.

The case study design used a 6-week practical AS level photography coursework assignment as an informal context in which students could explore an environmental theme relating to human interactions with their environments. Data were collected through weekly records of teacher-student classroom discussion and students' photography work journals. Students were interviewed on completion of the project via a semi-structured, audio-taped interview. Categories of experiences were drawn from four individual case studies to form individual findings and identify pattern and variation across the sample.

Two main observations emerge from the results which indicate opportunities for further research: Firstly, the way students chose to interpret the photography brief either presented, or limited, opportunities to have drawn upon science in this context. This action has been characterised as *interpretation* and *opportunity*. Secondly, students have drawn upon experiences from NC science that relate mainly to biology and the study of life processes and living things. As such, they do not appear to recognise the relevance of physics and chemistry to supporting environmental awareness and understanding. Therefore, I propose further research to investigate the linkages that occur between: (i) biology, physics and chemistry; and (ii) scientific and non-scientific content as students explore complex environmental issues. This might perhaps go some way towards facilitating transferrable knowledge and skills to enable interdisciplinary understanding in science that will support environmental literacy.

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Acronyms

DfEE	Department for Education and Employment
DSCF	Department for Schools, Children and Families
EE	Environmental education
ESD	Education for sustainable development
IUCN	International Union for the Conservation of Nature and Natural Resources
NC	National Curriculum
NCC	National Curriculum Council
OFSTED	Office for Standards in Education
QCA	Qualifications and Curriculum Authority
SCAA	School Curriculum and Assessment Authority
SD	Sustainable development
UNCED	United Nations Commission on Environment and Development
WCED	World Commission on Environment and Development

Chapter 1 Introduction

The purpose of this thesis is to consider if and how students in post-compulsory education draw upon their compulsory science education in a particular context whilst thinking about human interactions with their environments. This has been conducted through a case study investigating experiences drawn upon by students as they explore environmental subject matter with potential links to sustainable development and content addressed in National Curriculum science. Data for the case study were collected during and after a practical task in which students aged 16-18 years explored an environmental theme through photography. The photography project presented a practical context in which individuals might potentially draw upon any number of experiences in relation to subjects explored. Qualitative analysis of four individual case studies forms the basis of findings and discussion that detail how these students acted in this particular situation. The outcomes of the study will add to the literature examining the student experience of environmental education (EE) where there is an emphasis on compulsory science education.

1.1 Research problem

The 1988 Education Reform Act brought about the introduction of a National Curriculum for schools in England (NC) that, from the outset, included a commitment to EE as part of the wider curriculum. National Curriculum Council (NCC) guidelines on EE, published in 1990, specified that science education had a role to play in supporting the development of environmental awareness. A subsequent revision to the NC in 1995 placed science education in a unique position amongst subjects supporting EE in that it was the only one to carry required content and opportunities for study across all elements of its programme of study and in all four key stages. Thus, although geography also carried much of the required content for EE, this subject is not compulsory in key stage four.

In addition to its remit for EE, one aim of compulsory science education is to enable young people to draw upon what they learn in science to help them understand the contemporary world. So, is there any evidence to suggest that this happens? This is the focus of the thesis and the research problem is summarised as follows:

The majority of children in England experience eleven years of compulsory education that is shaped by the aims and content of the National Curriculum. Science education is a high-profile, core subject. It is also one of the disciplines identified in NC guidelines on EE as being integral to developing pupils' awareness, understanding and respect for environments. So, what happens at the end of this period? Are young people knowingly, or

otherwise, able to draw upon their experiences of compulsory science education as they explore environmental subject matter in an informal context? What are their perceptions of their experiences of NC science in relation to EE and ESD; and what, if anything, might their responses say about the contributions of compulsory science education to: (i) achieving the NC aims for EE/ESD; and (ii) facilitating scientific understanding that enables them to understand their environments and environmental issues?

This problem is considered as part of a process in which compulsory education plays a relatively short, yet intensive, role in the development of knowledge, skills and attitudes relevant to the environment and environmental issues.

1.2 Rationale

The rationale for this inquiry relates to the commitment of compulsory education to providing EE that can facilitate knowledge, skills and understanding towards a societal goal of environmental and economic sustainability in the 21st Century. Some of the earliest cohorts of pupils to have had the whole of their compulsory education steered by the NC completed their schooling in 2002 and 2003. These pupils experienced a programme of EE that, for ten years between 1990 and 2000, retained the same three-component format of education *about* the environment, education *in/through* the environment, and education *for* the environment. Revisions to the NC introduced in August 2000 marked the end of this three-component form of EE and the beginning of a programme focused firmly on the idea of Education for Sustainable Development (ESD) with the aim that the school curriculum should:

“[P]repare all pupils for the experiences and responsibilities of adult life. [] It should develop their awareness and understanding of, and respect for, the environments in which they live, and secure their commitment to sustainable development at a personal, national and global level.” (DfEE/QCA 1999a:11)

Reorienting EE towards ESD comes in response to international calls to engage the influence and resources of compulsory education in developing the knowledge, skills and understanding to allow citizens to live sustainably; and to understand and become involved in decision-making on environmental matters. The NC definition of ESD is as follows:

“Education for sustainable development enables pupils to develop the knowledge, skills and 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.” (DfEE/QCA 1999a:25)

However, whilst the purpose and direction of EE has changed, its nature and method of delivery remain the same. Both EE and ESD are cross-curricular, interdisciplinary programmes that draw upon elements of several subjects for the development of knowledge, skills and understanding. In the case of science education, this is also an intra-disciplinary process in that environmental knowledge and understanding includes interrelated aspects of biology, physics and chemistry. Yet, relatively little is understood about: (i) how students join up content from multiple subjects into a coherent understanding of human interactions with environments and other living things; and (ii) how science education is drawn upon as part of this process. To further complicate matters, a student's awareness, understanding and respect for environments might emerge from a synthesis of ideas and attitudes gained through a range of external social and cultural experiences and first-hand encounters with people and places. Thus, formal knowledge of science is not only interconnected with other formal knowledge across the curriculum, it is also assimilated into a wider worldview underpinned by a set of external life experiences that are unique to the individual. It is this process and interaction that is investigated in this study.

This is a professional doctorate in education and my interest in this research is underpinned by my experiences as a photography teacher in post-16 sixth-form education, and as an artist/photographer with a particular interest in environmental subjects. Photography coursework presents students with opportunities to examine a subject in depth over a period of weeks. It is also a particularly effective medium for facilitating practical first-hand exploration of environments. The nature of AS level photography involves gaining an understanding the subject and being able to communicate observations and insights through images supported through annotation, presentations and discussion. From a professional perspective, there are two questions that have arisen from my observations of how students carry out projects exploring environmental issues. Firstly, what do students need to know and understand in order to explore environmental subject matter with depth and insight? Secondly, what can I expect students to know and be able to do by the time they reach my classroom at the age of 16?

1.3 Contribution

Rickinson's (2001) review of the evidence base for learners and learning in EE identified three emerging foci for research as: *perceptions of nature*; *experiences of learning*; and *influences on adults*. This thesis sits within the second emergent focus of *experiences of learning* and targets the student voice on their experiences of compulsory science education as an under-researched area. This inquiry is not concerned with identifying learning outcomes, nor does it examine the intellectual processes involved in learning. Instead, it is concerned with identifying the range

and form of experiences drawn upon in relation to environmental subjects explored. As such, the case study offers an unusual window into students' experiences of compulsory science education since they were unaware of this focus until the latter stages of their post-project interview.

This thesis will be of interest to researchers and practitioners engaged in developing curriculum and practice for EE and ESD within the National Curriculum and NC science; as well as those concerned with investigating students' experiences of EE in contexts other than compulsory education. It might also be of interest to environmental organisations engaged in developing programmes of non-formal EE in liaison with schools and local communities.

1.4 Thesis framework

The central theme and outcomes of this thesis are developed through six chapters. The research problem and rationale for the inquiry have been identified in section 1.1. Theoretical perspectives relevant to developing and supporting ideas for this inquiry are examined in chapter 2. This is carried out through a review of literature on EE, ESD and science education where there is an emphasis on facilitating the understanding of science in real world contexts. The purpose of this review is to inform the development of the research questions. This is done through three sections: Section 2.1 draws on NC documents and academic and policy writing in order to identify the role of NC science in supporting EE and ESD from 1990-2000. Section 2.2 considers perspectives on problems arising from tensions between the nature and purpose of EE and the nature and purpose of compulsory education. Section 2.3 examines perspectives on what might be required to facilitate a goal of environmental literacy. It is argued that to be environmentally literate one must also be scientifically literate. Therefore, compulsory science education might better support EE/ESD through investigation of how young people draw upon their experiences of NC science in relation to their wider life experiences. The research questions are identified at the end of this section.

The design and methodology for the case study is detailed in chapter 3. The purpose of this chapter is to describe the case study design and identify the framework for the analysis. This is done in four sections: Section 3.1 presents a brief review of literature examining methodological issues relating to case study in educational research. This is followed in section 3.2 by a description of the case study design including: research site; role of researcher; rationale for choosing a photography project as the informal context for the research task; and details of the data sources and data collection. The process of sample selection is described in section 3.3. Section 3.4 presents the framework for the qualitative analysis of four individual case studies.

This section opens in 3.4.1 with details of the process of data reduction and is followed in 3.4.2 by the individual case study framework. This shows how existing studies are drawn upon to inform the initial categories for analysis and how the research questions are used to form the basis of a common structure for reporting the findings.

Chapter 4 presents the four individual case studies. Each case study narrative details the student's practical exploration of their chosen subject followed by the main subjects discussed in the interview. Summaries of data identified from the case study narrative are presented in Appendix 3.1-3.4. These data are drawn upon to identify findings in relation to the research questions (RQ1 and RQ2). The case study findings are then examined in relation to evidence in the narrative and any other factors that might have affected how individuals have responded in this particular instance. The case study conclusion considers: (i) if and how this student has drawn upon their experiences of compulsory science education in this context; and (ii) what, if anything, this case study says about how NC science has fulfilled its remit to support EE/ESD.

Chapter 5 draws together the findings from each individual case study into a summary and discussion of outcomes across the sample. Tables summarising data from the individual case studies are presented in Appendix 3.5. These data support the identification of the case study outcomes as a whole. Section 5.1 identifies the main findings of the case study for RQ1. Section 5.2 identifies the main findings of the case study for RQ2. This is followed by a general discussion of these outcomes in relation to literature reviewed in chapter 2.

Chapter 6 sets the case study outcomes in context of the research problem and considers what claims can, and cannot, be made from this inquiry. The three questions posed by the research problem, identified in section 1.1, serve as the guiding framework for section 6.1. On establishing how students have drawn upon their experiences of compulsory science education in this informal context, this section goes on to consider the implications of student actions for compulsory science education where there is an emphasis on EE/ESD – especially, what might be said about the contribution of school science to facilitating environmental literacy. This is followed in section 6.2 by an evaluation of the strengths and weakness of the case study design. The thesis concludes in section 6.3 by considering the outcomes of this inquiry in terms of highlighting areas for further research.

The main ideas to be developed in each chapter are detailed in an italicised introduction to the chapter and, where appropriate to assisting the reader, at the beginning of a section.

Chapter 2 Literature review

The purpose of this chapter is to examine perspectives on the role of compulsory science education in supporting EE and ESD with a view to informing the research questions for the case study. This is carried out through a review of: (i) academic and policy writing relating to the National Curriculum for schools in England from 1990-2000; and (ii) wider bodies of literature examining aspects of science education, EE, sustainable development and ESD. These bodies of literature are extensive and there is not space within this thesis to do justice to each one on an individual basis. Therefore, a synthesis of key ideas is drawn upon to support the development of the following points:

- 1. International debate and policy on the purpose and direction of EE from 1972-1992 is reflected in the NC frameworks for schools in England. Section 2.1 opens with a timeline of international developments in EE from 1972-1992 which details the progress of EE towards sustainable development (SD). This is drawn upon to show how international policy on EE is reflected in the NC frameworks for EE from 1990-2000. These frameworks are relevant to developing ideas for this inquiry because the research sample is drawn from an AS level photography cohort whose experiences of compulsory education took place between the years 1991 and 2003.*
- 2. The nature of and purpose of EE/ESD together with its low curriculum status in the NC, hold implications for the way compulsory science education contributes to EE/ESD.*
- 3. If the ultimate goal of EE is environmental literacy, then there is a need to recognise that everyday encounters with environments and environmental issues transcend experiences of compulsory science education. Therefore, an individual's formal knowledge of science might interact with, influence, and/or be influenced by, a range of other awareness, attitudes and values stemming from their wider life experiences. Therefore, it is argued that compulsory science education might better support EE and ESD through understanding how students draw upon their experiences of NC Science in relation to the other experiences that shape the way they think about human interactions with their environments.*

This chapter concludes with the development of the research questions for this inquiry.

2.1 Identifying the role of NC Science in supporting EE and ESD

The history and development of frameworks and rationales for EE are widely documented (e.g., Sterling 1992; Palmer 1998; McKeown and Hopkins 2003) and there is consensus that the timeline for the development of international goals, guidelines and policies on EE centres on the following six significant landmark events and their reports:

- 1972: UN Conference on the Human Environment held in Stockholm, Sweden.
- 1975: UNESCO/UNEP International Workshop on Environmental Education held in Belgrade, Yugoslavia and its report *The Belgrade Charter*.
- 1977: UNESCO First Inter-governmental Conference on Environmental Education held in Tbilisi, USSR and its report *The Tbilisi Declaration*.
- 1980: IUCN/UNEP/WWF *World Conservation Strategy*.
- 1987: World Commission on Environment and Development (WCED) and its report *Our Common Future* (also known as the *Brundtland Report*).
- 1992: UN Conference on Environment and Development (Earth Summit) held in Rio de Janeiro, Brazil and its two reports *Agenda 21* and the *Rio Declaration*.

According to McKeown and Hopkins (2003) the Stockholm conference evoked a spirit of environmental protection and concern relating to resource use and management that influenced the subsequent outcomes of Belgrade and Tbilisi. The *Belgrade Charter* (UNESCO/UNEP 1975) contained three goals for EE that were subsequently reinforced in the *Tbilisi Declaration* (UNESCO 1977). These goals were:

- to foster clear awareness of and concern about economic, social, political, and ecological interdependence in urban and rural areas;
- to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;
- to create new patterns of behaviour of individuals, groups and society as a whole towards the environment.

According to Palmer (1998:11), the goals and principles of the *Tbilisi Declaration* were ‘carried forward into and underpin the content of preliminary papers and final documentation in the National Curriculum for schools in England’. The principles of *Tbilisi Recommendation 2* characterise the nature of EE as:

- a lifelong process;
- interdisciplinary and holistic in nature;
- an approach to education as a whole, rather than a subject;

- concerned with the interrelationship and interconnectedness between human and natural systems;
- viewing the environment in its entirety including social, political, economic, technological, moral, aesthetic and spiritual aspects.

The NC description and aims for EE are shown in Table 1 on page 9. Firstly, it can be seen that the aims for EE reflect the Tbilisi goals of EE. Secondly, the description of EE, plus its inclusion in the NC framework as one of five interrelated cross-curricular themes, reflects the Tbilisi principles for EE. Thus, the influence of Tbilisi on the NC is manifest in both its purpose and nature. National Curriculum Council (NCC) guidelines on EE, published in 1990, indicate that EE was closely linked to four other themes of: *economic and industrial understanding*; *health education*; *careers education and guidance*; *education for citizenship*. Particular emphasis was placed on links to *education for citizenship* and *economic and industrial understanding* on the grounds that the former ‘introduces pupils to political processes and encourages them to take on social responsibility’ and the latter ‘is of particular importance in making decisions about environmental issues’ (NCC 1990:3). Table 1 (on page 9) shows that EE is framed in terms of three linked components: education *about* the environment (knowledge); education *for* the environment (values, attitudes and positive action); education *in/through* the environment (a resource). It is specified that these components are interrelated and that ‘as part of planning teachers should help pupils make the connections’ (NCC 1990:4).

Whilst indicating that all subjects should be involved in developing education *about* the environment, the NCC guidelines single out geography, science, technology and history as being ‘particularly relevant’ to this process (NCC 1990:4). At this time there were seventeen NC attainment targets for science education and nine of these were identified as being ‘particularly relevant’ to education *about* the environment. Opportunities for EE were identified in: AT1 *Exploration of science*; AT2 *The variety of life*; AT3 *Processes of life*; AT5 *Human influences on the earth*; AT6 *Types and uses of materials*; AT8 *Explaining how materials behave*; AT9 *Earth and atmosphere*; AT13 *Energy*; and AT17 *The nature of science* (ibid. p.5). In contrast, education *for* the environment is described in much more general terms as a whole curriculum drive to highlight ‘physical, geographical, biological, sociological, economic, political, technological, aesthetic, ethical and spiritual’ considerations. History, geography and religious education are mentioned as being particularly important in ‘helping pupils to clarify their values towards the environment’ (ibid. p.6). Subjects lending themselves to fieldwork and outdoor education are mentioned as being particularly relevant to education *in/through* the environment (ibid. p.7).

Table 1: The shape of EE in the NC for schools in England from 1990-1995	
Description	NC aims for EE
<p>Environmental education can be thought of as comprising three linked components:</p> <ul style="list-style-type: none"> ▪ education <i>about</i> the environment [knowledge] ▪ education <i>for</i> the environment [values, attitudes and positive action] ▪ education <i>in/through</i> the environment [the environment as a resource] <p>These contribute to planning in different ways. They are interrelated and as part of planning teachers should help pupils make the connections.</p> <p>All subjects in the curriculum have an individual contribution to make in developing environmental education and in its turn environmental education enriches and brings new perspectives to those subjects.</p>	<ul style="list-style-type: none"> ▪ To provide opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment. ▪ To encourage pupils to examine and interpret the environment from a variety of perspectives – physical, geographical, biological, sociological, economic, political, technological, historic, aesthetic, ethical and spiritual. ▪ To arouse pupils’ awareness and curiosity about the environment and encourage active participation in resolving environmental concerns <p>The long term aims of environmental education are to improve the management of the environment and promote satisfactory solutions to environmental issues.</p>

Table 2: The shape of EE in the NC for schools in England from 1995-1999	
Description	NC aims for EE
<p>Education <i>about</i> the environment involves developing a sound knowledge base to enable students to make sense of environmental issues.</p> <p>Education <i>in</i> the environment involves exploring environments through first-hand experiences. Education <i>through</i> the environment uses first-hand and secondary experiences as a stimulus for learning a wide range of skills.</p> <p>Education <i>for</i> the environment involves developing informed concern about, and encouraging sensitive use of, the environment with an emphasis on sustainable solutions to problems and recognising the conflicting interests and different perspectives that inform choices made.</p>	<ul style="list-style-type: none"> ▪ To provide all pupils with opportunities to acquire the knowledge, understanding and skills required to engage effectively with environmental issues, including those of sustainable development. ▪ To encourage pupils to examine and interpret the environment from a variety of perspectives – physical, geographical, biological, sociological, economic, political, technological, historic, aesthetic, ethical and spiritual. ▪ To arouse pupils’ awareness and curiosity about the environment and encourage active participation in resolving environmental concerns.

From this, it can be seen that the NC remit for compulsory science education at this time is largely in the form of providing education *about* the environment. This is a broad education in that it includes biology, physics, chemistry and earth science. It also specifically takes into account human influences on the earth. There is also some scope for science education to facilitate EE in the form of education *in/through* the environment through fieldwork and the use of secondary sources of environmental information. However, it is not specifically named in connection to developing environmental values and attitudes in the form of education *for* the environment.

The first major revision to the NC took place in 1995. This included changes to both science education and EE. The science education attainment targets were reduced to four: *Experimental and investigative Science; Life process and living things; Materials and their properties; Physical processes*; with five cross-disciplinary requirements: *Systematic enquiry; Application of science; Science in everyday life; The nature of scientific ideas; Communication; Health and safety* (DfEE 1995). EE was revised to include a focus on SD (SCAA/QCA 1996). This shift towards SD is now explained by referring back to the timeline on page 7. The term ‘sustainable development’ first entered the international forum through the World Conservation Strategy (WCS) in 1980. The WCS held three objectives:

- essential ecological processes and life-support systems must be maintained;
- genetic diversity must be preserved;
- any use of species or ecosystems must be sustainable (IUCN 1980).

However, this strategy was criticised as being ‘anti-development in that it stressed sustainability in terms of ecological terms and was concerned to a far lesser extent with economic development’ (Palmer 1998:61). Therefore, the World Commission on Environment and Development report *Our Common Future* (WCED 1987) is widely acknowledged as the seminal report for setting out the contemporary agenda for SD. The WCED definition for SD is:

“[D]evelopment that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED 1987: 43)

Our Common Future highlights the importance of education in raising the awareness, skills and behaviours to facilitate SD. Yet, it does not contain any specific goals for ESD. These goals came five years later in light of the United Nations Conference on Environment and Development and the publication of *Agenda 21* (UNCED 1992). *Agenda 21* has a chapter dedicated to the promotion of education, public awareness and training, and identifies three areas for action as: *reorienting education towards sustainable development; increasing public*

awareness; promoting training. The basis for action in reorienting education towards SD includes references to both formal and non-formal education and, as part of the proposed activities, governments are urged to, ‘strive to update or prepare strategies aimed at integrating environment and development as a cross-cutting issue into education at all levels within the next three years’ (*Agenda 21:36 (36.5b) UNCED 1992*).

Table 2 (on page 9) illustrates how the UK government’s response to *Agenda 21* is reflected in the first NC aim for EE which has been revised to include an emphasis on SD. The other aims remain unchanged. NC guidelines for EE were detailed in a separate publication: *Teaching Environmental Matters through the National Curriculum (SCAA/QCA 1996)*. This document is more detailed than its predecessor and sets out ‘required coverage’ and ‘opportunities’ for EE within geography, science education, and design and technology. The required coverage for science education includes content in each attainment target, and contains a breadth of learning relating to science and society, ecology, earth science, values, energy and human impact on the environment. At this time, science education is the only NC subject to carry required content for EE in all attainment targets and across all four key stages. It also carries proportionately more content than geography which is the other main subject allocated a substantial NC remit to support EE. However, in spite of an increased curriculum emphasis on SD, there are no specific references to SD as part of the required coverage in science education at this time.

The three-component framework for EE with some focus on SD was succeeded in 2000 by a new framework for ESD. Table 3 shows that the NC aim for ESD reflects the influence of *Our Common Future* (WCED 1987) and that its single aim is firmly action-oriented, i.e., educating *for SD* with a particular drive to ‘secure [pupils’] commitment to SD at a personal, national and global level’ (DfEE/QCA 1999a:25).

Table 3: the shape of EE in the NC for schools in England from 2000	
Description	NC aim
ESD enables pupils to develop the knowledge, skills and 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.	The school curriculum should develop pupils’ awareness and understanding of, and respect for, the environments in which they live, and secure their commitment to sustainable development at a personal, national and global level.

ESD in the NC is rooted in both EE and Development education (QCA 2006). Development education - a trend during the 1980s - progressed from highlighting issues affecting certain

developing countries, to a later focus on aspects that included ‘understanding the level of development in a particular country, necessitating a study of global economic and political systems [and] understanding development processes within and between all countries, rich and poor’ (Palmer 1998:28). Thus, it appears that ESD is different from EE. Yet, it occupies the same curriculum position. It also draws on a similar named subject base (including geography and science) for the development of knowledge, skills and understanding. The notable addition is citizenship as a new NC subject statutory in key stages 3 and 4 from 2002. The NC science subject booklet indicates how science education can contribute to *Learning across the curriculum (ESD)* 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.” (DfEE/QCA 1999b:9)

Yet, seemingly at odds with this statement, there is only strand of required content for SD within the science programme of study. This occurs in *Life processes and living things* within the theme of *Adaptation and Competition*. This strand indicates that pupils should be taught ‘about the importance of sustainable development’ (DfEE/QCA 1999b: KS3 p.31; KS4 p.50). There are no references to SD in key stages 1 or 2. Information in the programme of study indicating opportunities for ICT and links to other subjects do not indicate opportunities for *Learning across the curriculum*. Qualifications and Curriculum Authority (QCA) guidelines published online in 2002 described ESD in terms of seven interrelated key concepts: *Interdependence; Citizenship and stewardship; Needs and rights of future generations; Diversity; Quality of life; Sustainable change; Uncertainty and precaution*. Some science content is embedded in the descriptors for *Interdependence; Diversity; Uncertainty and precaution; and Sustainable change*. However, this is minimal compared to the previous required content in support of EE.

The timing of the release of the guidelines on ESD means that it is unlikely that any student participating in this research will be familiar with the seven key concepts of ESD. It is also unlikely that any student will associate learning relating to SD with their experiences of NC science since, as previously indicated, there was no remit for science to respond to SD in the 1995 programme of study. However, based on the required coverage for EE from 1990-1999, it is reasonable to expect that students at the end of their compulsory education would be equipped to draw upon content from each discipline of science education in relation to environmental subject matter explored. There are, however, problems with this that will now be examined.

2.2 Problems arising from the nature and purpose of EE

The problem of EE is encapsulated in Gayford's (1996:2) observation:

“[I]t is generally accepted throughout society and by governments, that environmental education is an essential requirement for the future survival of humanity, and therefore should be treated as a central concern for all areas of education. The call has been for both a more environmentally literate workforce and a more environmentally aware public. [...] An important question must be that, with all this support, why is environmental education not being followed through energetically in schools, colleges and in non-formal contexts all over the world?”

Gayford goes on to suggest that many of the problems faced by environmental educators stem from issues such as lack of agreed definition and conflicting views on the nature and purpose of EE. Issues surrounding the definitions and meanings applied to EE and ESD are addressed by authors including: Hart 1981; Gayford 1996; Wals 1998; Gough 2002; Reid 2002; Stables 2001. However, there is no clear-cut, one-solution-fits-all, definition. SD in particular, is a difficult concept to pin down because its definition and goals are dependent upon whether the underlying rationale is economic or environmental. The implications of trying to balance finite environmental resources against economic growth theory are summarised by Bonnett (2002:11): Firstly, he suggests that the problem with ESD relates to the goal of SD itself.

“By seeming to combine the highly desired goal of development with the equally highly desired goal of conservation of valuable things endangered, it is liable to be set up as a goal which is so obviously attractive as to divert attention from its problematic nature.”

He then identifies three sets of issues that he believes undermine the idea of SD:

- *Semantic*: It is possible for a society to simply to interpret the term in ways that are congenial to it. (See also Stables 2001; Stevenson 2007b).
- *Ethical*: Varying assumptions are being made about the rights and duties of humankind to the rest of nature and, for example, whether any such underlying ethic should be anthropocentric, bio-centric, or something else. (See also Attfield 2003; Armstrong and Botzler 2004).
- *Epistemological*: Given the high degrees of complexity of the natural and social systems [...] and our current imperfect state of knowledge about them, how are we to judge which actions will positively contribute to sustainable development?

Gayford (1996:2) argues that conflicting views on the nature and purpose of EE are more complex and problematic because: (i) the theoretical foundation of EE lies within both environmentalism and education; and (ii) to understand and engage with the complexity of environmental issues requires holistic thinking and methods of working that are at odds with the nature and purpose of compulsory education. Taking these points separately:

2.2.1 Environmentalism

Theoretical perspectives on environmentalism are complex and have been covered in depth by authors including O’Riordan 1981; 1988; Huckle 1983; 1990; Devall and Sessions 1985; Pepper 1996; Turner 1988. A simple characterisation and comparison of interpretations of the terms ‘deep’ and ‘shallow’ ecology (Naess 1973) is shown in Table 4. This summary is based on Palmer’s (1998) overview of the main issues.

Table 4: Characterisations of deep and shallow ecology	
Deep Ecology [<i>ecocentrism</i>]	Shallow Ecology [<i>technocentrism</i>]
Rejects the view of humans and nature as separate and different.	Supports the view that humans and nature are separate and different.
Holds the belief that humans are intimately a part of the natural environment and are at <i>one</i> with nature.	Holds the belief that humans can dominate the world around them.
Opposes anthropocentrism and focuses on the need for individual changes of attitudes, values and lifestyles to emphasise respect for, and peaceful cooperation with nature.	Upholds anthropocentrism and the <i>sole value assumption</i> that only the value of humanity and human concerns are recognised.

O’Riordan (1988) identified a basic distinction between deep and shallow ecology as ‘ecocentrism’ and ‘technocentrism’. Ecocentrism is biocentric in nature in that it ‘sees humankind as part of a global ecosystem, subject to ecological laws’ (Palmer1998:88). In contrast, technocentrism is anthropocentric in nature, i.e., it is human-centred and focused on human needs. Thus, whilst supporters of ecocentrism: (i) hold a sense of respect for nature in its own right, as well as for pragmatic reasons; and (ii) lack faith in modern, large-scale technology; someone with a technocentric worldview recognises environmental problems, yet believes that: (i) our current form of society will always solve them and achieve unlimited growth; or (ii) that environmental problems can be negotiated by careful economic and environmental management (Pepper 1996). So, how does this impact on compulsory education?

The answer to this relates to the purpose of education. The opening NC statement on values and purposes underpinning the school curriculum states:

‘Education influences and reflects the values of society and the kind of society we want it to be’ (DfEE/QCA 1999:10).

Thus, it depends whether the values of society are shaped by ecocentric or technocentric viewpoints. Technocentrism advocates modification of public attitudes towards the environment, whilst maintaining the status quo in existing structures of political and economic power (O’ Riordan 1988). In contrast, ecocentrism seeks a more radical review of the way society is organised and demands policy change towards conservation as the sole basis for defining criteria relating to the use of natural resources (Palmer 1998). In short, technocentrism with its emphasis on sustained economic growth makes more sense for developed countries where the stakeholders hold a vested interest in maintaining the status quo in existing systems. In effect, it becomes a safer political option to reorient action (and formal education) towards SD and invest in developing new technologies in the hope they will solve the environmental problems.

Another issue arises when proposed solutions to problems are perpetually labelled as complex and contested. Much valuable time is then spent debating possible ways forward. This is perhaps no bad thing in that, in order to address a problem one has to first to understand it. Yet, authors such as Orr (1992) and Brown (2006) argue that the environmental crisis is now so imminent that there is no longer time to bury action on disagreeable solutions in the debates examining the possibilities. Therefore, a sensible compromise appears to be Stables’ (2001:123) view that ‘we should look to clarify the use of terms such as ‘sustainable development’ in the contexts in which they appear, rather than to seek for some incontestable meaning for them ‘out there’.

2.2.2 The nature and purpose of compulsory education

The nature of and purpose EE have been previously identified in 2.1 (on pages 7-8). Differences in the nature and purpose of EE and the National Curriculum are now illustrated in Tables 5a and 5b (on pages 16-17). From these illustrations, it can be seen that the holistic, interdisciplinary and socially-oriented nature of EE is at odds with the unitary, subject-specific, assessment-driven NC framework. Some of the deeper issues underpinning this disparity will now be examined, beginning with Stevenson’s (2007a) perspectives on contradictions in purpose and practice between compulsory education and EE. First published in 1987, these

views are still relevant today. Stevenson identifies four potential barriers to achieving critical and action-oriented EE:

- the social and cultural purpose of schooling;
- curriculum and pedagogical practices;
- school organisation and the need for order;
- teachers' curriculum and pedagogical ideologies (ibid.)

Table 5a: Comparing the nature of EE with the nature of the NC

Environmental education is:

- a lifelong process;
- interdisciplinary and holistic in nature;
- an approach to education as a whole, rather than a subject;
- concerned with the interrelationship and interconnectedness between human and natural systems;
- concerned with viewing the environment in its entirety including social, political, economic, technological, moral, aesthetic and spiritual aspects.

The National Curriculum is:

- compulsory for children aged 5-16 years;
- structured through a statutory framework that contains statutory programmes of study for twelve subjects with 3 core subjects [English, Mathematics and Science];
- designed to facilitate the teaching of formal knowledge to large numbers of pupils, in large class sizes, across four key stages;
- formally assessed at the end of each key stage.

Learning across the curriculum includes:

- spiritual, moral, social and cultural development;
- personal, social and health education;
- key skills;
- other aspects of the school curriculum [the current location of ESD].

Learning across the curriculum is not formally assessed.

NC science education is:

- compulsory for children aged 5-16 years;
- a 3-discipline subject divided into 4 attainment targets that set out the knowledge, skills and understanding that pupils are expected to learn by the end of each key stage;
- influenced by eight level descriptions which describe the type and range of performance that pupils working at that level should characteristically demonstrate in key stages 1-3;
- formally assessed at the end of each key stage;
- a subject identified in *learning across the curriculum* as being relevant to ESD.

NC content directly related to ESD is minimal.

Pupil's progress and understanding relating to ESD is not formally assessed.

Table 5b: Comparing the purpose of EE with the purpose of the NC
<p><i>Environmental education objectives are:</i></p> <ul style="list-style-type: none"> ▪ <i>Awareness:</i> to help acquire an awareness and sensitivity to the total environment and its allied problems. ▪ <i>Knowledge:</i> to help gain a variety of experience in, and acquire a basic understanding of, the environment and its associated problems. ▪ <i>Attitudes:</i> to help acquire a set of values and feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection. ▪ <i>Skills:</i> to help acquire the skills for identifying and solving environmental problems. ▪ <i>Participation:</i> to provide an opportunity to be actively involved at all levels in working toward resolution of environmental problems.
<p><i>The National Curriculum:</i></p> <p>Responds to, reflects and influences the common values and purposes of society.</p> <p><i>2 broad aims:</i></p> <ul style="list-style-type: none"> i to promote the spiritual, moral, cultural, mental and physical development of pupils at the school and of society; ii to prepare pupils for the opportunities, responsibilities and experiences of adult life. <p><i>4 main purposes:</i></p> <ul style="list-style-type: none"> i to establish an entitlement to learning; ii to establish standards; iii to promote continuity and coherence in learning; iv to promote public understanding.
<p><i>NC science education:</i></p> <p>Responds to and supports the aims and purposes of the National Curriculum through delivering the programme of study for science and contributing where appropriate to <i>Learning across the National Curriculum</i>.</p>

Stevenson (ibid. p.146) suggests that the present day education system has evolved from nineteenth century institutions designed to transmit basic information to enable the practice of routine skills, and to maintain existing social conditions and relations. As such, this system was never intended to develop critical thinkers, social inquirers, problem solvers, or active participants in decision making. Thus, he indicates that, whilst an EE curriculum should be interdisciplinary, with content arising out of engagement with specific environmental problems, school curricula are discipline-based and most are predefined since they are designed to serve specific ends that can be readily assessed.

Palmer (1998:267) offers two additional reasons why ESD in particular poses questions for curriculum and practice: Firstly, ESD has the task of addressing 'an extremely wide-ranging and bewildering array of content'. Secondly, this content is:

- dynamic and ever-changing;
- characterised by highly complex interrelationships, priority problem causes, impacts and solutions;
- highly value-laden in that one person's solution may be another's catastrophe.

So, how and why should this hold implications for science education? The answer to this lies in the historical links between science education and EE. EE has its roots in natural history, and science is described by Shamos (1995:46) as 'our formal contact with nature'. Therefore, science education, as the study of the natural world, is well placed to support EE of this type. However, once the goals of EE were reconceptualised to include social issues, differing views on the relationship between EE and science education emerged (Gough 2002). According to Shamos (1995), the nature of science education in schools reflects a predominantly 19th Century conceptualisation of science as 'truth' based on an investigative method that is rational and objective. The purpose of the science curriculum was, and to a large extent still is, geared towards educating the relatively small population of students who will eventually become professional scientists in a particular specialist field (*ibid.*). As such, science education was/is not designed to prepare young people to understand science as it occurs in contexts where they are most likely to encounter it, i.e., in everyday situations. Vongalis-Macrow (2007:6) observes that 'the way scientific knowledge is taught to students and then how this knowledge is made 'messy' when transferred into real case situations presents a conundrum'. In addition to this, science education is not readily associated with the development of values, and historically has not engaged with social applications of science. Yet, according to Grace and Ratcliffe (2002:1167) 'science and values are closely connected in the human mind' and their research with pupils aged 15-16 found that: (i) pupils appear to prioritise values in decisions on conservation issues; and (ii) their use of values and scientific concepts is context-dependent. Thus, it becomes clear from all this that many issues must be resolved if science education is to achieve the NC aim to 'prepare all pupils for the opportunities, responsibilities and experiences of adult life' (DfEE/QCA 1999a:11).

Enabling young people to draw upon what they learn in science to help them understand the contemporary world is compatible with the rationale for scientific literacy (for detailed accounts of scientific literacy see Shamos 1995; Hurd 1998; Laugksch 2000). Hurd (1998:412) suggests that, if science education is to contribute effectively to the public understanding of science, 'the

curriculum sought is one that prepares students to cope with the changes influencing human welfare'. This, he believes 'requires a lived curriculum and a range of thinking skills related to the proper utilisation of science/technology information' (ibid. p.414). Authors such as Thomas and Durant (1987) and Millar (1996) state economic, utilitarian, cultural, social, democratic arguments for promoting scientific literacy as a vehicle to public understanding of science. This is relevant to EE in that science education is vital in teaching the science concepts that underpin environmental issues that might potentially facilitate pro-environmental behaviours (Littledyke 2008). This, of course, depends on what counts as pro-environmental behaviours. However, this debate aside, the curriculum structure and pedagogy of NC science complicates efforts to facilitate scientific literacy because, not only is NC science a discrete curriculum subject, it also contains its own discrete fields. Thus, to approach cross-curricular EE/ESD, both teacher and student require not only an interdisciplinary understanding of how science education interacts with other curriculum subjects, but also an intra-disciplinary understanding of science itself.

Finally, some authors argue that the current formal curriculum and pedagogy are inconsistent with what really needs to be done in terms of understanding human interrelationships with environments and other living things. Kwong (1997:87) for example, argues that educating *for* the environment simply results in 'an education campaign aimed at turning schoolchildren into environmentalists'. She suggests that some problems in facilitating student understanding of environmental issues stem from a belief that environmentalism leads to environmental literacy. However, in her view, this produces slogan-based environmentalism in schools, rather than an education that provides appropriate awareness and understanding of the environment that includes a sound knowledge of science and economics (ibid). Orr (1994:5-7) goes a step further and suggests that many causes of environmental decline are, in reality, 'not the work of ignorant people' but of highly educated, successful individuals. Thus, it is his view that, 'without significant precautions, education can equip people merely to be more effective vandals of the earth' (ibid.). He expands on this by stating:

“[A]ll education is environmental education. By what is included or excluded, students are taught that they are part of or apart from the natural world. To teach economics, for example, without reference to the laws of thermodynamics or ecology is to teach a fundamentally important ecological lesson: that physics and ecology have nothing to do with the economy. It just happens to be dead wrong.” Orr (1994:12)

As such, Orr argues that it is not *more* education that is required, but the right kind of education. So, what constitutes the 'right kind' of education and what is the role of science education in supporting this?

2.3 The right kind of education?

According to Disinger and Roth (1992:1), ‘the bottom-line goal’ of EE is to create environmentally literate citizenry. Yet, what does this mean in practice and is this feasible given the mismatch between curriculum and practice highlighted in the previous section? Roth (1992:14), as the originator of the term, defines environmental literacy as involving ‘human discourse about inter-relationships with the environment’ and states:

“It is essentially the degree of our capacity to perceive and interpret the relative health of environmental systems and to take appropriate action to maintain, restore, or improve the health of those systems.

This is a statement of intent. Yet, what is ‘appropriate action’ and what would be needed to facilitate this? Roth continues his definition:

“Environmental literacy should be defined likewise in terms of observable behaviours. That is, people should be able to demonstrate in some observable form what they have learned – their knowledge of key concepts, skills acquired, disposition towards issues, and the like.” (Ibid.)

Littledyke (2008:11) suggests a need for ‘curriculum integration to demonstrate complex interactive environmental effects [and that] central features of this approach would be to develop scientific understanding of key concepts that show how features of the universe are deeply interrelated’. Thus, from this, it is assumed that in order to be environmentally literate one must also be scientifically literate. Yet, Roth (1992) suggests that environmental literacy extends beyond aspects of scientific literacy in that it also includes aspects of economic literacy, geography literacy and an historical understanding of how various issues came to be. Brown (2006) concurs and, in particular, believes that much can be learned about the consequences of human impacts on environments through the historical study of environmental factors associated with the demise of ancient civilizations. He also suggests that lessons can be learned from the speed with which societal restructuring and the redistribution of resources was mobilised by the USA government in World War II - his point being that social restructuring within a short timescale is possible and not unprecedented.

An additional way of thinking about approaches to EE relates to the interconnectedness of systems (Orr 1992; Capra 2002; Colucci-Gray 2006). Orr (1992:92) believes that nothing less than ecological literacy is required to facilitate sustainability, and that to be ecologically literate ‘implies a broad understanding of how people and societies relate to each other and to natural

systems, and how they might do so sustainably [and that this] presumes both an awareness of the interrelatedness of life and knowledge of how the world works as a physical system'. He goes on to suggest that the basis for ecological literacy 'is the comprehension of the interrelatedness of life grounded in the study of natural history, ecology and thermodynamics' (ibid. p.93). Yet, the essential problem of EE relates back to Gayford's (1996) observation cited at the beginning of section 2.2. If EE is seen as central to the future survival of humanity, then why is it not being followed through energetically in schools? The root of this appears to lie in the purpose and priorities of the National Curriculum. For example, it was shown in 2.1 that EE/ESD is included as part of the wider, as opposed to statutory, curriculum. Therefore, whilst disciplines are obliged to respond to required content for EE/ESD identified in their particular programme of study, there is no statutory requirement for schools to plan cross-curricular learning to facilitate pupil understanding of how knowledge and skills from different disciplines interconnect in real world contexts. An additional barrier is that the outcomes of EE/ESD are not formally assessed. Yet, Orr (1992:89) believes the problem runs much deeper than this and criticises a system where ideas 'originate at the top of society [and] are passed down to a passive citizenry in the form of laws, policies and technologies'. He argues that, 'since there is no particular need for an ecologically literate and ecologically competent public, EE is most often regarded as an extra in the curriculum, not as a core requirement or as an aspect pervading the entire educational process' (ibid.). Orr's solution is to reorient education towards facilitating 'ecologically proficient' minds which, he argues, calls for a redesign of education itself to place EE at the core of the curriculum. Yet, this thesis is not concerned with debating the restructuring of compulsory education. Instead, it is concerned with investigating how we might work more effectively to support EE/ESD within existing structures. Therefore, the first thing to consider is what pupils at the age of 16 might be expected to know at the end of their compulsory science education, and then how they might draw upon this formal knowledge in an informal context.

2.3.1 Development of research questions

"It is a clearly stated goal of school science education that young people should be able to use the science knowledge that they acquire in school in the various facets of their future lives, whether as workers, parents, carers or as citizens." (Driver *et al* 1996:137)

It is inevitable that young people will interact with their environments, and it is likely that all will encounter and engage with environmental issues at some stage in their lives. So, from the literature reviewed, there appears to be consensus that formal knowledge of natural systems underpinned by science relating to ecology, energy transfer, energy conservation and earth science, would be desirable, if not essential, to facilitating environmental literacy. In addition to

this, pupils should understand human social, cultural, economic, political, and values systems and the way these relate to, and are interdependent with, natural systems. Finally, there is a need to enable pupils to understand ways in which these elements come together in real life situations. Yet, how might we measure environmental literacy? Roth (1992:9) identifies three dimensions of environmental literacy as *nominal*, *functional* and *operational* and describes an individual achieving functional environmental literacy as one who is:

- developing a broad knowledge and understanding of the nature of, and interactions between, human social systems and other natural systems;
- able to analyse, synthesise and evaluate information using primary and secondary sources;
- able to evaluate issues on the basis of sound evidence and personal values and ethics.

One question arising from this appears to be: Why doesn't compulsory education facilitate environmental literacy? Yet, perhaps this question should be reframed as: Do pupils achieve some level of functional scientific and environmental literacy by the time they reach the age of 16 and, if so, what shape does this take? It is clear from issues examined in this review that NC science is not in a position to equip all pupils with all the knowledge and skills they might potentially need to engage with all environmental issues they might potentially encounter as adults. So, what might be possible within the present structures for compulsory education, and what do we need to know in order to inform this? The NC remit for science education in support of EE/ESD from 1990-2000 was identified in 2.1. However, this only indicates what pupils must learn. It says little about how pupils could be taught to join together formal knowledge into a coherent understanding of environments and environmental issues. There is also a world outside school and there is a disparate literature examining aspects of how science education interacts with external life experiences. This includes:

- Relationships between formal and informal learning in science (Lucas 1981; 1983; Maarschalk 1988; Tamir 1991; Gerber *et al* 2001; Osborne and Dillon 2007).
- Nonformal environmental learning including *self-directed learning* (Mocker and Spear 1982; Heimlich 1993) and *free-choice learning* (Falk 2005; Heimlich 2005; Kola-Olusanya 2005).
- Primary children's views on science and environmental issues (Littledyke 2004).
- How students draw upon science in relation to complex socio-scientific issues (Ratcliffe 1997; Grace and Ratcliffe 2002; Ratcliffe and Grace 2003; Ekborg 2003).
- Influences on the development of environmental knowledge and pro-environmental behaviours (Hillcote *et al* 1995; Connell *et al* 1999).
- Significant life experiences (Tanner 1980; Palmer and Suggate 1996; Chawla 1998).

Tanner's seminal ideas on Significant Life Experiences (SLE) emerged during the 1960s. These ideas, based on his casual talks with conservationists, were rooted in his observation that there appeared to be a pattern of childhood influences that underpinned pro-environmental behaviours (Tanner1998:419). Palmer and Suggate's (1996) quantitative study on SLE built on Tanner's work. They carried out studies investigating experiences influencing the pro-environmental behaviours of educators in the UK and identified the following experiences in the Under 30 age group (n=54) ranked from highest to lowest numbers of responses:

- *education* [secondary; tertiary]
- *people* [family; older friends]
- *media* [TV, books, papers]
- *outdoor* [childhood experiences of nature]; *organisations* [Greenpeace; CND]
- *negative* [media coverage of environmental disasters]
- *travel; other sources* [not-specified]
- *work*
- *religion;*
- *pets; having children*

In a later work, Chawla (1998:380) observes that, whilst most research on SLE reveals things about exchanges with physical environments (i.e., influential people and places), less is known about the internal environment (i.e., needs, emotions and interests) and how this influences children's responses to these people and places (ibid.). In an unrelated study, Kyburz-Graber (2000:2) observes that, 'we receive most of our information on environmental changes through the media, which influences our opinions [and that] we filter out that information and those interpretations which fit in with our own personal views'. So, does a similar process of filtration apply to scientific knowledge drawn upon in informal contexts? Ekborg's (2003) study on how student teachers (n=15) use scientific conceptions to discuss a complex environmental issue provides useful insight into how external factors such as personal opinions, values and economic awareness can interact with conceptual understanding in science. Ekborg observed that students found science concepts more difficult to apply in unstructured discussion and that they demonstrated a limited ability to draw on science when discussing and arguing a complex environmental issue. She identified two problems: (i) although students learnt science in a context, they did not learn the concepts well enough to draw on their understanding in unstructured discussion; and (ii) the teaching did not treat the linkages between scientific and non-scientific aspects and therefore, students found it difficult to make the connections.

Other studies examining relationships between science education and EE include Littleddyke's (2004) case study examining English primary children's (n=138) views on science and environmental issues. Experiences related to the development of children's environmental cognitive and moral development identified in this study include:

- *science education* [classroom discussion; teacher interest in EE; topics covered]
- *influential adults* [especially parents];
- *media sources* including: *broadcast media* [national news and children's television programmes] and *published material* [books].

Littleddyke also highlights teachers' environmental awareness as a factor influencing children's understandings of issues (ibid.). The idea of the teacher as 'subject/agent of change' (Stevenson 2007b) and as a motivating or limiting factor in developing pupils' environmental awareness is a recurring theme in the literature. Connell *et al* (1999) and Palmer and Suggate (1996) found that teachers were influential in three ways: (i) through in engaging the interest of the student; (ii) in increasing awareness and understanding of environmental issues; and (iii) in facilitating pro-environmental attitudes. Yet, Kyburz-Graber (1998), in examining the role of biology teachers in interdisciplinary environmental teaching/learning contexts, observed some reluctance of teachers to engage with a critical socio-ecological approach to interdisciplinary EE. Thus, although perceived by colleagues as being experts for EE, the biology teachers' role was 'marginal' with respect to the development of aspects of socio-ecological EE (ibid. p.237). The author suggests this adherence to the traditional science teacher role was because:

'They are natural scientists and have developed a self-concept of a science teacher being responsible for the transmission of objective scientific facts. Their understanding of environmental problems is based on natural science. [...] Furthermore, they did not seem to be interested in questions concerning social science knowledge about environmental issues.' (Ibid. p.239)

Pilot and follow-up case studies investigating young people's environmental knowledge and attitudes in Australian cities (Hillcote *et al* 1995; Connell *et al* 1999) questioned 4 groups of students aged 15-16 (pilot study) and 24 groups of students aged 16-17 (follow-up study). Each focus group contained between 7-9 students (exact numbers not specified). The main experiences identified across these studies include:

- *personal experiences* [being out in the bush with family and friends; participating in activities such as Outward Bound and school camps or environmental groups];
- *media sources* including: *broadcast media* [TV programmes such as the news, documentaries and some advertising]; *print media* [newspapers];

- *school and school subjects* [geography; biology];
- *other sources* [visual stimulation; friends; family; music].

Connell *et al.* (1999:108) reported that personal experiences were the most trusted experiences. However, with the exception of some television documentaries, the least trusted source of environmental information was the media. Television news was perceived as being particularly unreliable and students felt that media awareness was essential to offset media sensationalism and the presentation of limited, biased perspectives.

These studies as a whole lend weight to Tanner's (1998) idea that there is some observable pattern to experiences that facilitate environmental awareness and attitudes. For example, common experiences include school, media and influential people. Add to this mix the potential free-choice experiences gained from settings identified by Kola-Olusanya (2005) as: *home (family); museums; zoos; nature centres; parks and wilderness*; and there appears to be a wealth of life experiences that students might bring to any informal context. Yet, how does this work? Thomas and Durant (1987:13) suggest that 'to be scientifically literate is not to be expert in anything particular, but rather to be able to deal effectively with matters as they arise'. Thus, it is argued here, that in order to understand the efficacy of EE where there is an emphasis on science education, there is a need to recognise and understand the practicalities of how students draw on aspects of their science education as they engage with environmental matters in real world contexts - the focus being on demonstrating awareness through action i.e., what students actually do in informal situations, as opposed to taught content they can recall and repeat in formal assessment. Thus, whilst some encounters with environmental subject matter might offer potential opportunities to draw upon scientific awareness and understanding, the extent to which students actually do this, and the other life experiences at work in this process, is an under-researched area. The research problem for this inquiry has been previously identified in section 1.1. This problem will now be investigated through two research questions:

2.3.2 Research Questions:

RQ1: *What do students say about their experiences of compulsory science education and are their perceptions of its contribution to their EE/ESD consistent with any tacit scientific content drawn upon in this context?*

RQ2: *What else is drawn upon by students as they explore environmental subjects in this context, and how does this interact with their experiences of compulsory science education?*

Chapter 3 Design and methodology

The purpose of this chapter is to describe the case study design and identify the framework for the analysis. The main structure of the chapter consists of four sections that have been previously described in 1.3. A brief italicised overview is presented at the start of each section to guide the reader through the ideas to be developed. The chapter begins in section 3.1 with a brief review of literature examining methodological issues relating to case study in educational research. These ideas are used to inform the case study design that follows in 3.2.

3.1 Case study in educational research

Educational case study as a style of research has been described as the use of case study methods to ‘enrich the discourse of educators [through] systematic and reflective documentation of evidence’ (Stenhouse 1985:50). Yin (1994:13) defines a case study as ‘an empirical inquiry that investigates a contemporary phenomenon within its real-life context’ and Bell (1993:8) believes the ‘case study approach is particularly appropriate for individual researchers because it gives an opportunity for one aspect of a problem to be studied in some depth within a limited time scale’. According to Bell, its strength is that ‘it allows the researcher to concentrate on a specific instance or situation and to identify, or attempt to identify, the various interactive processes at work’ (ibid.). Kyburz-Graber (2004:54) describes case study as ‘a comprehensive research strategy including qualitative and quantitative methods informed by a distinct theoretical background’ and suggests that the advantage of case study is that this enables the researcher to ask questions of ‘what’, ‘why’ and ‘how’ through:

- analysing an existing, real-life situation in all its complexity;
- exploring it as close to the people concerned as possible;
- describing the situation in as much detail as possible;
- explaining the findings in a clear and comprehensible way (ibid.)

A distinguishing feature of case study is that data are collected from a variety of sources thus, facilitating a process of triangulation. Robson (1996:383) describes triangulation as a ‘means of testing one source of information against other sources’. The importance of triangulation in case study research relates to the reliability and validity of data collected. According to Bell (1993:64-65), reliability is the extent to which a test or procedure produces similar results under constant conditions and on all occasions, whilst validity indicates whether an item measures or describes what it is supposed to measure or describe.

Several authors including: Stenhouse 1985; Yin 1993; 1994; Stake 1995; 2000; have sought to identify specific types of case study. Yin (1993) identifies three types of case study as:

- exploratory*: aimed at defining the questions and hypotheses of a subsequent (not necessarily case) study;
- descriptive*: presents a complete description of a phenomenon within its context;
- explanatory*: presents data bearing on cause and effect relationships – explaining which causes produced which effects.

Stake (1995; 2000:237) also identifies three case study types and characterises these as:

- intrinsic*: the study of a single instance undertaken because the case itself is of interest;
- instrumental*: where the case itself is secondary to ‘provid[ing] insight into an issue or refinement of theory’;
- collective*: an extension of the instrumental case study in that it consists of several instrumental studies examining a single problem. Each single, unique, instance then contributes to building a wider understanding of this problem.

Similarities can be drawn between Yin’s *descriptive case study* and Stake’s *intrinsic case study* in that both study a single instance in order to understand what happens in this situation. However, Bassey (1999:27) suggests these typologies are underpinned by fundamental ontological and epistemological differences. For example, ‘Yin’s writing tends towards the positivist (or scientific) paradigm [whereas] Stake’s is firmly within the interpretivist paradigm’. Detailed accounts of positivist and interpretivist paradigms are provided by authors including: Barr Greenfield 1975, Burrell and Morgan 1979, Cohen and Manion 1994. A concise summary of the methodological implications is offered by Hillcoat *et al* (1995:161):

“The quantitative researcher’s view of reality is radically different from the qualitative researcher’s view of reality. The former views reality as objective and external to the individual, while the latter maintains that reality is internally constructed within the individual. These fundamentally different views have important implications for what is regarded as valid knowledge. Quantitative approaches see valid knowledge as generalizable and predictable, while qualitative approaches see valid knowledge as context-specific only.”

The purpose of Hillcoat *et al*’s paper is to report their exploration of the effectiveness of the focus group interview in researching young people’s environmental knowledge and

attitudes qualitatively. They conclude that this method of interview ‘can construct a picture of young people’s environmental knowledge and attitudes that is closer to their reality than can quantitative questionnaires’ (ibid. p.170). Their paper does not however, address the debate on the purpose and outcomes of case study research. One issue of this debate appears to concern meanings attached to the terms *method* and *methodology*. Strauss and Corbin (1998:3) define *methods* as procedures and techniques for gathering and analysing data and *methodology* as a way of thinking about and studying social reality. Based on this distinction, the difference relates to whether a case study is framed in terms of:

- a method for gathering data from a variety of sources; or
- a methodological approach to analysing and interpreting data in order to add to existing knowledge.

This links to once more to assumptions about knowledge. The main dispute centres on whether the study of a single instance can lead to generalization and the formation of theory. The argument against case study as methodology is underpinned by beliefs that:

- qualitative interpretive research is too subjective and thus, compromises researcher objectivity;
- the methodology lacks rigour and thus, compromises the reliability and validity of data collected;
- qualitative analysis of a single-event is so specific to one set of circumstances that it should not be considered conducive to the formation of generalizations and theory.

The counter argument is that the notion of objectivity is flawed from the outset. Authors including Eisner (1993), Medawar (1963; 1984) and Walford (2001); are critical of an intellectual tradition that Eisner (1993:53) suggests is ‘a legacy of the Enlightenment and the effort to create a tidy, intellectually orderly world’. He asserts that this has facilitated ‘the naïve realism that pervades our culture’ (ibid.). Medawar (1984:51) challenges claims that present scientific method as the only vehicle for revealing objective truths. He argues that, in the real world there can be ‘no such thing as ‘the’ scientific method [since] a scientist uses a very great variety of exploratory stratagems and [...] uses no procedure of discovery that can be logically scripted’. Walford (2001:1-2) concurs, suggesting that autobiographical accounts of research by scientists, and academic studies of science by sociologists, ‘show that natural science research is frequently not carefully planned and conducted according to set procedures, but often centres on compromises, short-cuts, hunches and serendipitous occurrences’. This supports a view that objectivity cannot be assumed to be a measure of methodological rigour.

Methodological rigour is described as ‘the key to effectiveness and quality of research’ (Evans 2002:19). In comparing case study methodology with other scientific methods (not individually identified), Kyburz-Graber (2004:63) suggests that case studies can sometimes be used as ‘a method of weak, superficial inquiry into specific situations and thus, lack the necessary scientific rigour’. However, based on previous arguments undermining the reality of scientific objectivity, a question to ask here is, why is there any need to justify case study in terms of being scientific when the merits of qualitative, interpretive case study research ought to be judged on its reliability and validity? According to Bell (1993) if a case study measures or describes what it is supposed to measure or describe then the research is valid. However, she concedes that validity is a more complex concept than reliability, reasoning that, ‘if an item is unreliable, then it must also lack validity, [whereas] a reliable item is not necessarily also valid [because] it could produce the same or similar responses on all occasions yet, not be measuring what it is supposed to measure’ (ibid. p64-65). A potential solution to this dilemma is offered by Kyburz-Graber (2004:58) who suggests that case study methodology can be regarded as rigorous, reliable and valid if the following quality criteria are fulfilled:

- a theoretical basis including research questions is described;
- triangulation is ensured by using multiple sources of evidence;
- a chain of evidence is designed with traceable reasons and arguments;
- the case study research is fully documented;
- the case study report is compiled through an iterative review and rewriting process.

The issue of whether case studies can, and/or should lead to the formation of theory and generalizations is controversial. This thesis is not concerned with generating educational theory. Therefore, the discussion now focuses on: (i) whether it is possible to generalize about the actions of wider populations from the outcomes of a single-study event; and (ii) whether generalization should be the ultimate goal of all case studies. Corcoran *et al* (2002) criticise case studies that are descriptive rather than transformative. In contrast, Schofield (1993:92) observes that ‘many qualitative researchers reject generalizability as a goal [and] many give it a low priority or see it as irrelevant to their goals’. Yet, is this really the point? In terms of educational research, it would seem more important to judge each case in relation to what it is possible to say about that particular situation. Thus, there is little to be gained from attempting to make inappropriate claims relating to the wider impact of a case study simply to justify its status as a methodology. Dillon and Reid (2004:24) respond to Corcoran *et al*’s (2002) criticism of descriptive case studies by citing Brown and Dowling’s (1998:165) view that ‘professional educational practice and academic educational research are [...] distinct fields of activity’. They use this observation to suggest that ‘research does not have to be transformative. Rather, ‘it is

the use of research ‘evidence’ that is or is not transformative, not the research itself’ (Dillon and Reid 2004:30). One interpretation of Dillon and Reid’s thinking would be to suggest that adding to existing literature in academic educational research is, in itself, an important endeavour.

So, what does all this mean for this thesis? Firstly, the purpose of the case study is to tell a story of the actions of a small group of students in one particular context. Therefore the analysis will be qualitative and descriptive in nature. The case study design is original in that there is no established method of using AS photography coursework as an informal context in which to examine experiences of compulsory science education. Therefore, its outcomes cannot be transformative since they are indicative of the actions of these students situated in this particular context. However, although the outcomes of this thesis will not facilitate generalization, they will add to an emergent literature on student experiences of EE that might at some stage inform educational practice.

3.2 Case study design

The research task involved the exploration of an environmental theme through an AS level photography coursework project. This informal context was designed to enable students to explore an environmental theme whilst operating in familiar surroundings and under normal working conditions. The research task offered a single starting point for investigation, yet was sufficiently open-ended to invite the exploration of a photography brief in a personal way. Some data were collected in an ongoing process throughout the task using methods and opportunities arising naturally within normal routines and approaches to photography coursework. The case study design is described in three stages: 3.2.1 identifies the research site and role of the researcher; 3.2.2 describes the design of the photography project; 3.2.3 details the phases of the data collection and data sources used.

3.2.1 Role of researcher

The data collection for the case study took place in January-April 2004 in a sixth form college in the North of England. The college is situated on the outskirts of a large industrial town surrounded by rural communities. As such, it attracts students from a relatively wide geographical area and a number of different secondary schools. Participants in the case study were drawn from the 2003-04 AS level photography cohort (n=88) distributed across six teaching groups. Most students in the cohort were aged 16-17 years and in their first year of

study at the college. There were also a small number of second year students aged 17-18 years in each group.

The reasons for choosing this research site, and AS photography as the informal context through which to investigate the research problem, relates to opportunity. Firstly, this is a professional doctorate and four years experience of teaching and assessing AS/A level photography at this college had allowed me to observe how students used their photography coursework to explore environmental themes. Secondly, my position as a photography teacher allowed me to adopt a practitioner-researcher role informed by a professional understanding of the college ethos, student culture and departmental practice. There were three advantages to adopting this role: Firstly, decisions relating to the timing of the research project were less problematic. For example, scheduling the project six months into the course allowed me time to establish positive teaching relationships with this cohort, and ensured that students had acquired sufficient knowledge, skills and technical understanding in photography to enable them to explore an environmental theme with a degree of independence. Secondly, familiarity with curriculum content and departmental practice allowed the design of a research task that could be absorbed into the normal coursework structure. Teaching contact with all groups meant that data could be collected during lessons as part of a normal routine. This also provided opportunities to monitor the project and observe any spontaneous interactions between students. Thirdly, prior knowledge of students' preferred learning styles and ways of working made it possible to judge the most appropriate time to elicit responses from individuals during classroom discussion. For example, some students take seemingly random photographs for the first few weeks and only begin to organise and refine their ideas towards the end of a project, whilst others operate in a much more structured way.

The disadvantage in adopting this role was the potential impact of the researcher. Three potential problems were identified:

- i ethical issues relating to the conduct of research;
- ii the student tendency to wish to respond in ways they feel might please the teacher;
- iii the teacher giving advice that might influence the direction and content of a project.

Ethical issues were addressed through the selection process. To comply with ethical guidelines on undertaking research with young people (British Psychological Society 1993) the approach allowed students to make an informed choice on whether or not to participate in the research task. In practical terms this involved:

-
- i making a formal application to the Principal of the college to request permission to carry out the research;
 - ii requesting the support of colleagues in the department;
 - iii designing an introductory presentation for the photography brief that disclosed details of the research.

The issue of the natural tendency of students to want to please their teachers was addressed by considering what constitutes standard departmental practice for photography coursework – particularly, regarding student-teacher discussion of work. All photography groups were routinely team-taught in order to maximise the input of specialist expertise and minimise the imposition of any in-house style. In addition to this, students were encouraged to seek opinions about their work from a wider audience. In this way they either gained a consensus view on an idea, or were challenged by a range of opinions. This encouraged students to make informed choices on the direction and content of their work. It also facilitated the development of skills and confidence to defend their choices. Therefore, photography students were familiar with the idea that it was safe to hold and express views different from those of their teachers. Although this could not eliminate the problem, it might serve to minimise its effects.

The third issue of teacher influence on the direction of students' work held the potential to compromise the validity of the research on the grounds that classroom discussions might also count as experiences students draw upon to inform their thinking. The teacher's role in one-to-one discussion with students often involves suggesting appropriate sources of information for their research and identifying specific images for them to look at and analyse. This presented a potential conflict of interest between the roles of teacher and researcher. To become an impartial observer would mean acting differently as a teacher. Yet, acting differently as a teacher would alter the dynamics of the situation being investigated. Therefore, to address this problem, it was decided to preserve the integrity of the situation by teaching in line with departmental practice and keeping researcher's field notes of all input that might potentially have relevance to the outcomes of the case study.

3.2.2 Photography project

All AS level photography coursework at this college begins with a brief. The purpose of a brief is to offer students a starting point for their ideas through providing a list of titles and suggested areas of study. Interpretation of the brief is left to individual choice and students are actively encouraged to find creative and innovative ways of responding. A variety of factors might influence ways in which individuals interpret a theme or title. For example, their personal

interest in a particular issue, the availability of appropriate subjects to photograph, and/or their preferences for particular ways of working in photography. This balance of guidance and independence would be incorporated into the design of the research task.

The photography brief designed for the research task was entitled *Man-made Landscapes* (MML). The MML brief (shown in Appendix 1) was one of six themes offered for this coursework unit. It presented students with an opportunity to explore human changes to, and interactions with, environments; with the flexibility to consider:

- the reasons why humans adapt and develop landscapes to meet different needs;
- what happens to wildlife when landscapes change;
- ways in which humans and other living things co-exist and compete for space and resources;
- issues relating to sustainable development, biodiversity and conservation.

The photography brief was designed as an aid to stimulate thinking. As such students were not expected to stick rigidly to any idea suggested on the brief. Whilst this was a risky strategy in that it might potentially result in students diversifying in unforeseen ways, it was again judged to be more important to preserve the integrity of the situation rather than exert atypical controls on the outcomes. The whole point was to observe students' actions in a real life situation. Therefore, attempts to standardise the normally flexible working practices would compromise the research.

A coursework unit in AS level photography is routinely launched through an introductory presentation. This presentation identifies the aims of the unit, introduces the titles for the brief, and familiarises students with some of the techniques and approaches they might consider using. This is supported by examples of images from artists/photographers who have explored similar themes. For the purposes of the research task, an introductory presentation was designed to disclose the aims of the research and gain informed consent from all students who wished to respond to the MML brief. Students were also made aware of their right to confidentiality and anonymity, and of their right to withdraw from the research at any stage. The presentation did not reveal the research focus on experiences of compulsory science education since this would have compromised the outcomes of the case study. The delivery of the presentation was no more indicative of methods, approaches and artists' work than was usual in an introductory presentation.

3.2.3 Data Collection

Data collection for the research took place as part of normal classroom routines throughout the six-week period of the photography project. Additional data were collected on completion of the project via an audio-taped interview. Data were collected using three sources:

- *the student's Independent Study Plan*
- *the student's photography work journal*
- *a semi-structured, focused interview*

These data sources were supported by field notes that recorded any guidance and/or intervention on my part that might be relevant to the outcomes of the research. The notes also contained a record of all the introductory presentations and any relevant spontaneous discussions between participants and others. Details of the main data sources are now described.

Independent Study Plan (ISP): Ongoing classroom records of teacher-student discussions are kept as a matter of course. This is the teachers' record of what has been discussed, what has been advised, and what interim study targets have been negotiated. The ISP contains information on the student's ideas for their project; the planning and development of these ideas; teacher input; and resources used. Therefore, as a data source, the ISP precluded the need for any pre-interviews to elicit data on students' initial ideas and methods of working. It was also a record of my routine input as a photography teacher. Data from the ISP were drawn upon to inform the interview questioning and the content of the case study narrative. These data were used to stimulate and verify responses made in the interview.

Work journal: Each student produces a work journal detailing their project as it unfolds. Its purpose in AS photography is to provide evidence that the student has met the assessment objectives. This involves recording:

- ideas, observations, experiences and insights;
- technical details of materials and processes used;
- details of research to inform the development of ideas;
- details of the final outcome of the project.

The work journal also serves a second purpose in that most photographers keep some kind of informal record of their work. This is just one example of how students might do this creatively. It is their personal record. Therefore, a work journal might be presented in any form such as a sketchbook, display panels, a DVD, a PowerPoint presentation. Yet, all contain a pictorial and

written account of their exploration of a theme. As such, the work journals produced in response to the MML brief contained rich data that were drawn upon to stimulate interview questioning and to develop the content of the case study narrative.

Semi-structured focused interview: Students were interviewed as soon as possible on completion of their photography project. Data were collected via an audio-taped interview after Tomlinson's (1989) *hierarchical focusing* methodology. The decision to use individual interviews, as opposed to focus groups such as those used by Hillcote *et al* (1995), Connell *et al* (1999), Littlelyke (2004), was to enable an in-depth conversation that would allow the student to talk about their photography project and wider issues that might emerge from subjects explored. This research seeks to gain insight into individual action and this could not be established through a focus group situation where some students might contribute more frequently than others. For this same reason, the potential diversity of themes explored rendered a single standardised interview schedule inappropriate. Therefore, an interview structure was adapted from Tomlinson's (1989:162) methodology of 'a hierarchical agenda of questions [that would allow] a gradual progression from open to closed framing'.

An advantage of a hierarchical interview agenda is its flexibility, i.e., it allows for variation in students' ideas whilst affording continuity of questioning across the sample. A potential downfall of such flexibility is that discussion drifts too far from the intended focus. To offset this problem, an interview skeleton framework was designed to correspond to the pattern of progression of ideas in a work journal. This is a break from Tomlinson's methodology. However, this approach enabled each student to expand on their thinking within a familiar pattern of development of ideas before being asked more specific questions relating to their experiences of EE and ESD in compulsory science education. Details of the interview agenda and the interview framework are presented in Appendix 2. Five elements for questioning were identified:

1. reasons for choosing to respond to the MML brief;
2. practical exploration of the chosen theme;
3. wider thinking on human interactions with their environments;
4. experiences of compulsory science education in relation to EE and ESD;
5. reflections on the photography project.

The questions in the interview framework served as a prompt and were not always the exact phrases used. The framework was fine-tuned to suit each student.

3.3 Selecting the case study sample

The case study sample was selected from the number of students who had completed the photography project. The sample was selected in two stages. The first stage involved identifying the students to be interviewed. The second stage involved identifying the case study sample from the data sets. A summary of this process is presented at the end of this section.

Stage 1 [identifying students to be interviewed]:

Ten students completed the photography project and eight of them had sufficient relevant content in their work journal to stimulate interview questioning. These students were invited for interview. This offered a pool of data sets from which a smaller sample could be selected.

Stage 2 [sample selection]:

Selection criteria related to students' experiences of compulsory science education. Students selected were those who:

- i had studied GCSE double science and demonstrated a level of skills and understanding in formal assessment that placed them within the A*-C national standards for attainment;
- ii were not studying GCSE science as part of their post-16 programme.

Four students met these criteria. This sample was small enough to allow detailed reporting of the individual case studies within the length of the thesis, and large enough to offer some indication of pattern and variation in responses across the sample.

Summary of the selection process

Pseudonym	Age	Photography project		Selected for Interview	Selected for Sample
		Work journal	ISP		
James	18	✓	✓	✓	✓
Nathan	17	✓	✓	✓	x
Suzanne	16	✓	✓	✓	✓
Hannah	16	✓	✓	✓	x
Matthew	16	✓	✓	✓	x
Ciaron	18	✓	✓	✓	✓
Rebecca	18	✓	✓	✓	x
Michael	17	✓	✓	✓	✓
Liam	17	x	✓	x	x
Katie	16	x	✓	x	x

Case study sample

Code	Student	Age	GCSE science	Completed 5-16 education	Post-16 programme
CS1	James	18	B/B	July 2002	Photography; Media Studies; Geology; General Studies
CS2	Suzanne	16	B/B	July 2003	Photography; Fine Art; English; General Studies
CS3	Ciaron	18	A*/A*	July 2002	Photography; Media Studies; Politics; General Studies
CS4	Michael	17	C/C	July 2003	Photography; Media Studies; Geography; General Studies

3.4 Framework for Analysis

The final section of this chapter is used to describe the development of a framework for the qualitative analysis of four individual case studies. It sets out the sequence of data reduction and reporting that guides the analysis from the raw data through to the individual case study findings. This begins in 3.4.1 by detailing the initial processes of data reduction underpinning the development of a common framework for the case study narrative. This is followed in 3.4.2 by a description of the individual case study framework itself. This explains the stages involved in identifying: (i) the categories for the analysis; (ii) the final summaries of data to inform the findings; and (iii) the common structure for reporting the findings.

3.4.1 Data reduction

The raw data collected comprised:

- images and text contained within the student's work journal;
- ISP records of teacher-student classroom discussions;
- audio-taped interviews;
- researcher's field notes.

Once the full transcripts of the interviews had been produced, a process of data reduction began with an evaluation of the quality of the data collected. The ISP records provided the most succinct overview of the practical aspects of each photography project and details of the students' first and last week of work established:

- i their reasons for choosing the MML brief; their initial ideas for the project; and their research and connections to the work of others; and

- ii a description of their final piece including: the medium/technique(s) used; reasons for selecting these images; details of the composition and presentation of the piece; the message (if any) to be conveyed through the image(s) and their thoughts on audience and how the viewer might respond.

More detailed accounts of this practical development were contained in the work journals. It was therefore, a relatively simple task to identify and tag pages containing images and relevant annotation relating to the environmental subjects explored. This information expanded on detail in the ISP and acted as supplementary data to cross-reference and support information drawn from the interview transcripts. One problem with this was that the amount of detail recorded in each work journal varied. Therefore, it was decided that the primary data should be drawn from the interview transcript since this contained the most comprehensive information.

The initial process of data reduction for the interview transcript involved a system of colour coding and annotation to identify:

- subjects discussed;
- experiences mentioned by the student;
- tacit content consistent with that of NC science;
- other tacit content that relating to: other NC subjects; values; other factors (e.g., economic, social, cultural, political, aesthetic, spiritual awareness)

Although this was useful and supported the subsequent development of ideas, the coding at this stage did not elicit a coherent story. The solution to this was to focus instead on subjects discussed. The full interview extracts for each subject discussed were then incorporated into an individual working document for each student. The final document synthesised summaries of data from the interview, work journal, ISP and researcher's field notes into a structured sequential framework as follows:

1. Overview of the practical development of ideas [source: ISP]
2. Student's description of their project [source: interview; work journal; field notes]
3. Student's reflections on their project [source: interview; work journal; ISP]
4. Wider subjects arising from the project [source: interview; work journal; field notes]
5. Student's experiences of EE/ESD in compulsory education [source: interview]

These data formed the basis the individual case study narratives by generating a story unique to the individual within a common framework that allowed consistency in reporting across the sample. This framework is now described:

3.4.2 Individual case study framework

Each case study is identified by a code and the student's pseudonym (e.g., CS1: James) and is reported in five parts:

- Part 1 [Photography project]
- Part 2 [Case study narrative]
- Part 3 [Case study findings]
- Part 4 [General observations]
- Part 5 [Case study conclusion]

Part 1 [Photography project]

The case study opens with a brief overview of the student's photography project. This indicates the title for the project and the main theme explored. This includes a description of the practical development of ideas, the student's reasons for responding to the MML brief, and their reflections on the outcomes of their work. The purpose of this section is to identify the context for each case study. The reader is introduced to the student by means of the student's explanation of the purpose of their work and their motivation for exploring environmental subject matter through photography.

Part 2 [Case study narrative]

The main subjects discussed are described under headings reflecting the content of the dialogue. Each narrative is unique to the student, yet all contain some content in common; for example, discussion of experiences of compulsory education and familiarity with SD. Where student responses are included directly within a point being made, their comments are distinguished from the researcher's observations through the use of quotation marks. For example: James suggests his family are 'all basically outdoor people'. However, where more specific and/or longer extracts from the data sources are presented, the evidence is indented. For example:

I just think it's kind of hard to define what nature is because . . . we've got so much presence on the planet that it's hard to define. There's no set area if you know what I mean?

In context of the dialogue:

- three spaced dots between words (e.g., . . .) indicates hesitation;
- closed square brackets (e.g. []) indicate places where content including digression, unrelated conversation and banter has been edited out to allow the student's point to be stated more succinctly.

Part 3 [Case study findings]

On establishing a narrative for each case study the next problem was choosing how best to identify and report findings relevant to the focus of the inquiry. The aim was to achieve consistency in reporting that would identify the individual case study findings and also allow comparisons of results to be made across the sample. The analysis began with reference to the research questions that are repeated below:

***RQ1:** What do students say about their experiences of compulsory science education and are their perceptions of its contribution to their EE/ESD consistent with any tacit scientific content drawn upon in this context?*

***RQ2:** What else has been drawn upon by students as they explore environmental subjects in this context, and how does this interact with their experiences of compulsory science education?*

The first stage in preparing to answer the research questions was to establish some categories for the analysis. This required a solution that would enable a distinction to be made between experiences of compulsory education (this would address RQ1) and other experiences that might contribute to students' environmental awareness (this would address RQ2). The initial process was informed by reference to academic writing examining the relationships between formal, non-formal and informal education where there is an emphasis on science education (e.g., Lucas 1981, 1983; Maarschalk 1988; Tamir 1990) and environmental learning (e.g., Mocker and Spear 1982; Heimlich 1993, 2005; Falk 2005). The opening exercise was to consider the merits of five descriptors used in the literature to describe learning experiences and learning settings associated with scientific literacy and EE. These are: *formal; non-formal; informal; self-directed; free-choice*. Each descriptor appears to be characterised by an indicator that relates to: (i) ways of acquiring information and skills (e.g., through *experience, education, schooling*); or (ii) to the situations where this occurs (e.g., in *environments, settings, contexts*). The most consistently agreed definition applies to *formal education*. According to Falk (2005:270), 'historically, *formal* has been the term used to refer to school and university-based education, and by extension the learning that occurs there.' Maarschalk (1988:136) describes *formal education* as 'education that takes place in a planned way at recognised institutions such as schools, colleges, universities, and so on'. These characterisations of *formal* are adopted in this thesis and will be refined later in this section in context of defining the terms used in the analysis and reporting.

There is far less consensus on definitions applied to experiences outside the sphere of formal education and learning. The two most commonly used terms are *non-formal* and *informal*. Yet, there are problems with this. For example, Maarschalk's (1988:136) observation that some research papers use the terms *informal* and *non-formal* interchangeably prompted his attempt to draw clear distinctions between these terms in context of examining the relationship between scientific literacy and informal learning. In doing so, he cites definitions for education first presented by the South African Human Science Research Council (1981) which state that:

'Non-formal education is education that proceeds in a planned but highly adaptable way in institutions, organisations, and situations outside the sphere of formal and informal education; for example, in-service training, field trips and museum visits, educational television and radio, and so on.

Informal education is education that is given in situations in life that come about spontaneously, for example, within the family circle, the neighbourhood, and so on.'

(Maarschalk 1988:137)

Tamir (1990:34) observes that the definitions cited by Maarschalk 'all differ essentially in the context they offer for learning'. This emphasis also differs from other definitions for non-school sources of informal learning (e.g., Lucas 1981; 1983) which reflect the learner's encounters with learning sources and whether these encounters are, as Lucas suggests, *accidental* or *intentional* (ibid.). Further definitions centre on who retains the control of learning and the situations in which this where this takes place. For example, Mocker and Spear's (1982) *Lifelong Learning Model* uses a two-by-two matrix to indicate the level of control between learner and institution in formal, non-formal, informal and self-directed learning. *Self-directed learning* is described as learning where the learner controls both the objectives and the means of learning (Mocker and Spear 1982). The illustration below is an interpretation of the matrix which demonstrates the relationship between institutional and learner control. From this it can be seen that learning in formal, non-formal and informal settings involves some element of institutional control that is not apparent in self-directed learning which, Mocker and Spear suggest, represents the ultimate autonomy in learning (ibid.).

Learning setting	the institution controls:		the learner controls:	
	the objectives	the means	the objectives	the means
formal	✓	✓	-	-
non-formal	-	✓	✓	-
informal	✓	-	-	✓
self-directed	-	-	✓	✓

More recent extensions of ideas relating to self-directed learning and learning settings have been introduced by authors including Heimlich (2005) and Falk (2005). A new facet of environmental learning has been identified and characterised as *free-choice learning*. According to Falk (2005:265) *free-choice* learning is where ‘the learner exercises a large degree of choice and control over the what, when and why of learning’. He goes on to add:

‘Free-choice learning typically, but not necessarily occurs outside school. It refers to the type of self-directed learning that regularly occurs in settings like national parks, nature centres, natural history museums, zoos and aquariums, a wide range of community-based organisations, and through the use of print and electronic media.’ (Ibid. p.270)

Yet, at face value, Falk’s definition of free-choice learning appears to share some characteristics in common with earlier descriptors for non-formal education (e.g., Maarschalk 1988) and non-formal learning settings (e.g., Mocker and Spear 1982). This serves to highlight a problem that, in spite of receiving increasing recognition and use, the definitions for *non-formal*, *informal* and *self-directed* experiences continue to overlap. Furthermore, in spite of authors’ efforts to unpick and separate these experiences into specific definitions, confusion ensues as more terms are added to the mix. What becomes clear from this body literature is that attempts to define experiences that contribute to both scientific literacy and EE are complex and problematic because the processes, relationships, interactions and settings involved are difficult to separate with any certainty. As such, there is little more to be gained in this thesis from pursuing the debate on boundaries between existing definitions for experiences. This said, it is acknowledged that where a lack of clear definition occurs, what is understood and conveyed by the author might be misconstrued by a reader who brings their own assumptions about the meaning of terms to their interpretation of the text. Therefore, for the purposes of this thesis, the following definitions are adopted:

- Maarschalk’s (1988) previously cited definitions for *non-formal* and *informal education*;
- Mocker and Spear’s (1982) definition for *self-directed learning*.

However, these terms are not used as specific categories for the analysis. Instead, based on observations that the terms *formal*, *non-formal* and *informal* and *free-choice* all feature some degree of institutional input, two initial categories are identified as:

- Institutional experiences
- Other life experiences

For the purposes of this thesis, an *institutional experience* is provided by and/or takes place in a government or non-governmental organisation or society that carries a particular educational and/or social remit. For example: schools; youth organisations; environmental trusts; museums; zoos; and so on.

Other terms used in the analysis are defined as follows:

Experience signifies encounters/familiarity with: knowledge and skills; information, events and actions; feelings, perceptions, values, attitudes and beliefs.

Learning signifies the acquisition of knowledge, skills and understanding as part of formal education and other life experiences.

Education signifies an ethos and process that carries deliberate intent to facilitate learning and is characterised through its guiding principles, organisational structure and pedagogy.

Education in schools, colleges and universities is defined in the first instance as *formal education*:

Formal education is an *institutional experience* that comprises *compulsory education* and *post-compulsory education*.

Compulsory education comprises for pupils aged 5-16 years based on the statutory NC programmes of study in England.

Post-compulsory education comprises all planned and highly structured academic and vocational provision offered by schools, colleges and universities that serves to complement and extend experiences of compulsory education.

Formal knowledge signifies learning acquired through formal education.

All experiences outside formal education are characterised as *other life experiences*.

Other life experiences include both *institutional* and *other experiences*:

Institutional experiences in this context include; for example: youth organisations; environmental and conservation groups; museums and galleries; zoos; public libraries; religious groups. For the purposes of this thesis, media and publishing are categorised as institutional sources of environmental information in that material might be, either overtly educational, or hold some agenda to develop awareness and understanding of environments and environmental issues through the presentation of differing standpoints on issues supported by factual explanation.

Other experiences have been variously identified and characterised in studies by Hillcote *et al.* 1995; Connell *et al.* 1999; Palmer and Suggate 1996; Littledyke 2004 (see Chapter 2.3.1). The most commonly identified experiences across these studies were *family* and *personal experience*.

Other frequently used terms are: *awareness*, *understanding* and *respect for* environments. These terms are drawn from, but not defined by, terminology used in the NC aim for environmental learning (DfEE/QCA 1999). Thus, in context of this thesis:

awareness signifies an individual's familiarity with their surroundings and their ability to observe and notice things in these surroundings;

understanding signifies the ways in which individuals draw upon knowledge and skills to develop and communicate their thinking on environments and relationships in these environments;

respect for environments signifies values, attitudes and behaviours that indicate care and sensitivity towards environments and other living things.

Analysis of the narrative

On establishing a working vocabulary of terms, and the two initial categories for the analysis, the next stage was to determine the types and range of experiences and content drawn upon for subjects discussed. This called for a final phase of data reduction that involved two stages: Firstly, data were drawn from each case study narrative and recorded under the following categories:

- Institutional experiences
- Other [espoused] experiences
- Other [non-specified] experiences

These data detailed the range of experiences and content drawn upon by each student. Secondly, these data were summarised for each individual student and across the sample using two categories that directly corresponded to the research questions:

1. Experiences of compulsory science education (findings for RQ1)
2. Experiences other than compulsory science education (findings for RQ2)

Data relevant to RQ1 included:

- the student's spontaneous references to compulsory science education;
- their responses to direct questioning on this subject;
- any tacit links to compulsory science education.

Data relevant to RQ2 included:

- students' experiences of compulsory education;
- other life experiences [categorised as: *family and upbringing*; *personal experiences*; and *institutional experiences*];
- any non-specified experiences.

The final tables of summaries of data are presented in Appendix 3.1-3.4. Each table contains a list of experiences and content drawn upon by each student that would ultimately be summarised across the sample indicate pattern and variation in responses. In terms of findings, espoused experiences must necessarily carry more weight than any non-specified (tacit) evidence because these are the experiences that students actually recognise as being meaningful to them in this particular context. However, the inclusion of tacit experiences and content as part of the analysis is useful when seeking to recognise if and how students' perceptions of their experiences of compulsory science education match against any evidence of formal science knowledge drawn upon in context of discussing different subjects. For example, a student might indicate that they disliked science lessons at school. However, there is tacit evidence to suggest that, in spite of their perceptions, their compulsory science education appears to have equipped them to draw spontaneously upon formal science knowledge when opportunities arise. Yet, the only valid claim that might be made in relation to such tacit evidence is that an example might appear *consistent* with experiences of compulsory science education on the grounds that similar content exists in the NC science programme of study.

Reporting the findings

It made sense to report the findings under the headings identified for summaries of data since these were based on the research questions. In keeping with this, experiences of compulsory science education (RQ1) are reported as follows:

RQ1 Finding 1 [Experiences of science education]: This indicates whether or not the student has made any spontaneous references to their experiences of science education in their photography project and/or interview.

RQ1 Finding 2 [Perceptions of the relevance of science education to EE/ESD]: This presents the student voice on their experiences of compulsory science education by indicating: (i) their attitudes to science education; and (ii) what, if any, aspects of this experience they believe has contributed to developing their awareness, understanding and respect for environments and other living things.

RQ1 Finding 3 [Tacit evidence of content consistent with NC science]: This indicates whether the student has drawn upon any formal science knowledge in this particular instance and, if so, in what contexts this occurred.

Experiences other than compulsory science education (RQ2) are reported as follows:

RQ2 Finding 1 [Formal education]: The summaries of data showed that all students had drawn upon experiences from both compulsory and post-compulsory education in context of their photography project and interview. As such, it was decided to use the overarching term of *formal education* for reporting these findings. Experiences of post-compulsory education are included for two reasons: (i) they are experiences that these students have linked to EE/ESD; and (ii) their responses serve to highlight any new experiences relevant to developing awareness, understanding and respect for environments that might be encountered by young people who choose to extend their formal education beyond the age of 16.

RQ2 Finding 2 [Other life experiences]: These experiences are reported as:

- *family and upbringing* [e.g., relationships with immediate and extended family; shared interests, experiences and values];
- *personal experiences* [e.g., student interests; first-hand experiences; self-directed learning; peer relationships; encounters with non-related people];
- *institutional experiences* [e.g., experiences of youth and/or environmental organisations].

RQ2 Finding 3 [Non-specified experiences]: This indicates if and how students supported their ideas with other experiences and awareness that either were not, or could not be, fully explained in context of discussion.

Part 4 [General observations]

The case study findings are followed by the researcher's observations about the student's photography project and interview. Specifically: (i) if and how their interpretation of the MML brief appears to have presented and/or limited opportunities for them to draw upon formal science knowledge in this context; and (ii) the interplay of formal knowledge, values, attitudes and other awareness (e.g., aesthetic, economic, social, cultural) that is evident as they have explored and developed their thinking on environmental subjects.

Part 5 [Case study conclusion]

Each case study ends with a consideration of what, if anything, the actions of the student might say about how they have drawn upon their experiences of compulsory science education in this informal context.

Chapter 4 Individual case studies

This chapter comprises four individual case studies. The case study framework has previously been detailed in section 3.5. The following list identifies each case study and indicates where the corresponding tables of summaries of data are located:

- *CS1: James Appendix 3.1*
- *CS2: Suzanne Appendix 3.2*
- *CS3: Ciaron Appendix 3.3*
- *CS4: Michael Appendix 3.4*

CS(n).3 in each case study presents the individual findings in relation to RQ1 and RQ2. Therefore, in order to preclude the need to indentify the research questions each time, they are repeated below:

Research Questions:

RQ1: *What do students say about their experiences of compulsory science education and are their perceptions of its contribution to their EE/ESD consistent with any tacit scientific content drawn upon in this context?*

RQ2: *What else is drawn upon by students as they explore environmental subjects in this context, and how does this interact with their experiences of compulsory science education?*

CS1: James

CS1.1 Photography project

James' project, entitled *Rubbish as Its Own Object*, centres on an idea that Man-made landscapes are created from the sheer volume of rubbish generated by humans. A single photoshoot documents a small area of waste ground in a local residential area and depicts refuse consistent with discarded building materials and fly-tipped domestic waste. Sections from these images have been merged to construct a photomontage and this abstract portrayal, of what James describes as a 'mountain' of waste, constitutes the final outcome for the project. He indicates in the interview that he had no wish to convey any particular statement about rubbish to the viewer. The purpose of this piece is merely to create a pictorial response which might:

Show the vastness . . . it's an unclimbable amount, the amount of rubbish produced by people it's . . . insane really.

James identifies the introductory presentation as the main influence on his decision to respond to the MML brief. Researcher's field notes indicate that, during the presentation, James contributed to a discussion of artists' work wherein he presented views on how privately owned land might be used for wider common purposes such as agriculture and forestry. He also suggested that woodland management could be particularly beneficial to the environment if land owners used traditional sustainable methods of harvesting of wood. When asked how he had arrived at these views, James indicates that his brother-in-law is a farmer and that his father had been a joiner.

In the interview, James explains how the presentation had started a thought process:

I'd already done that light project which I'd used Meatyard's trees in. So I thought, 'Trees? Nature?' [*uses hands to weigh up ideas*] And I thought [*laughs*] 'I'm up for a bit of this – a bit of this nature', and [*becomes serious*] it's also a thing I believe in, 'cos I like nature – I'm an outside person.

He links his preference for outdoor, but not urban, environments to a general family lifestyle. He suggests that his family are 'all basically outdoor people' and talks about family holidays and other shared leisure activities. He then spontaneously draws attention to his learning difficulty:

Yeah, and also with my dyslexia, I've never been like, a book person - as in writing – I mean . . . I really like *reading* books, but I like reading a book outside. Sort of, you

get on your bike, you head off somewhere, you sit down and . . . there you are!
(shrugs shoulders)

He ends this exchange with a positive appraisal of his upbringing:

Yeah, I can't say it's been a bad one.

James had been a Scout and, although he believes this experience was 'not specifically' relevant to developing the way he thinks about environments, it did raise his awareness of outdoor environments and certain ecological attitudes and behaviours. For example:

Clean up where you've been – leave it as you've found it, preserve nature, only take what you need to use. If you kill something in the wild well then you have to use it all! You don't just like . . . there's no point in just killing it and leaving it . . . like . . . *Eskimos!* If they kill . . . a caribou, they'll skin it, they'll eat the flesh, they'll use the bones, they'll use the whole thing, and if there *is* anything left, well . . . I don't know? They return it to the wild I suppose, which is the way it should be done.

ISP records indicate that James' idea remained constant throughout his photography project. He began with a clear plan and worked resolutely towards achieving this goal. On completion, he was openly satisfied with the style and content of his photomontage and was keen to display it within the department.

As he reflects on this experience in the interview James suggests that, for him, photography is an effective way of exploring environments because it allows him to notice things on a multi-sensory level.

It's the whole environment isn't it? You've got sounds, you've got smell, you can feel the wind - it's just how it feels. It feels good outside.

He does however, recognise that others might not engage in the same way and, although he likes the idea of starting people thinking about issues relating to rubbish, he is aware that it is difficult to manipulate, or accurately predict, a viewer's response.

At the end of the day an image can be . . . can mean something completely different to each person . . . due to their life . . . how their life is [] they could have a completely different angle on something I could not possibly think about 'cos of the way they've been brought up.

CS1.2 Main subjects discussed in interview

CS1.2.1 Rubbish as its Own Object

The opening statement in James' work journal reads:

I am going to use rubbish as my working image. Not as a statement about rubbish, but because it's not a thing. It has no form or label. It's just rubbish.

In the interview, James defines rubbish as '[] something that cannot be used for any other purpose . . . something that's been discarded - thrown away'. He also describes rubbish as 'not very good' - a comment interpreted to mean something of a poor standard and/or undesirable. In explaining his main idea of rubbish as its own object, James suggests that observations made during a previous visit to a coastal landfill site had caused him to think about the aesthetic qualities (i.e., the form) of accumulated rubbish:

You can focus in on a piece of rubbish like, I dunno . . . a broken bottle or something like that – a piece of rubbish, but if you put it all together on mass it just flows, it becomes its own object . . . like a . . . cliff face – it's become its own object.

When asked what had influenced his perceptions of rubbish, James refers to what he terms, 'My strong moral upbringing.'

CS1.2.2 Rubbish as an environmental issue

As he continues, James talks about his final piece and justifies his decision not to convey any particularly overt message about rubbish to the viewer by suggesting that statements used to promote specific public environmental behaviours do not always present the full picture.

In many cases recycling isn't always the best option, 'cos it costs more to the environment to recycle the waste than it does to destroy it . . . 'cos, you produce the same amount in a recycling plant as you do in an incinerator . . . and you're getting a low-grade product which just ends up nowhere anyway 'cos there aren't that many people who use recycled paper. You'd be better off planting more trees than spending the money recycling . . . and if you have a managed forest you can use it for ages and other things can live there. A lot of people think recycling has got to be a good thing – good for the environment, but it's not always the case if you look deeper into it.

James attributes his views on recycling to self-directed reading and informal discussion:

I think of myself as a fairly well-read person, but I also have discussions with people, generally in the pub or something! (*laughing*) I like getting a bit of an argument going - about politics or some statement. I'm very argumentative so I always back up . . . make sure my facts are well backed up in case I have to defend an argument.

In preparation to defend his views, James accesses media information to deepen his awareness and understanding of issues that might potentially arise in discussion. He identifies the sources of this information as the Internet and broadcast media including Sky news and BBC news. Yet, he is sceptical of the reliability of media information and suggests that he uses his spare time to follow up news stories. He indicates that he uses the *Google* search engine to aid 'research on all the broader areas of it'.

James' final comments on this subject are vehemently expressed and demonstrate his values relating to personal responsibility and the things he believes people should automatically know and do in relation to rubbish:

You can't just sit back and hope for someone else to sort it out – like you can't just blame the government, 'Oh the government's not doing enough recycling!' when you're the ones sat back eating the McDonald's and throwing the rubbish on the floor! Or, 'There isn't a bin around.' Well you should go and look for a bin! Do you know what I mean?

CS1.2.3 Landscapes

James judges the visual impact of his photomontage to be important and indicates that he likes 'a good looking landscape'. However, he does not believe that the aesthetic qualities of landscapes have any real bearing on people's attitudes and behaviours towards environments.

I think it's more the way people are brought up rather than the way something looks. Whether people are brought up to respect environments – or not . . . and it's generally not these days.

When asked how he arrived at this view, he suggests it results from what he terms his 'general interaction with the world'.

James describes his favourite kind of landscape as, 'One that is worked by tractors, with rolling hills and a lone tree':

I *love* lone trees – where the farmer's left a big tree . . . a big oak or something like that. (*laughs*) Did you know that an oak's a whole world on its own? [] Well, it's a whole

ecosystem . . . from your tiny insects that are eating . . . living off the tree itself, up to your birds that are eating the insects . . . and then you've got squirrels and land animals – and you get a badger set underneath and . . . it's just incomprehensible the amount of stuff that you can have going on.

James' description of feeding relationships and the idea of interdependence between organisms, presented as an almost linear description, is consistent with an answer a pupil might present in a science lesson. This is an approach that continues as he moves on to describe things he noticed whilst taking photographs of rubbish. In response to his annotation 'nature claiming back what's hers', he first explains:

Nature survives . . . and struggles through and just . . . subdues the rubbish and grows over it . . . 'cos . . . a plant . . . 'cos . . . your seed is an incredible thing . . . a seed will just keep growing . . . because like, you could throw one on concrete and it would find a crack and as long as it's got moisture and what it needs to survive . . . it'll be like - nature will always find a way. If the rubbish is left alone, nature will come back.

He then describes his understanding of this process:

Well . . . you'll get your starter plants – normally a weed, or grass, or nettles . . . nettles will bring in butterflies and moths and such and . . . also . . . erm . . . aphids and stuff like that . . . and that's what your caterpillars are eating – the nettles. Then the aphids will bring in ladybirds and all your type . . . insect system starts off, and your insects are going to bring in animals like birds and such . . . and . . . your birds . . . your birds will bring in animals such as cats and stuff and once you've got a good nature system, and it's got plants forming like dock leaves along with the grass, then you'll get your small land animals like rabbits and such, then like, your herbivores will bring in like, your carnivores and so on.

This description of succession is fairly consistent with elements of NC science *Living things in their environment*. However, his final statement breaks from this and reflects his personal judgement of human attitudes to other living things:

Then there'll be us at the top wiping them all out again with chemicals!

CS1.2.4 Human interrelationships with environments

James indicates that his ideas for the photography project do not reflect his general thinking on man-made landscapes. In expanding on this, he initially characterises man-made environments as 'managed' and 'urban'. He then focuses on the benefits of managed woodland:

Actually, if it's done in a proper way, it can look better than a natural woodland 'cos it allows the air space and everything can grow 'cos the light can get down - so you have a proper carpet of bluebells or whatever.

As he continues, James suggests there is probably very little natural landscape in the UK since most land is, or has been at some time, managed or owned. He suggests that natural landscapes hold economic potential if footpaths are created to encourage public access and that, once a footpath exists, the landscape must be managed in order maintain it. He attributes this understanding to lifestyle and upbringing:

Just from the way I've been brought up I think . . . just my way of life I think.

James appears distinctly less enthusiastic about urban environments and only describes environmentally damaging effects of urban development.

Well, a man-made environment – as in an urban environment . . . that can throw the whole environment out . . . the entire weather system out of whack can't it? I mean . . . if you clear a forest for farm land, you are going to get different weather systems happening . . . and you are going to get poor grade soil and all that . . . and you're going to get different river systems . . . especially as it is now – the way the floods are increasing, especially in cities due to all the concrete in the inner cities and the drainage systems, so when it rains . . . the soil isn't getting water it needs, 'cos rain is going straight into a river instead of into the sub-soil . . . and . . . your whole water table is out of whack then.

He goes on to explain how natural groundwater resources such as the London aquifer become depleted as a result of urban drainage systems that divert surface water directly into rivers. He is also able to predict potential social, economic and environmental consequences of this:

After a bit, they're going to have to build a dam somewhere and pipe it in.

James warns that his views on the impact of human activities on environments are controversial:

Ooh . . . [rubs hands together theatrically] . . . well, I believe it's all to do with Capitalist governments. [laughs] This is gonna be good! Well, [becomes serious] with Capitalism it's all to do with profit really . . . it's true . . . it's just all profit. The human impact on the environment can be judged on the amount of profit these days. Well, you've got your groups like Greenpeace and so on, but they're not going to be able to stop a corporation in the end . . . because they can't afford to. It all comes down to money in the end.

James' enthusiastic response and ready answer suggests this is not the first time that he has discussed this subject. As predicted, James' 'controversial' views emerged in response the next question of whether he felt it was a human responsibility to protect the environment:

J: Well, not to protect it – if we just left it alone and didn't interfere . . . but . . . we shouldn't keep expanding like we are doing . . . we could do with a bit of a plague really!

I: (*laughs*) What?

J: (*laughing*) Well, yeah I know it *sounds* really bad . . . and I'm not wishing it would happen . . . but I'm thinking of something natural, worldwide and indiscriminate that would take out about two-thirds maybe? (*responds to I's raised eyebrows and laughs*) What? It would just about bring us back down to manageable numbers!

Two things emerged from this exchange: Firstly, James' perception that the environment would not need protection if we left it alone and didn't interfere' appears to contradict his previously aired views on the positive benefits of managed environments. Secondly, when prompted for his thoughts on less extreme methods of reducing the impact of human activities on environments, he revisits the idea of individual responsibility:

Well, the government will have you thinking that one man can't make a difference, but I reckon they can . . . each person can make their own difference . . . and not just that little bit of difference like obviously recycling your own cans and so on, but you should teach like, your children to do that, and relatives and friends. I think you've got to make a bit of a nuisance of yourself and say, '*Hang on - pick that up*' . . . not in a harsh way – I mean you can't actually *make* them pick things up . . . but if you keep on repeating the same message, it gets in people's brains and keeps them thinking about it, and hopefully the guilt will wear them down and they'll start doing it for themselves.

He ends this exchange with a spontaneous generalisation about urban lifestyle:

A lot of people in cities don't really know . . . they don't have a clue what's going on in the world [] they just live in their nine-to-five lives in an office . . . just earning their money to buy material goods . . . a DVD or something. It's a very closed world . . . but if you open up your mind, there's so much stuff to learn about. [] The way to help the environment is to keep taking in information so that you, yourself, know what's going on - and then make sure you don't do it! If everyone did that . . . (*shrugs shoulders*).

CS1.2.5 Environmental awareness

It is becoming clear that James believes that people should be self-motivated to become environmentally aware and, when asked what he felt he needed to know before starting this project, James' immediate response was, 'Knowing how to use a computer'.

I find being computer literate is a very useful tool, because in this Century it's everything . . . you can get access to nearly anything you want through computers. It's really useful the amount of stuff . . . especially stuff that people don't want you reading.

In expanding on this, he talks about the availability of a set of CDs highlighting conspiracy theories:

This is going to make me look like a right crackpot! [*pause as we both laugh at this personal appraisal*] But (*become serious*) they have different angles on things – like things that the government is not showing you.

James goes on to suggest that the government 'uses the media as a tool to convey their ideas to the masses' and that he believes people should be sceptical of such information. He suggests the presence of a political/media 'smoke screen' and indicates that further reading might reveal hidden agendas. This response adds weight to James' previously stated views that environmental information should not be taken at face value.

CS1.2.6 Familiarity with SD

James confirms that he is familiar with the term SD. Yet, he immediately marks this an 'unbelievable term':

Well, to keep it sustainable and to keep it developing seems impossible. I think . . . I don't think it's within human means to do it. We can't manage our own systems enough to . . . to keep an equilibrium with the rest of the world.

James supports this view with two arguments. The first of these relates to how humans find ways to prolong life despite the environmental consequences:

Well, yes . . . think about what America did! Fair enough, they've got malaria, and that kills a lot of people - but that's not necessarily a bad thing when put into perspective of the whole grand scheme of things . . . I mean the Earth - I'm not saying let's kill people – I don't mean it like that! I'm not a psychopath or a cult man! I'm just saying that there needs to be a natural loss of people. I mean you wouldn't think about it with animals. Animals get malaria and they die out and that keeps the numbers pretty equal.

Like, say you've got a group of animals, if there gets to be too many and they don't have enough food they die out and the food that they eat increases again, and it keeps a natural equilibrium . . . (*now talking with real passion*) but . . . *we . . . we'll* just keep exterminating . . . *omnivore everything up . . .* and if that doesn't work, then we'll invent some chemicals to do it for us!

The second argument relates to James' perception that human causes of extinction are underpinned by a calculated intent to 'wipe out' other living things. James explains this view in terms the ecological effects of chemical controls, and supports his stance against the use of DDT through his understanding of ecological factors that regulate animal populations and how toxins build up in food chains:

It's like I was saying about the Americans and the mosquitoes. They went with DDT and just wiped things out – just masses of them . . . then . . . they say, '*Well it's great, it gets rid of mosquitoes!*' And, well, they're annoying and nobody likes them anyway. But it's also killing all the birds that eat the mosquitoes, and killing fish, and it's just wiped out whole massive acreages!

His final observations on this subject relate to the environmental consequences of war:

And Vietnam and Agent Orange . . . the *whole* of Vietnam - that was just . . . irresponsible . . . and all because the American armed forces are naff – so useless at fighting they have to drop chemicals and nuclear bombs! They are the only nation to have dropped a nuclear bomb on another nation! [] If you think of it this way . . . the Americans spend . . . something around four billion dollars a day on defence budget, but they didn't sign that environmental agreement did they?

James' commentary on SD as a whole serves to highlight his perceptions and judgement of US cultural values and priorities. However, although James does not support the idea of SD, his final observation suggests he does not view human activity *per se* as a threat to ecological balance:

No . . . not if it's done correctly! Your Romans right? Well, they had planning []. They built things differently – they built things to last and they built them around nature rather than to interfere with nature. The way they went about things, even like building roads . . . they used materials that were there and . . . it was just a lot greener then . . . although . . . I suppose they didn't have any modern industrial process, so . . . (*long pause whilst thinking then shrugs*).

This statement supports earlier tacit references to environmentally sustainable practices in CS1.1 and CS1.2.2 and suggests that James approves of an idea of sustainability. He appears to believe that there is a ‘correct’ way for humans to interact with environments which involves two principles: (i) leave it alone and don’t interfere; and (ii) build things to last and build around nature. These two principles appear mutually contradictory in that both built and managed environments must necessarily interfere with nature if ‘nature’ is conceptualised as pristine wilderness. This suggests that James is applying his own meaning to the term ‘it’ and that this ‘it’ is somehow separate from, and can exist without, humankind.

CS1.2.7 Experiences of compulsory education

James initially links his familiarity with SD to general experience as he suggests, ‘I just picked it up out of the ether, all odds and ends, listening and reading’. On being asked if he felt his school science had prepared him in any way to engage with environmental issues and SD, he observes, ‘It didn’t cover sustainable development - not in a broad way’. He then adds:

Geography came in with a lot of the environmental issues . . . ‘cos my geography teacher, he was semi-into the environmental stuff – more than some of the other ones we had and . . . he was . . . he was just trying to make us more aware of some of the things going on out there [].

James suggests that this particular teacher raised his awareness of where food came from and what happens to items such as yogurt pots and crisp packets once they are discarded. He implies that children take such things for granted, i.e., ‘you put the packet in the bin and the next day it’s gone’, and his general conclusion is that young people ‘just need to be taught to think’. James states a preference for geography on two counts: (i) the subject appealed to his ‘outdooriness’ which, he suggests, had been heavily influenced his parents’ interests; and (ii) he prefers subjects with a practical content owing to his learning difficulties.

As the questioning focuses more specifically on science education, James refers to his GCSE Double Science grades (‘a couple of Bs’) and then offers the following observations:

School’s good – school starts you off, especially science, ‘cos it makes you think about different areas that you might not key into your brain otherwise. []. Well, maybe not about anything on the environment, but especially when talking about space and like, planets and stuff . . . and just the way everything happens in the world. It’s also good ‘cos you get chance to mess around with chemicals . . . (*laughing*) remember . . . I’m a bit of a lad!

James identifies two factors that he believes influences success in science education. These are 'your teacher' and 'your interest in science'. He then suggests that there are four types of science student: 'academics interested in grades'; 'those who enjoy learning'; 'those with learning difficulties'; and 'slack people who choose not to learn'. On being questioned about his perceptions of himself as a learner, James identifies himself as, 'somewhere between a slack person and a person who is hungry for knowledge'. He also describes himself as a 'School of Life person':

I'd rather have a bit of a life, 'cos I think, you only get the one shot . . . 'cos a lot of people go off to university and then get a job and a working nine-to-five . . . but I'd rather go – I want a bit of a life and go travelling and see what's going on out there.

He supports this statement with a spontaneous comparison of ways in which he explored the environment in his photography project and his experiences of compulsory education:

Well I'd rather go out and do the things I do now. . . I didn't really like science projects at school - they always had a lot of writing.

Writing is a problem for James. He mentioned his dyslexia in CS1.1 and now he talks about its effects on his performance at school and why he preferred practical subjects:

Yeah . . . it's quite bad for me really, 'cos I know quite a lot of stuff, but I can't pass exams 'cos I can't write . . . but there's not much I can do about the system . . . so there are a lot of people out there getting better marks than me when they don't know anything like as much as I do.

Finally, when asked if he had covered issues relating to conservation at school, James once more identifies geography as the main experience. This time he also makes an insightful comparison between his experiences of science education and geography:

Well you were asking me about science, but I think it was geography that was the main subject for teaching me something about the environment. []. My school science taught me about how the environment works . . . as in how plants work and such things like that . . . so then you've got an idea that a plant needs sunlight and . . . all the basics . . . and taught me all like how animals work . . . like . . . how you've got a food chain and all that . . . and that's all part of an environmental system . . . but science didn't bring it all together, it didn't focus it into one big environmental package, like how we impact on it, or anything like that. With geography and with science . . . well, science covered the technical and geography covered like . . . the aspects of bringing it all together and showing us how it all interacted.

CS1.3 Case study findings

CS1.3.1 Experiences of compulsory science education

RQ1 Finding 1 [Experiences of science education]: There are no spontaneous references to experiences of compulsory science education in this case study.

RQ1 Finding 2 [Perceptions of the relevance of science education to EE/ESD]: James does not view science education as being particularly relevant to EE and does not associate it with developing his awareness of SD. He displays a generally positive attitude to his experiences of school science, yet believes that success in science is dependent upon the teacher, the interest of the student, and the student's ability to learn. The latter is particularly important to James owing to his personal experiences of managing dyslexia. He indicates that he did not like science projects owing to their emphasis on writing.

James describes science education as 'technical' awareness of life processes and living things and recognises links between this scientific content and the human content in geography. His observations in CS1.2.7 suggest that, although he is aware of subject demarcation, he recognises the interrelatedness of scientific and geographical content in understanding environments and environmental issues – especially human interactions with their environments.

RQ1 Finding 3 [Tacit evidence of content consistent with NC science]: There is a difference between James' perceptions of science education's relevance to EE/SD and the way he actively draws upon formal science knowledge in context of exploring environmental subject matter. Subjects arising from his exploration of *Rubbish as its own object* offered him opportunities to draw upon science content in the following contexts:

- CS1.2.2 Rubbish as an environmental issue
- CS1.2.3 Landscapes
- CS1.2.4 Human interrelationships with environments
- CS1.2.6 Familiarity with SD

CS1.3.2 Experiences other than compulsory science education

RQ2 Finding 1 [Formal education]:

Compulsory education: Geography is the main experience James associates with EE. It is clear from statements in CS1.2.7 that he engaged more with his experiences of geography than with his experiences of science education. Three factors appear to underpin this. Firstly, the nature

and content of geography appealed to James' 'outdooriness' – a factor he links to his childhood experiences as a Scout and his parents' encouragement for him to assume their interests and lifestyle. Secondly, he was motivated by his geography teacher's interest in environmental issues. Thirdly, James has a learning disability. He believes that he cannot write and therefore, prefers experiences that offer kinaesthetic and sensory engagement with environments.

Other espoused links to formal education include ICT. In CS1.2.5 James states his belief that computer literacy is 'a very useful tool' and suggests that he makes use of electronic media to support his self-directed reading on 'things that the government is not showing you'. There is also a tacit link to history in CS1.2.6 as he talks about Roman use of building materials.

Post-compulsory education: Tacit links: (i) James' media awareness has perhaps been enhanced by his media studies course; and (ii) content in his discussion of environmental impacts of urban environments in CS1.2.4 is consistent with aspects of AS/A level geology.

RQ2 Finding 2 [Other life experiences]:

Family and upbringing: The most frequently espoused experiences in this case study reflect those James most associates with the development of his values, i.e., his relationships with his immediate and extended family and his personal experiences. James talks about his family with great affection and his responses suggest that a general outdoor lifestyle has pervaded his upbringing. James' understanding of agricultural environments and sustainable woodland management appears to stem from the occupational expertise of his father and brother-in-law. He also believes that experiences of upbringing influence an individual's:

- perceptions of environments;
- respect for environments;
- sense of individual responsibility towards environments.

Personal experiences: James beliefs and values are supported through his first-hand experiences of being outdoors and through self-directed reading. These actions appear motivated by his interest in outdoor environments and his enjoyment of informal discussion and debate in social situations.

Institutional experiences: James had been a Scout. He is also interested in current affairs and likes to keep himself informed on environmental and political issues. Media sources drawn upon include national news bulletins. However, James believes that media information should not be trusted and that individuals should not take media reports at face value.

RQ2 Finding 3 [Non-specified experiences]: James' environmental attitudes and understanding appear to be supported by a range of non-specified experiences relating to cultural, economic, social, political, and aesthetic factors. Sources of this awareness are sometimes explained loosely in terms of, 'my way of life' and, 'my general interaction with the world'.

CS1.4 General observations

James' choice of subject to explore through photography created several opportunities to draw upon science in relation to main theme of *Rubbish as its own object*. His views on recycling in CS1.2.2 demonstrate an awareness of issues relating to energy, resource use and ecology as he makes comparisons between the environmental costs of recycling paper and the sustainable properties of managed woodland. In expressing these views, James effectively makes a cost-benefit judgement on recycling underpinned by his understanding of economics and science.

First-hand observations of changes that occur when refuse is left undisturbed are described in terms succession, i.e., the life processes of green plants, how animals feed on vegetation, and predator-prey relationships. This demonstrates some awareness of trophic levels in ecosystems. Yet, it is difficult to judge whether this is attributable to James' experiences of NC science. There might be other influential factors at work. For example: (i) James' immediate family are interested in outdoor environments and his brother-in-law is a farmer; (ii) James is observant and engages in self-directed learning. So, is there any other evidence? The way James communicates might provide some insight. His vocabulary and his sequential description of plant-to-insect-to-bird-to-cat reflect the kind of linear representations of food chains demonstrated in science lessons. Thus, it is reasonable to suggest that he might be drawing upon formal knowledge of *Green plants as organisms* and *Living things in their environment*.

James incorporates substantial scientific reasoning into his argument against the idea of SD. This content is drawn upon in relation to his belief that humans are incapable of 'managing their own systems' and appears to relate to *Application of Science* as he considers the benefits and drawbacks of scientific and technological developments in context of human health issues and the environmental impact of war. He also appears to draw upon content from *Life processes and living things* as he talks about: (i) the accumulation of toxic materials in food chains (DDT); (ii) how humans compete for resources ('omnivore everything up'); and (iii) how the impact of human activity on the environment is related to population size and economic factors. This content is closely interwoven with other economic, political, social and cultural awareness in a

passionately expressed argument against human values in relation to: (i) non-human life; (ii) human conflict which results in environmental destruction; and (iii) human applications of science, i.e., the use of pesticides, that hold long term ecological consequences for other living things.

James' references to Eskimo cultural practices in CS1.1 demonstrate his ability to: (i) draw upon his awareness of how other cultures use natural resources; and (ii) evaluate how these environmental practices conform to his own values. James' clear approval of using natural resources in ways that result in little waste, suggests his personal values favour traditional ecological practices of the types still used by some indigenous cultures. These ecological values, and his notion of interdependency between human and non-human environments, are applied consistently in his arguments on human interrelationships with their environments. However, his perception that human activity *per se* is not destructive to environments is perhaps an oversimplistic viewpoint that might be improved by making a more effective links between aspects of formal knowledge. For example, in CS1.2.6, James demonstrates a rather naïve perception of the environmental impact of Roman technology and actually begins to recognise flaws in his argument as he talks. Yet, he is unable to resolve this. His argument also conflicts with an earlier view that military activity poses a threat to environments. Therefore, James might potentially revise, or strengthen, his position with a better scientific understanding of the global environmental impact of resources used to support the Roman Empire. This is an example of where teaching pupils to recognise linkages between history, science, geography, economics and politics might facilitate a better understanding of human interactions with environments.

James' references to individual responsibility suggest that he believes in the power of the individual to make a difference and that all people should be responsible for their own environmental actions. His values are evident in his strength of feeling on specific issues and he is not easily swayed from his adopted stance. His perceptions and feelings on these issues appear largely driven by his personal values and assumptions about how things should be done. As such, his views emerge as being very black and white and his arguments are subjective, frank and strongly defended. Interestingly, the phrasing of the questioning elicited contrasting perspectives on human interrelationships with environments. For example, when asked for his views on man-made environments, James observations included positive comments relating to managed environments - indicating his belief that some human impacts on environments offer potential social, aesthetic and ecological benefits. In contrast, when asked for his views on the impact of human activities on environments, James' thinking focused almost entirely on negative outcomes.

CS1.5 Case study conclusion

Examined as face value, there is little in this case study to suggest that James' compulsory science education features highly amongst the experiences that he recognises as developing his awareness, understanding and respect for environments. Yet, he has clearly demonstrated that he is able to draw upon his understanding of science to support his position on environmental issues. His language, and the way he supports his reasoning with pertinent examples, suggests that he is interested in environmental issues and is developing a sophisticated awareness of human interactions with their environments and other living things. In exploring issues arising from Rubbish as its own object, James has drawn upon his awareness and understanding of: (i) scientific, cultural, social, economic and political factors relating to human interactions with environments and other living things; (ii) scientific understanding relating to managed and urban environments; (iii) aesthetic values relating to the impact of human activities on the environment; and (iv) scientific understanding relating to environmental issues such as recycling and SD. The language and structure through which he has communicated this suggests a tacit link to elements of NC science. This scientific content is interrelated with:

- *other formal knowledge [literacy and ICT skills, geography, history];*
- *social, cultural, economic, political, aesthetic and media awareness;*
- *personal, social and cultural values.*

James' supporting written work for his project was minimal. Yet, his annotation was articulate and served as a good stimulus for the interview questioning. His performance in the interview was confident and he communicated his views on complex environmental issues in a relaxed and entertaining manner. This case study as a whole serves to demonstrate how James has assimilated learning from a variety of experiences into a coherent worldview on human interactions with their environments and other living things. His thinking is naïve at times. Yet, on the whole, his commentary is insightful and clearly articulated. This suggests that James has achieved some level of functional environmental literacy which enables him to engage with environmental matters as-and-when opportunities arise. Even so, any claims relating to the success of science education in fulfilling its role to support EE/ESD, which are based on the outcomes of this case study, must be tentative since James' believes geography is the main school subject linked to EE. He has also indicated that other experiences such as family, upbringing and self-directed learning have been more influential in shaping his awareness, understanding and respect for environments.

CS2: Suzanne

CS2.1 Photography project

Suzanne's project, entitled *Human Changes to Landscapes*, explores social, economic and environmental effects of woodland clearance in local environments. Practical exploration comprises three photoshoots taken in two different locations: (i) a private golf course in the grounds of a large country estate; and (ii) areas in and around the college site. Four images have been merged to create two multiple-image compositions that serve as the final piece for the project. Suzanne identifies the purpose of these images in her work journal:

Image 1 shows a car park where there once would have been woodland. This represents the changes we make to landscapes by showing what is put in place of a cleared area.

Image 2 shows an image of the golf course - an idea of a large space, yet only two people using it. The fence shows that this is not a public area so most people cannot use this area now - only members of the golf club. The colour suggests the whole world is warped around them.

The background layer of both images consists of a woodland scene. This is inverted, i.e., it appears in negative and, therefore, stands out against its overlay which represents the developed environment. The composition is further enhanced by a creative use of strong colour to produce a visual effect that is both abstract and striking.

Suzanne had initially decided to respond to the *Portraits* brief on the grounds that this was compatible with her previous coursework. However, by the end of the introductory presentation she had changed her mind. In the interview, she explains that this decision was influenced by an event that had occurred the previous day. She had visited a country park with her boyfriend and they had walked along a public footpath through woodland which brought them to the edge of a golf course. Based on her boyfriend's local knowledge, they had assumed they were still on a public right of way and so continued walking. However, their presence on the golf course was challenged by some players and this resulted in a confrontation. Angered by this, her boyfriend informed Suzanne of changes to the park landscape that had been made in order to develop the golf course.

As Suzanne's account unfolds it becomes apparent that her decision to respond to the MML brief was spontaneous and related to her anger at the injustice of this situation.

The golf course people had a go at us. (*laughs*) I'm trying to get back at what they've done to *my* landscape! []. We'd looked at the golf course and I thought it was a bit bad how they'd done it, and I'd wanted to say something against it to them anyway, and then this came up and I thought I could have a go . . . have a nag about it in this Unit.

As such, Suzanne's final piece was not designed to be a purely pictorial response. Her images were intended to convey certain ideas about human attitudes and behaviours:

I thought on this one [*points to image 2*] - the one with the little golf people on . . . there were only those two on the entire golf course and it was . . . like, everyone else was in the woodlands walking dogs and enjoying that, and there was only two people being able to enjoy the entire golf course.

With rich, saturated colour distorting the each layer, this image is evocative of storm light and is thus, threatening in its impact. Suzanne evaluates this effect by stating:

I like the image because I feel like there are these two people there, but their whole world seems to be warped around them.

According to ISP records, Suzanne's ideas did not deviate from her initial planning and, although she encountered some technical problems with merging the pairs of images, she was satisfied with the final result. When asked in the interview if she felt her images had symbolised her views on human interrelationships with environments, she replies:

Yes . . . like, mostly it seems that we have to twist the environment around us, to suit us, instead of being able to adapt and just live with the environment.

Her image of the golf course attracted much interest and positive feedback from her peers. Yet, she was undecided as to whether the project as a whole had facilitated any greater understanding of human interactions with their environments. Her conclusion was:

Some people can be kind and open to everything . . . and then some people will ignore it and just like . . . just go and do something else.

This was clearly an issue Suzanne had felt strongly about at the time and, when asked if she felt exploring this through photography had helped in any way, she observes:

Yes . . . in getting it off my chest (*laughs*) but maybe not with my anger!

CS2.2 Main subjects discussed in the interview

CS2.2.1 Ideas for the project

Suzanne identifies three main ideas for her project in her work journal:

1. To show the beauty of what we are spoiling.
2. To show what we are doing to natural woodlands which should be preserved for wildlife.
3. To show what we are putting there in its place.

She then indicates the problem:

In [*name*] Park, there used to be a lake, which was home to vast amounts of wildlife and attracted many families. However this PUBLIC lake was filled in to create a new golf course, which is only open to those who have a MEMBERSHIP! I feel that this is a major travesty and wish to show through taking pictures of another lake in the park and then the cleared area for the golf course EXACTLY what beauty they have destroyed!

Her use of upper case letters when expressing these thoughts serve to demonstrate her strength of feeling on this issue and, in the interview, Suzanne sets out her position:

I was just thinking about . . . erm . . . how Man had changed the landscape and was just generally destroying what was there originally and putting in what he felt should be there instead.

She goes on to describe what she had expected to see and record during her photoshoots:

Well . . . erm . . . when we'd been before . . . there's always been ducks and this time there were those Canada geese. Before, we have seen a few deer running around in the woods . . . erm . . . as well as people who go and take their animals and we . . . erm . . . saw a heron once.

Whilst taking photographs, Suzanne also observed some wider social benefits of public access to landscapes that hold mutual benefits for both people and wildlife:

There was loads of people just around the lake feeding the ducks and obviously they get joy out of . . . pleasure out of being there and the ducks get fed.

However, she goes on to imply that competing priorities can affect people's attitudes towards environments:

I've been thinking about how certain groups of people just want things to be their way. Erm . . . maybe like the rest get on with it, but certain people will always want something their way.

CS2.2.2 Awareness of environments

Suzanne links her general interest in environmental subjects to her parents' interest in environmental issues.

They kind of interest me generally because my parents used to be members of Greenpeace and so I've got like posters from when . . . erm . . . they were actually leaders of a thing that used to be in (*place name*) or (*place name*) but they actually used to go and put up the big stalls and hang posters up and get petitions and stuff.

Suzanne indicates that she had been too young to participate in these activities. Yet, when discussing her prior awareness of issues explored in her project, she indicates that her parents had always held information and leaflets on issues such as pollution and deforestation. When asked if she had discussed her ideas with her parents, and/or used any of this Greenpeace information to inform her project, Suzanne indicates that she had not talked to them and that there was a practical reason why she had not accessed this literature:

I couldn't find them unfortunately, because we moved house last year we've put them all away.

Whether this is an excuse to explain an oversight on her part, or whether this is indeed the case, is impossible to judge. Based on evidence in her work journal, Suzanne's research to inform this issue is patchy and indicative of a student who has prioritised first-hand recording and observation through photography over carrying out anything beyond image analysis to satisfy the coursework requirements. Suzanne did, however, discuss her ideas with her photography teachers and explains:

I was wanting to get an idea of your opinion of my ideas at that time . . . so . . . if you thought I was on track with what I wanted to do or not?

When asked if she had considered asking her photography teachers about information relating to the environmental issue itself, she appeared a little surprised by the question.

No (*slight pause as she considers this*) it just didn't occur to me. Maybe should have done?

This implies a perception that, although photography teachers have expertise in photography, they are not recognised as having specialist expertise relating to subjects explored through photography.

As this exchange continues, it becomes clear that Suzanne's exploration of the issues at the country park was largely informed through her boyfriend's anecdotal accounts which she had subsequently supported through first-hand observation whilst taking photographs.

He told me what they'd actually filled in . . . and they'd actually filled in this lake that had been there before to make this golf course. So we went and had a look and . . . you can only go there if you pay money.

As such, she did not seek out any historical information relating to the country park and the development of the golf course.

This was mostly what I already knew, but if I didn't know about it I'd probably go to somewhere that did. If there was an information desk which would . . . if there was like . . . a book on the history of the woodland . . . of the area . . . then I would probably have a flick through that to see if there was anything I could pull out, on anything I could find at all, on why the area had been cleared like that. Also, I would probably look for books in the library on deforestation.

Suzanne attributes her existing knowledge of the issues explored in her project to variety of experiences:

I've watched a few programmes on environmental issues on the TV and . . . erm . . . my auntie and uncle live in quite a wooded area and so they're always doing things to help and then they'll tell me. My parents are in Greenpeace so, as I've said before . . . maybe it has just sunk in . . . they've probably said stuff to me that's just gone in.

Her initial photoshoot was informed by photographic images and biographical information on artists who had explored similar environmental subjects. Suzanne identifies the sources of this information as: the Internet; books on wildlife; and books on photography. She judged the content of the wildlife books to be unsuitable for this purpose. However, she was attracted to David T. Hanson's (1997) book *Waste Land* and describes how she conducted additional Internet searches to look at similar types of images:

I thought if I typed in . . . erm . . . what my ideas were into Google . . . the images would actually come up in the image search. []. I typed in 'deforestation'. Then 'pollution' came up with the power station.

Suzanne suggests that she automatically uses the Internet as a way of accessing information, and that she had searched for artists whose work would ‘fit in’ with her ideas. She also indicates that her choice of images to include in her work journal as evidence of research was influenced by the artist’s interpretation of the issue rather than the content of the image. She then demonstrates that ICT skills are useful in enabling the Internet user to know how to search for information:

You have to do searches within searches. []. If I found the image I wanted, then maybe I’d do another run using the name of the photographer to find . . . like, parts that related to that photographer, or that relate to that picture, or that relate to their work in general.

In evaluating the content of information retrieved from websites, she observes:

Some of them were really good for what I wanted, but some of them they’re just like, you go on them and there is actually nothing of what you want at all. Like, some of them have pictures from the people you want, but they won’t have the titles on, or the dates or anything like that?

Although a confident Internet user, Suzanne believes that people are the most reliable sources of environmental information. Yet, she was unsure as to who might offer appropriate scientific expertise to support her understanding of the environmental issues explored. She tentatively suggests ‘maybe environmentalists’ – defined as, ‘Members of environmental organisations’. She is however, unable to describe what form this expertise might take.

CS2.2.3 Effects of woodland clearance

Suzanne had used the terms ‘natural woodland’ and ‘wildlife’ quite frequently during her project and interview. She defines ‘natural woodland’ as:

One that’s stood there for a long time . . . maybe like . . . for thousands of years . . . and that hasn’t been disturbed by Man.

And ‘wildlife’ as:

Like . . . from like . . . from little insects to . . . like birds and . . . all of the animals that would probably use the woodland . . . like there’s deer and frogs and just . . . little animals that . . . erm . . . that might inhabit the woodland.

She attributes this awareness to watching nature programmes and ‘school’:

If you watch nature programmes ‘wildlife’ always means animals. If you’re in school, ‘wildlife’ means animals.

Suzanne's use of the term wildlife can be seen in context of her annotations on images selected from her third photoshoot:

Enlargement 15: I really like this image. It is of a cleared area. This has now turned to marshland and has been walled off. I like how the grass has grown and covers the marsh over. I feel this image depicts the effects that clearance can cause. In this case it has made a home for life that lives in marshy areas.

Enlargement 16: I was walking around the lake to see if there were any other good shots I could get, when I saw these Canada Geese residing in the park. [] I'm pleased with how it [reference to image] has turned out, as it shows some of the wildlife that benefit from having these kinds of areas.

Enlargement 20: I feel this image shows what plant life resides around the lake. As well as the trees there is moss and some tall grass which as you can see is thriving. I feel this photograph could be used to show what plant life has been destroyed by filling in the lake.

These annotations demonstrate Suzanne's perceptions of the effects of woodland clearance. Yet, there appears to be some distinction between the terms 'life', 'wildlife' and 'plant life'. Suzanne had previously indicated that 'wildlife' means 'animals'. Therefore, this term is readily distinguished from her reference to 'plant life'. However, it is not clear whether there is any further difference in meaning between her use of the term 'life' and her meanings for 'wildlife' and 'plant life'.

The annotations as a whole relate to changes to habitat and demonstrate Suzanne's awareness that there can be both detrimental and beneficial outcomes of woodland clearance. She understands that some species (plant and animal) will suffer through habitat loss, whilst others (plant and animal) thrive because they are adapted to the changed environment. However, when asked if she felt there was there any particular information relevant to the points she was making she did not, as anticipated, refer to aspects of science. Instead, she suggested that it would be useful to know: (i) 'why it was being cleared'; and (ii) 'if there was something that was going to be put there to maybe put the good back in'. She then explains what she means by this:

S: It is important to have something that would be equally as good in there instead of just taking out a big chunk of forest and putting nothing back into the earth. I can't really explain it . . . I can't put it into words.

I: What are you visualising?

S: It's like . . . when you get new motorways put in, they put trees at the side of the roads to try and balance out what they've done. But, in this particular place, there was nothing put back in . . . it was just taken out and left . . . they just took out the lake for the golf course and I've found out that apparently there are two other golf courses in the area already.

From this it would appear that, even though golf courses are effectively green spaces, as opposed to urban environments, Suzanne equates the development of the golf course with 'putting nothing back into the earth'. This appears counter to her previous understanding that clearance creates habitat for life adapted to changed environments, and points towards other influential factors that relate to social and economic awareness, emotion and personal values. This is evident in her implication that there are already sufficient golf courses in this area.

As the discussion moves on to focus on other effects of woodland clearance, Suzanne comments on the aesthetic impacts of changes to landscapes and observes that clearance 'kind of makes the place look ugly as well'. There are no indications as to where Suzanne's aesthetic values and her perceptions of beauty stem from, or indeed anything to offer any further insight into what these entail. However, throughout the project Suzanne indicates that she considers beauty to be important, and that she associates woodland environments with both beauty and ecological stability. In doing so, she makes a tacit reference to issues associated with SD and recognising the needs and rights of future generations:

Like it's all really nice and beautiful, and they've taken it out, and the future generations won't be able to experience that same beauty that people have felt before, 'cos it's now gone and it won't ever come back.

When asked if she felt the effects of clearance were detrimental to wildlife, she offers a reasonably balanced view of the process which conforms to the previously cited observations in her work journal:

Not for some types, but maybe for the ones that were living there before. There were . . . like . . . little birds nesting in the trees and now they have no home.

Yet, when the same question is applied to the development of the golf course, Suzanne's balanced perspective disappears. Her initial response is that open spaces are detrimental to wildlife (birds) on two counts:

Well there wouldn't be as much area for birds to nest in . . . erm . . . because it is a wide open space and they wouldn't have anywhere to hide from predators.

Her final graphic comment indicates her perceptions of what might happen to some wildlife:

If there were any rabbits creating burrows on the golf course they'd probably [*performs stabbing and wringing neck actions*]. []. Remove them!

Suzanne is clearly allowing her emotions to colour her judgment here. She has no respect for members of the golf club and this appears to be reflected in how she expects these people to behave towards wildlife.

CS2.2.4 Message conveyed through final piece

Suzanne wanted to convey a message to the viewer that humans choose to adapt, rather than live with, their environments. She indicates that this perception of human actions and priorities reflects her general thinking about environmental issues. As an example of her general thinking, she talks about her views on world events:

S: It was . . . like . . . about the Kyoto protocol as well, and how America's pulled out of it because it doesn't suit them, so they're forsaking the world's future just for themselves.

I: Interesting point. Can you expand on this?

S: I think it's because their economy thrives on being able to do these certain things that need to be taken out. . . erm . . . because they all seem . . . I dunno . . . it's just that America has always been portrayed as the money-grabbers, the greedy ones, and that they don't want to do that, so the rest of the world has to suffer instead of them just being able to make a compromise.

This demonstrates political and economic awareness. It also conveys Suzanne's thoughts on American cultural values. Yet, Suzanne identifies the primary source of this insight as her interest in music which, she suggests, coincided with aspects of her General Studies course and led to some self-directed research:

Well . . . erm . . . I recently got into a band . . . a really political band and one of their songs is all about America pulling out of the Kyoto protocol, and so I heard that and I thought, '*Ooh that's good!*'. Also, in General Studies they had a whole thing on it as

well . . . so that came after that, and then I went away and just researched it on the Internet.

CS2.2.5 Sustainable development

Since Suzanne had already touched on issues relating to sustainability and the ecological effects of changes to landscapes, it seemed sensible to probe her familiarity with issues relating to SD. In response, Suzanne indicated that she had not heard of SD. So, moving on from this, the questioning focused on her views on conservation. Her initial attempts to attach any meaning the term ‘biodiversity’ were tentative:

The term is familiar. I think it’s like . . . the rate at which plants grow and . . . the areas in which they grow. I’ve heard the word, but I can’t . . . I don’t know what it means at all.

On the subject of wildlife conservation, Suzanne talks about ‘conservation parks’ in terms of ‘places where animals are protected if there is an endangered species’. When asked what she thought wild animals needed protecting from, she observes:

Man for one . . . and maybe any predators. The conservation parks . . . they’ve endangered species and . . . like . . . people who . . . when people prey on their skins and stuff. Like tigers, I’d expect to see them in a wildlife conservation park ‘cos you are conserving that species and . . . if you don’t then they’ll be no more. Protection from people actually doing things to them, rather than natural things that are happening.

Although Suzanne does not indicate the source of this insight, her comments imply familiarity with issues related to poaching. There is also a tacit suggestion that human actions are different from ‘natural things that are happening’ - a point that was being pursued until she suddenly interrupted her flow of ideas with spontaneous laughter and an announcement of, ‘I’ve just remembered where I’ve heard biodiversity now! It’s on a computer game I’ve got!’ She goes on to explain that the program is about aliens and that it is fantasy rather than science. However, the principle of the game has raised some kind of awareness that environments contain a range of species that are associated with what Suzanne describes as, ‘a certain type of terrain’.

CS2.2.6 Experiences of compulsory education

Suzanne had previously spontaneously linked her understanding of the term 'wildlife' to her school experiences and she confirmed this as she talked about her experiences of EE in compulsory education.

S: Yes . . . like there are some things you learn in school . . . like . . . I'll probably revert back to them and think about what's been there.

I: Could you give any specific examples of this?

S: Like . . . like . . . say with wildlife . . . it's been taught that wildlife always means animals . . . little wild animals running around . . . in school.

Yet, as the focus turns to her experiences of science education, Suzanne's response is both negative and emphatic. When asked if she considered anything she had learned in school science to be relevant to her photography project, she becomes openly irritated.

No! *Science* . . . what's that? I've never been good at science and I've never really got on with it. I just hated it so much and my teachers told me I was rubbish at it. One of my teachers . . . I gave him my coursework in and he gave it back to me . . . and when I asked him what was wrong with it and he told me that it was just a load of rubbish. And I was like . . . I've worked for hours on this piece of coursework and he just told me it was rubbish and threw it back in my face. So I've never really got on with science.

In spite of this, Suzanne's next comment suggests she believes that science, as opposed to science education, is relevant to developing awareness and understanding environmental issues:

Yes . . . like in the research into certain areas and the science that's involved to actually make the research possible. Like . . . you've got to have . . . if you've got technical equipment then it's all been scientifically formed . . . and tested . . . erm . . . so I think it's relevant in that. Also, if there's like . . . if you like . . . trying out certain areas where animals will be suited if they are being re-homed.

CS2.3 Case study findings

CS2.3.1 Experiences of compulsory science education

RQ1 Finding 1 [Experiences of science education]: There are no spontaneous references to experiences of compulsory science education in this case study.

RQ1 Finding 2 [Perceptions of the relevance of science education to EE/ESD]: Suzanne does not connect her experiences of compulsory science education to EE and has not heard of the term SD. She did not engage with questioning relating to her experiences of science education other than to state that she did not enjoy the experience. It is clear that she considers herself to be ‘rubbish at science’ and this perception appears to have been compounded by the attitudes and behaviour of a particular science teacher. In contrast, she recognises the value of science in furthering what is known about environments and conservation through research, and expresses a view that, ‘If you’ve got technical equipment, then it’s all been scientifically formed and tested’.

RQ1 Finding 3 [Tacit evidence of content consistent with NC science]: In making her decision to respond to the MML brief, Suzanne’s first-hand personal experiences have coincided with a practical opportunity to explore her feelings over a particular situation. This generated opportunities to draw upon science in the following context:

- CS2.2.3 Effects of woodland clearance

Tacit content drawn upon in this context is consistent with NC science *Life processes and living things; Application of science* and *Communication*.

CS2.3.2 Experiences other than compulsory science education

RQ2 Finding 1 [Formal education]:

Compulsory education: Suzanne makes one spontaneous reference to ‘school’ in connection with her understanding of the term ‘wildlife’.

Post-compulsory education: As she talked about her awareness of American attitudes to environmental concerns, Suzanne indicated that her General Studies course, together with her current interest in a particular form of music, made her want to find out more about the Kyoto Protocol through self-directed study.

RQ2 Finding 2 [Other life experiences]:

Family and upbringing: Suzanne mentions her parents’ involvement with Greenpeace as a factor in facilitating her general interest in environmental issues, and with developing her awareness and understanding of specific issues. She also mentions the proactive environmental attitudes of her aunt and uncle. This suggests there is a general family position on environmental issues that facilitates action to promote conservation.

Personal experiences: A significant social influence on Suzanne at this time is her relationship with her boyfriend. Her project is based on first-hand observations stemming from their mutual experiences at the country park. Her understanding of this situation is underpinned by her boyfriend's anecdotal evidence, her personal values, and some limited self-directed research to inform her photography. Suzanne is the only student in the sample to link an interest in music to developing aspects of environmental awareness. She also links one particular computer game to developing her awareness of the term 'biodiversity'

Institutional experiences: Suzanne connects her awareness of environmental issues to television (nature) programmes.

RQ2 Finding 3 [Non-specified experiences]: Suzanne's actions demonstrate an understanding that human changes to environments involve aesthetic, cultural, economic, social, political, media and ecological factors. There are however, no indications how she might have arrived at this understanding. She also expresses strong personal values relating to aesthetics, economics, elitism and equality. Since Suzanne links her environmental awareness to the interests of her parents and extended family, her personal values possibly reflect the influence of her upbringing. Yet, there is no clear evidence that this is the case, and her personal interest in the music of what she terms, 'a really political band', might equally be in the frame.

CS2.4 General observations

Suzanne's motivation for undertaking this project was primarily her resentment at being confronted over her accidental trespass onto a golf course in a country park. Although she was not overly familiar with the country park prior to this project, she quickly identified with this environment - even at one point referring to it possessively as 'my' landscape. Probably the single most powerful influence on Suzanne's thinking for this project was her relationship with her boyfriend. Their mutual experiences at the country park, combined with his anecdotal evidence relating to historical changes to the estate, shaped Suzanne's perspectives on the golf course. Suzanne's feelings about the golf course do not appear to relate to her understanding of ecology, but rather to her need to protest at her treatment by the golfers. Her values relating to an economic rationale for restricting public access to landscapes are strongly stated in her work journal. As such, her views on the golf course as an environment are coloured by her keen sense of injustice.

So, did Suzanne's interpretation of the MML brief affect her opportunities to draw upon science in this context? The theme presented opportunities to draw upon science in just one of the subjects discussed in the interview. This was also evidenced in her work journal through her annotations of photoshoots 1 and 2. The way Suzanne acted, as shown in CS2.2.3, was to examine the ecological implications of changes to an ecosystem for wildlife (some species lose, some species gain) and the social implications of changes to landscapes for people who use this environment. It is clear that she is able to link her understanding of science to the care of living things and the environment. She is also acutely aware that the impact of human activities on the environments is related to economics. She is able to explain that different habitats support different plants and animals and draws on scientific vocabulary as she describes the things she observed in the park. For example, trees, moss, grass, insects, birds, deer, frog, heron, rabbits. Her understanding of the ecological impact of woodland clearance is also interrelated with her aesthetic values. This involves her perceptions of 'ugly' and 'beauty'. Her views on this subject demonstrate an unconscious link to ideas of sustainability as she observes that whatever beauty is destroyed by changes to landscapes now is no longer available for future generations to experience and appreciate. However, when asked if she was familiar with SD, Suzanne indicates that she had not heard of this term.

The issue of human changes to landscapes is one Suzanne has reacted to rather than researched. The golf course is not a recent development as she had assumed it to be. Yet, sections of the park estate were, at some point in time, landscaped to form a municipal golf course which has subsequently become a private enterprise. It is this aspect of change that Suzanne finds distasteful – the idea that access to an environment should be restricted to those who can afford to pay. Therefore, the exclusion of the general public from land previously available for community use formed the main focus of Suzanne's project, and the ecological impacts explored were presented as evidence in support of her argument. The outcome is that, although Suzanne recognises that human changes to landscapes can benefit species adapted to the changed environments, she only ever portrays the development of the golf course in terms of being detrimental to wildlife and restrictive to certain people. This suggests that emotional, rather than scientific, reasoning underpins Suzanne's judgement of this situation. Yet, would a better understanding of science have helped Suzanne take a less emotional position on this issue? It would perhaps have allowed her to present a far more informed and balanced overview of the situation. However, Suzanne's values reject elitism and, under these circumstances, it is unlikely that a better understanding of science would change this. This finding lends weight to Ekborg's (2003) observation that an improved conceptual understanding would not necessarily make a student change their mind on a controversial issue.

CS2.5 Case study conclusion

The MML brief presented Suzanne with a timely, practical vehicle through which she might explore her feelings about what had happened during her visit to a country park. In exploring issues arising from this, she has drawn upon her awareness and understanding of: (i) social and economic factors underpinning changes to landscapes; (ii) scientific factors relating to changes to habitats and adaptation; and (iii) aesthetic values relating to her perceptions of beauty and ugliness. This scientific content is interrelated with:

- *other formal knowledge [literacy and ICT skills];*
- *social and economic awareness;*
- *personal, social and aesthetic values.*

Suzanne's annotation of her project is detailed and was helpful in supporting her responses in the interview. Although angry at the members of the golf club who had challenged her, she also exhibited a wider sense of equality that took into account the impacts of change for wildlife, people and pets. Yet, Suzanne was unexpectedly self-conscious in the interview and might have felt more comfortable had this taken place in a familiar classroom environment as opposed to the college interview room. Her responses in the interview were often short and, of all the interviews across the sample, this one required the most intervention to elicit detail. However, in spite of this, Suzanne talked about her chosen theme with enthusiasm and demonstrated an attitude of care for the environment.

Suzanne's awareness that change affects future generations is consistent with ideas of sustainability. However, any claim relating to the success of science education in fulfilling its role to support EE/ESD must take into account Suzanne's espoused antipathy towards the subject. If judged in relation to her CGSE result in science, and her work ethic in AS photography, Suzanne is a good student. Yet, she has clearly not engaged with her science education and has left school with a view of herself as someone who is 'rubbish' at science. Whilst it is recognised that this case study presents only Suzanne's version of events, this is still an undesirable outcome of science education. A positive outcome is that, in spite of her school experiences, Suzanne recognises the social and cultural value of science as a means of advancing what is known about the environment and conservation. This suggests that she perceives an essential difference between science education and science – the former is judged to be intimidating and uninspiring, whilst the latter is seen as acceptable and useful to society in furthering research.

CS3: Ciaron

CS3.1 Photography project

Ciaron's project, entitled *The Impact of Human Activity on the Environment*, began as a visual contrast of natural and man-made landscapes and ended as a documentary of human impacts on human environments. Practical exploration comprised four photoshoots documenting areas in and around urban environments. The fourth and final photoshoot was driven by an idea that environments are changed by the impact of advertising and, for this idea, Ciaron recorded images of billboards, posters and graffiti. Ciaron's annotation indicates his emphasis on exploring the aesthetic impact of advertising:

I was looking at the billboard because of the fact it is unused. In a world where advertising is everywhere it is strange to see wasted space. Someone has gone to the effort of putting this up and now it has effected the environment by being a white square rather than its intended purpose.

Ciaron selected two black and white prints for his final piece. Both images are representational in style. The first shows an empty, decaying billboard on the side of a building. The second shows what Ciaron describes as an 'anti-war/anti-government poster'. The purpose of the piece is:

To make people want to notice their environment and how we change this by how we advertise or display propaganda or deface or enhance walls with graffiti.

Ciaron had been absent for the introductory presentation. However, on his return he requested a copy of the MML brief. In the interview, Ciaron indicated that he had wanted to continue his interest in documentary photography, yet he had also wanted to try something different. Therefore, of all the titles offered, he felt the MML brief presented him with the greatest scope for ideas on the grounds that, 'the environment covers everything':

Most of my stuff had been very city-based, urban stuff. It was . . . nothing very natural in it, and I kind of . . . I wanted to do something other than stuff I'd done before. So, I thought taking pictures in the woods is the furthest from anything I've done, so I'll go and take some 'naty' photos, you know?

However, this did not transpire quite as Ciaron had anticipated – a view encapsulated in the following extract from his work journal:

The project should be titled Evolution, because it is the first unit where my work has truly, well evolved. Usually I more or less know where I'm headed, and along the way I play and explore different ideas while never straying too far from the master plan. My ideas for this unit have moved much more organically.

Although his final piece was well received by his peers, Ciaron was ambivalent about its impact. He is clear that, whilst an image might engage the viewer, 'it can only show them what you saw at the time'. Therefore, he felt the second image in particular was ambiguous and that viewers might read the poster rather than recognise its environmental impact.

I didn't want it to be, 'The message is, No More Lies Mr Blair', I wanted it to be, 'This is what's out there - look at the visuals of it, not the political underlying message!'

In spite of this concern, Ciaron felt this project had encouraged him to engage with 'environmental stuff' and suggested that, as a method of exploring issues, 'photography can force you to look into things in a little more depth'. He says of this experience:

It's not something I'd normally think about, or talk about, and . . . but . . . for the few weeks I was working on this, it kind of bumped it up the list a little bit and when somebody mentioned something about it, I kind of paid a little more attention to it. It's still not one of my top list, but I've done this now - I have looked at the impact of human activities on environment and it's always gonna stick in my mind.

CS3.2 Main subjects discussed in interview

CS3.2.1 Definitions and environmental awareness

Ciaron's definition of environment is framed in terms of the human impacts explored in the project:

The environment I was looking at initially was pre-human impact so, something that has little or no human impact on it. Later, it kind of changed into meaning the environment as in the cities we live in, and the impact of humans on the environment in which we live. This could be looked at as the impact on the impact that we've already made.

Ciaron indicates that he is aware of 'the basic stuff' yet, does not consider himself to be particularly environmentally aware.

Um . . . I dunno. I think I'm aware of stuff. I try to pay attention to stuff like that but, as far as . . . er . . . Greenpeace, hippie-style stuff . . . I don't know as much as I probably should 'cos . . . I know it's stuff you ought to keep and eye on. I know the basic stuff,

but I wouldn't call myself an expert or anything. [] I'm aware maybe in that I'm aware that it's there. I'm aware that it's happening - but I'm not . . . I dunno . . . it's not one of my major interests you know?

As he talks more about his interests and priorities, Ciaron suggests that there are things in his life which have a more direct effect on him than environmental issues and observes that:

If I lived in a log cabin in the woods and a logging company came along and chopped down all my woods I'd probably be full on at it, but that's never happened to me, so I guess I have a different take on it.

Ciaron identifies media coverage of environmental issues as a source of his environmental awareness and describes this as a 'subconscious' way of absorbing information.

I dunno . . . it's fairly covered in the general media. I mean I get a lot of it from that and I'm assuming that's my main source of . . . kind of, a subconscious way of getting information. You just see it on TV and you learn about it without even realising. Yeah, I just think it's kind of around you and if you are slightly open-minded and keeping an eye on stuff, you can learn it and see it without really having to look for it.

CS3.2.2 Ideas on human impacts on nature

Ciaron's initial idea for the project was to contrast urban landscapes with nature. He had explored something similar to this in a previous coursework unit and draws attention to this in his work journal. Yet, in the interview he suggests this was not an idea he intended to pursue:

Yeah, but it wasn't an idea like it was for the Geometric Shapes brief where one of the ones was a dandelion through a chain-link fence which . . . well, you know, pretty basic idea for that title . . . you know, nature - a little flowery thing, and then the human impact of the urban imagery - chain-link fences, but it wasn't really . . . no, I don't think so.

However, an initial lack of ideas and confidence about this subject meant Ciaron was unable to follow his usual method of working, i.e., to start with the final idea and contrive the progression of ideas to fit. As such, he discussed potential ideas with his mother on their journey to college.

C: Um . . . the '*natury*' stuff, a little bit yeah . . . with my Mom, 'cos she drives me into college and we drive right though the woods that have the borders with the '*No Admittance*' signs on them.

I: Is this part of your normal communication process when thinking about ideas?

C: Well, yeah . . . sometimes you need someone to say, 'No, that's brainless, don't do that!' just to make sure you don't go off doing something that's completely stupid!

Ciaron's first photoshoot recorded aspects of a local woodland and he explains his reason for choosing this site:

I had a slight ulterior motive. People build [BMX] bike jumps in woods and I'd kind of been talking over with a few friends about finding a good spot in like, a clearing in a wood, to build some . . . so I was up for wandering around the woods more that I would have.

As Ciaron explored the woods and took photographs he began to notice aspects of this environment that he subsequently recorded in his work journal:

There are a few 'entrances' to the woods. One thing I had noticed about these 'entrances' in the past was the 'Private. No Admission' signs. I had always thought it was kind of funny how someone could fence off some woods. I suppose if someone owned the land they could, but why would they care if anyone went in there?

Researcher's field notes show that Ciaron discussed the woodland images with his photography teacher and that the conversation touched on issues relating to commercial woodland management. However, Ciaron expressed a wish to move away from this idea and the discussion focused on ways he might do this. He expands on one particular point:

We discussed in the lesson whether I intended to convey a positive or negative message. []. I think I wanted to give a slightly more negative look because I thought it would make a better photograph. It barely even entered my mind of showing the positive impact of human activity on the environment because . . . well . . . I don't know . . . I can't even think of any.

He then qualifies this:

Well maybe it's there . . . I mean roads would probably be a positive impact, otherwise we can't drive nowhere, but . . . looking at it from a kind of an eco-warrior standpoint well, them roads are messing up the environment! I dunno, it's different ways of looking at it.

Ciaron indicates that his initial intention for the project was not to balance positive against negative impacts, but simply to show a physical line, 'like a border' between the two (natural and man-made environments). Yet, although he observes that buildings and natural features are 'bumping heads at the line', he believes that there is no distinct dividing line between natural and human environments:

No . . . it floats in between each other but, I think you'd have to know your stuff with environmental issues a little more than I would.

CS3.2.3 Sources of environmental information

Ciaron indicates that his ideas for this project were largely informed through looking at existing photographs. He suggests that these images influenced his ideas for subject matter rather than his visual approach. However, he then qualifies this statement by adding:

Nothing you think up is going to be original. It's always going to be a twist on something you saw on some show once that's subconsciously in your mind.

Ciaron indicates that if he had chosen to follow up his original idea on woodland environments he would probably have 'flicked around on the Internet for information'. He then makes two observations about the Internet as a source of environmental information. The first relates to ease of use:

Yeah, it's useful with oddball, weird subjects that you maybe only know a little tiny amount about. You can get . . . all you need is kind of like a rough title of what it is, and then you can use a search engine and something will pop up that you can look at.

In contrast, Ciaron suggests that in order to find a relevant book on a subject, the reader needs some familiarity with both the subject and the author's credentials.

The second observation relates to the reliability information retrieved. Ciaron believes that Internet content is safer when: (i) more than one website presents similar information; and (ii) the user takes note of who is providing the information. He suggests the user needs to be aware of the website's 'angle' and that all information presented is subjective:

As long as you look at where it's coming from you can take it as reliable - that it's *reliable* as *their* point of view. Just like anything, it's always going to be opinions and stuff. Unless you know it's from somewhere that you think is fact for sure but, there is *nowhere* that will give you *unbiased* facts!

As an example, Ciaron suggests that a forestry corporation and Greenpeace will present opposing perspectives on the same issue:

You know, if it's a *national forestry corporation* website and they're telling you about tree stuff, then . . . of course they're going to tell you that they're going to be nice to the woods, and no animals were hurt, and all that, because it's like, *their* angle on it.

Whereas, you know, a Greenpeace website will tell you *they're killing everything in sight!*

CS3.2.4 Social impacts on environments

Annotation in Ciaron's work journal indicates that his initial photoshoots were quite investigative, and that he found the later photoshoots easier in that he could draw on his familiarity with urban environments and his personal experiences of living in cities. Photoshoot 2 is significant in that it marked the turning point in his ideas towards the exploration of human impacts on human environments. An entry in his work journal describes an industrial location with a lake adjacent to a retail park containing the ubiquitous McDonald's restaurant. He makes the following observations:

I always thought it would be cool to get a photo of the un-developed area to the East with the golden arches in the foreground. The golden arches almost being the international symbol for globalization and development.

The lake was supposed to represent nature, to be compared to the human impact in the foreground, but I soon realised though that there was nothing natural about the lake as it was all man-made so, it was just the impact of human activity on previous human activity. I kind of liked this concept, as really, most human activity affects the already effected environments, to find un-effected environments you have to go to the rainforest or a desert.

Ciaron explains how the latter observation tied in with advice from his photography teacher to look at the work of particular artists, including Josef Koudleka. The following observation on Koudelka's exploration of cultural breakdown is recorded in Ciaron's work journal:

Now this is a social issue, rather than a physical one (which is what the environment is).
Yet the physical environment is affected by social issues.

Following up this comment in the interview, Ciaron observes that social climate affects both the way a country is run and how it looks, and that conservation is going to be less of an issue for people living in poverty-stricken countries owing to their more pressing social needs.

Um . . . if a country is poor and they're struggling to feed the people that live there, they're going to . . . conservation is going to be less of an issue for them. They're not going to think, '*Save the trees!*' They're going to think, '*We need to build a house so cut*

the trees down and build us a house! They're not going to think, *'Oh there's wild deer!'* They're going to think, *'Damn I'm hungry – I'm gonna eat me a deer!'*

To further illustrate this view, Ciaron compares the lifestyle and expectations of people living in Brazil and the USA and makes two points: Firstly, Brazil's cities are more integrated with their natural surroundings than those of the USA where, he believes, 'nature stuff is kind of pushed away and it's not such a big deal'. Secondly, American citizens might demand that Brazil conserve its rainforests without realising that, to Brazilians, these forests are 'probably a big source of their income'. On being asked how he arrived at this view, Ciaron indicates that looking at images for this project had started a thought process which allowed him to draw on his existing awareness. He explains:

I think a lot of my knowledge, I already have. Whether I know I have it already is different! Maybe this just drew out of me a need to use it and say something about it. []. If anyone asks, you might be able to tell them but, if you've never been asked, how do you know if you know it?

CS3.2.5 Human impacts on human environments

Ciaron suggests that, whilst the vandalism of a local telephone box presented an opportunity to document negative impacts of human activities, it was images he had recorded of a billboard that had inspired him to explore the impact of advertising on the environment. Ciaron observes that advertising is 'a driving force behind so many things that are done' and explains that he began looking at posters as: (i) a means of communicating ideas; and (ii) as being both 'visual' and 'effecting' things. In explaining the latter, he suggests that, whilst vandalism affects things physically, the act of putting up a poster does not actually break or destroy things since it can be removed. Yet, he believes that posters 'affect' environments through their visual impact and 'reflect' environments in that torn down posters and graffiti can be indicative of what he terms 'a bad neighbourhood'.

It may be because they're not as strict on that stuff, 'cos they have bigger problems for the authorities to deal with like, crime or housing problems . . . so picture on walls are the least of their problems. So, yeah, it affects the environment, but it also reflects the environment . . . it's not down town in some crisp, clean city.

Ciaron suggests that his preference for urban 'city' environments stems from his childhood experiences of living in Houston, Texas and Tucson, Arizona. On comparing US and UK cities, Ciaron observes a standardisation of urban design in England. He finds such uniformity visually

uninteresting and indicates the aesthetic qualities of environments are important 'because it's what's around you and you kind of need to look at it'. He also believes that people respond differently to environments 'based on their knowledge of where they've come from'. Ciaron expresses a desire to encourage people to notice their surroundings and think about things. As he relates this idea to his photography, he indicates that, for him, a good image is one that: (i) conveys a message; (ii) is visually exciting; and (iii) would make him look at it. However, he acknowledges that others might see things differently:

You know, different people are gonna look at different things. They're gonna be brought up on different stuff, so they're gonna think something different – like that bank commercial where that symbol means different things in different countries.

Ciaron identifies 'general knowledge of the world' as being relevant to understanding the impact of human activities on the environment and states:

You gotta have some basic common sense about things, and you gotta know some basic stuff like there's a world outside your home town. That'll help with looking at the environment, or politics, or anything.

However, Ciaron is not entirely sure how people might acquire this. He relates his own awareness and understanding to his upbringing:

I was lucky enough really. I was born in Texas but my Mom's English and my Dad was born in Arizona, but he spent pretty much his whole teenage years in Europe travelling, 'cos my Granddad travelled for work.

Although Ciaron describes his father as being 'not educated [] in a school-type sense', he believes his parents are 'well-educated' insofar as they know what is going on. He explains:

I mean, I was taught . . . they made sure that I knew certain things like world stuff, like racism's bad, and we need to be fair to people and look – there's England on the other side of the ocean!

He also observes that there must be parents out there who do not educate their children in the same way. Ciaron appears unable to relate to such an insular mindset and, by way of contrast, describes his own way of thinking:

When I think, I can imagine how the world spreads out . . . I can pan back and think this is going on here, and that's going on there, and I know that things are going on. But if you don't know about that stuff you're going to have a really tunnel-visioned outlook. I think I've picked this way of thinking up just by having it kind of fed to me through well-

travelled parents and my upbringing. Then travelling myself with them has kind of helped me to realise stuff.

CS3.2.6 Experiences of compulsory education

Travel and relocation also affected Ciaron's compulsory education and he describes an unconventional experience of school beginning with 'public elementary school' in the USA which covered basic literacy, numeracy and some history. He does not remember learning science yet observes:

I think we did social science which was the history stuff, but . . . I think that stage of education only prepares you for the next stage, it doesn't necessarily teach you anything you need.

Ciaron suggests that, owing to his parents' judgement that 'American schools were bad', he did not enter the US High School system. Instead, he was educated at a 'church-based' private school where his mother taught. His general verdict on this experience is that, 'I think it was probably a pretty bad school!' However, he mitigates this view with a more positive reflection on the curriculum:

[W]e did science and stuff - I was pretty 'snap' with my science there – and we did math and English language and literature and history.

He credits his history teacher with introducing him to aspects of world history and suggests that this was unusual for American curriculum content. Ciaron sees this as something positive and believes it introduced him to 'a little more knowledge' than he might otherwise have had.

Finally, Ciaron explains how his mother opted to home-school her children prior to the family's return to England:

So, yeah, but then things kicked off when my Mom stopped working there. From this point, she home-schooled us, me and my little brother for like a year or two, just before coming over here. It kind of worked out good, because my Mom was aware that the education stuff was going to be different and this was a key reason for us moving back. It wasn't the only reason, but it was kind of – better education and I can actually go to a real school without having to be frisked at the door for weapons. So we used our home-schooling years as a transition into the English curriculum. My Mom had my Granddad, who lives over here, send us over books, revision guides and whatnot, for . . . it would have been for me . . . Years 8 and 9.

Ciaron's honest appraisal of his home-schooling experience suggests the boys took advantage of this situation and he accepts responsibility for his lack of application:

I mean, Mom really tried! I mean she did *good* for getting me to learn anything, but it got to the point of like, doing two hours of loose study and we'd be off doing something else.

Yet, in spite of this, Ciaron believes that he made the transition into English secondary education with relatively few problems and, aside from noticing some minor cultural differences, the main difficulty encountered was when teachers referred to NC content from previous key stages that he was unfamiliar with:

I didn't find the curriculum stuff that different but I did find that when I started school here they started saying stuff like, '*We did this in Year 9*' and I was like, '*Oh . . . no we didn't!*' That happened in a couple of subjects and even in a GCSE mock exam in geography – map reading with co-ordinates. Because it's covered in Year 9 it's a given that you can do it. I mean, once it was explained it was easy, but *everyone else* understood 'cos they'd been told it a year ago.

The initial question on his experiences of GCSE science provoked a remarkable and unexpected response in that Ciaron immediately looked horrified and crossed all limbs in a defensive posture. He began to relax as he acknowledged his A* achievement in Double Science and further discussion revealed that this reaction was related to his experiences of post-16 science education rather than anything encountered at school.

[*laughing*] Yeah, I was this close [*hand gesture: small gap between thumb and forefinger*] to being 'Mr Science Man' coming here. On the induction day, when they have the little talks on each thing, I didn't know what I wanted to do. I knew I wanted to do photography, but basically my grades – I got 'A's in science and I got 'A's in math, so I was lined up to do physics and chemistry and all kinds of stuff like that and, five minutes into the talks, I thought, '*No Way!*'

On being presented with an opportunity to comment on NC science content, Ciaron's responses are more relaxed. He recognises content relating to competition and adaptation and then suggests that he had 'looked at some of that stuff with like, fertilizers messing up ecosystems and rivers'. He says of this experience:

I found that quite cool 'cos it was like that . . . seven degrees of separation style where the fertilizers make the bacteria grow, which then blocks out the oxygen for the fish, and the fish die and so on. It kind of all added on.

He identifies the SC2 content as ‘biology’ and characterises it as ‘standard GCSE stuff.

I mean, I don’t know if I could write an essay on a lot of this stuff but, I remember covering it and I think I found that it wasn’t the hardest part of science for me.

In expanding on this, Ciaron explains that he preferred physics and chemistry owing to his natural aptitude for ‘facts and figures and numbers’ and states:

At the time I was thinking about how it was easiest to get the best grade, or utilise my best skills which are memorising facts, figures and numbers. That’s changed now. I do subjects I enjoy and I can use in a positive way.

Moving on, Ciaron indicates that he is familiar with the term SD. However, he is not entirely sure of its meaning, or of where he has heard the term. As he thinks aloud, he makes a tentative link to his compulsory science education:

Sustainable . . . it can be sustained so it’s not gonna run out, it can be kept up. I don’t know in what context . . . I might have heard it in science in passing a couple of years ago . . . but unless you were to tell me exactly what it means, I’m not sure.

As he continues, Ciaron refers to ‘energy resource stuff’ and uses the terms ‘renewable’ and ‘non-renewable’. He observes that this content might be along the lines of SD yet, he does not recall this being taught specifically as SD. On being asked if there were any subjects at school that he felt had covered the impact of human activities on environments, Ciaron replies:

Um . . . we’ve been talking about science stuff, but when I think of environmental stuff, I always think about the geography we did. That’s where I . . . mentally, I’m sitting in my geography class when I’m thinking about environmental stuff.

As he expands on this, Ciaron explains that, since the focus of US geography is on cities and countries, he was surprised to find that geography in the English curriculum contained more environmental content:

Geography jumped me by surprise. I was thinking it was going to be more American-style geography of cities, countries, where stuff is more about where things are. In reality, it was a little more . . . I think. I was talking to someone about this the other day, it’s like the environment, you know? Science *of* the environment - you look at how the world works and I thought it had quite a lot to do with the biology stuff. I mean not just biology, ‘cos where do glaciers come into it? It’s kind of science-y.

He goes on to talk about exploring ‘urbanisation’ through first first-hand observation:

[‘C]os we did a project on [*name*] and we had to go and look at all the shops and how it has expanded out and all that.

On being asked if he felt that geography content tied in with aspects of ecology covered in science, his initial response was, ‘I don’t think it did’. However, as he articulates his thoughts on population he begins to recognise ways in which biology and human geography might interrelate. He begins to identify connections as he thinks aloud, and states:

I dunno . . . it may be my blurred memory mixing things, because just then when I was talking about the death rate and birth rate mirroring – we did that in science, but . . . we did development stuff with people in geography so, it’s kind of the same stuff. I think probably the animals and plants and stuff we looked at was biology - science - whereas, the same thing happening to people, we probably looked at in geography.

When asked if anything influences the way he observes his surroundings, Ciaron identifies his experiences of AS level photography on the grounds that this has trained him to be more visually aware of aspects of his surroundings. He suggests that it is also ‘cool’ to think about how others might respond to what they see, and consider how others might hold different perspectives on the same thing. He adds:

I wonder sometimes if other people look at things in the same depth as me? I dunno [*laughs*] maybe I’m a little weird?

CS3.3 Case study findings

CS3.3.1 Experiences of compulsory science education

RQ1 Finding 1 [Experiences of science education]: There are no spontaneous references to experiences of compulsory science education in this case study.

RQ1 Finding 2 [Perceptions of the relevance of science education to EE/ESD]: Ciaron is reasonably positive about his experiences of science education at school, yet does not particularly associate this experience with EE. He is able to recognise and talk about content learnt in key stage 4 and indicates that he found biology relatively easy. He describes learning about ways in which fertilizers affect ecosystems and rivers as ‘quite cool’ in its similarity to his understanding of the idea of seven degrees of separation. Yet, he preferred physics and chemistry on the grounds that his best skills are in memorising what he terms ‘facts, figures and numbers’. He also demonstrates an element of pragmatism in choosing to study subjects at GCSE that he felt would gain him the best grades. Ciaron demonstrates some familiarity with

the term SD and makes a tentative link to compulsory science education as he talks about its relevance to ‘energy resource stuff’. In doing so, he uses the terms ‘renewable’ and ‘non-renewable’. Yet, whilst he observes that this content might be consistent with ideas relating to SD, he does not recall being taught specifically about SD at school.

RQ1 Finding 3 [Tacit evidence of content consistent with NC science]: There is little evidence of science content in the narrative. Ciaron’s project explores the impact of human activities on the environment. Therefore, the theme itself holds the potential to present opportunities to draw upon science, and there are some tacit links to *Application of Science* and *Communication* in the way that Ciaron recognises and describes social and economic impacts on the physical environment. For example, he is aware that the human impact on environments is related to economic factors and is able to talk about this in terms of competing priorities for resources. He also recognises that there are few remaining environments that have not been changed in some way by human activities. However, Ciaron’s decision to shift the focus of his project away from what he terms ‘nature stuff’ towards exploring the aesthetic impact of advertising on urban environments meant that his understanding of science became irrelevant to supporting his ideas in this particular context.

CS3.3.2 Experiences other than science education

RQ2 Finding 1 [Formal education]:

Compulsory education: Ciaron talks favourably about UK compulsory education in comparison to his experiences of formal education in the USA. Ciaron identifies geography as the main curriculum subject linked to EE and indicates that the UK NC programme of study contains more environmental content than US geography. He does not however, link geography facilitating his familiarity with SD. In terms of other espoused experiences, Ciaron credits his history teacher in the USA with introducing him to aspects of world history than he might not otherwise have experienced.

Ciaron makes tacit links to formal content in geography, ICT and history as he discusses aspects of human impacts on human environments.

Post-compulsory education: Ciaron’s media awareness and understanding of the visual impact of advertising suggests tacit links to content in AS/A level media studies.

RQ2 Finding 2 [Other life experiences]:

Family and upbringing: It is clear that Ciaron's childhood experiences differ in some ways from those of other students in the sample. These differences stem from being resident in the USA until the age of 14. Ciaron has parents of different nationalities - his father is American and his mother is British - and the nature of his father's career resulted in international travel and relocation. These factors have been influential in facilitating Ciaron's familiarity with different environments. His parents' values and attitudes towards formal education have shaped Ciaron's experiences of school. Their judgement that 'American schools were bad' led him to experience a range of formal learning environments that included State elementary, private education and home-schooling. Ciaron indicates that 'a better standard of education' was one factor underpinning the family's return to the UK, and that his mother's career as a teacher had enabled her to design a home-school programme that prepared him for entry to UK education. In addition to this, Ciaron indicates that his parents encouraged him to develop a broad outlook on life and to be aware of the world.

Personal experiences: Ciaron expresses a strong preference for urban, especially city, environments and he links this to his childhood experiences of living in the USA and travel with his parents. His keen interest in BMX cycling was mentioned as an ulterior motive for his initial exploration of local woodland.

Institutional experiences: Ciaron is aware of TV coverage of environmental subjects.

RQ2 Finding 3 [Non-specified experiences]: Ciaron's environmental awareness and familiarity with urban environments appears to be supported by what he terms a general 'subconscious' way of absorbing information and other experiences that underpin his: (i) personal values and priorities relating to the environment; (ii) social and cultural awareness; (iii) his perceptions of environmental organisations such as Greenpeace.

CS3.4 General observations

Ciaron perceives the environment to be something physical that is affected by human activities. He is aware that few environments remain untouched by humankind and is able to link his first-hand experiences of environments to his awareness and understanding of cultural, political and economic factors which underpin human interactions with environments. He understands that environmental issues are complex and that people can perceive urban development in different ways, i.e., as something beneficial to humans, or as something damaging to the environment. He

presents clear ideas on the aesthetic impacts, and commercial influences, of advertising and refers to the McDonald's 'golden arches' brand as being symbolic of globalization. However, his stereotyped perception of environmental awareness as 'Greenpeace, hippie type stuff' suggests he views environmentalism as something that is not universally well received. It is unclear however, whether this outlook mirrors his shared family values, his broader cultural experiences, or whether this is simply Ciaron's individual worldview.

Ciaron freely admits that environmental issues are not a priority interest in his life. Yet, his views on environments reflect his values in that he believes people should be observant of their surroundings and sufficiently open-minded to develop what he terms 'common sense' knowledge of the world. He is unsure of how people might actually acquire this and attributes his own common sense to a 'lucky' upbringing. He believes that his parents instilled in him a set of values reflecting their own ideas on social responsibility and that this, plus his experiences of travelling with them, has introduced him to places and situations that have broadened his awareness of cultural differences and how these affect lifestyle and values. He appears to enjoy a close relationship with his family and, in particular, seems to value the opinions of his mother. He considers his parents to be 'well-educated' in a worldly, as opposed to academic, sense. Ciaron's experiences of living in the USA mean that he is able to talk with some authority on American cultural attitudes and behaviours.

CS3.5 Case study conclusion

There is little in this case study to suggest that Ciaron has drawn upon any experiences from his compulsory science education in this informal context. There are few obvious references to content consistent with NC science. However, no claim is made relating to the success science education in fulfilling its role to support EE/ESD since this outcome is not indicative of Ciaron's lack of understanding in science. This is an example of a case where the direction chosen for the development of ideas precluded the need to draw upon scientific understanding. As such, content drawn upon is essentially visual, social and cultural in nature because this is more appropriate to achieving the desired outcome for the photography project. In exploring the theme of the Impact of Human Activities on the Environment, Ciaron's ideas have been largely informed by: (i) first-hand experiences stemming from a distinctive upbringing; (ii) his familiarity with USA and UK environments and cultures; and (iii) his awareness of social, economic and cultural factors that shape and manipulate human attitudes and behaviours towards environments.

Ciaron's written commentary for his photography project is detailed and articulate, as were his contributions in the interview. Here is a high-achieving, well-travelled student who presents himself as being both observant and astute. His self-awareness is such that he not only identifies his interests and strengths, but also recognises that limitations can be imposed by these factors. Ciaron's reliance on his interest and familiarity with particular environments is certainly evident in the progression of his ideas in the photography project. Having declared a wish to try something different from his usual exploration of urban subjects, he was soon looking for ways to adapt his ideas on human impacts on environments that would allow him to return to his comfort zone. Thus, it was only when he began documenting human-centred, urban issues that he really started to connect with the project.

Ciaron is clearly interested in his surroundings and would like others to become similarly visually aware. He is however, realistic in his recognition that others might not be drawn towards 'analysing' their environments in the same way. He talks about a 'subconscious' absorption of information from media and image sources, and recognises that individuals are all influenced in some way by what they see. From this, he observes that the idea of 'originality' is problematic since ideas might stem from latent awareness gained from previous experiences. He also makes a point of, 'how know do you know what you know until someone asks you?' This suggests he believes that most of what is learned remains dormant until an appropriate stimulus comes along to facilitate recall.

CS4: Michael

CS4.1 Photography project

Michael's photography project, entitled *Human Imprint*, explores his perceptions of ways in which humans interact with nature. He identifies three main interactions and characterises these as: *Capturing/preserving nature*; *Competing with/dominating nature*; *Destroying nature*. Practical exploration comprises three photoshoots at sites including local woodland, the Humber Bridge, and a drainage dike on the outskirts of his local town. Michael selected one image from each photoshoot to form the final piece for the project. The only changes made to these images are some minor technical adjustments to enhance composition. The purpose of this piece is recorded in Michael's ISP:

Image 1: Capturing/preserving nature shows how we preserve nature. The idea of preserving wildlife for show, or for identification, by killing it and mounting it in a glass box seems to go against the idea of conserving species alive so they can breed.

Image 2: Competing with/dominating nature shows how we work with nature. Altering a landscape does not always mean we are destroying it, so this image is intended to show the beauty of man-made structures when set against natural landscapes.

Image 3: Destroying nature shows how we destroy nature by dumping rubbish. The shopping trolley has become an icon for the way people disrespect the environment. Wherever you go there seems to be a shopping trolley dumped in a ditch, or in the woods, or in the canal.

Michael says of the piece as a whole:

I think I was just trying to show the different ways that we treat nature and that in some ways it can be good, and in others it's bad at the same time – so, there's people that are trying to do good for nature and trying to help it, and in the same area there's other sort of people who are constantly destroying it.

Michael's reasons for responding to the MML brief were essentially pragmatic and largely driven by a lack of inspiration as he initially experimented with other ideas. He had started to respond to the *Nature* brief and then realised that he had no real interest in recording portraits of animals in the style of a nature photographer. Michael explains this in the interview:

I think it was because I didn't plan to do anything like that at first and I just went with *Nature*. I just carried on with the nature thing and worked on that, then I realised my ideas fitted with the MML brief and that just allowed me to do what I wanted to do.

Once he had made this decision, Michael worked single-mindedly to complete the project on time and, under the circumstances, he was reasonably pleased with the final outcome. His imaginative portrayal of *Capturing/preserving nature* was particularly well received by his peers. Michael felt this was the most thought-provoking of the three images owing to its underlying message of 'kill in order to preserve'. He also judged this image to be the most important outcome of the project on the grounds that it 'asks the most questions'. However, he indicates that the final piece as a whole was not intended to convey 'any clear kind of moral' and therefore, was not aimed at any particular audience. He says of this decision:

In the end, if they can look at the picture and think for themselves about the same sort of things that I've tried to make it look like I'm showing, then it's worked.

As Michael reflects on his experiences of exploring environmental subject matter through photography, he suggests that the practical act of taking photographs had enabled him to 'actively compare different parts and different settings, and the differences between them'. As such, he felt this approach 'definitely broadened how, and what, I thought about it'. His response when asked if this was a subject he might think about again sometime was:

Yeah . . . because if you've studied something actively and then you see it, you notice it more . . . I think I'd definitely notice more about what's going on around me nature-wise from doing this.

CS4.2 Main subjects discussed in interview

CS4.2.1 Perceptions of humans and nature

Michael observes that humans can interact with nature in several different ways within a single locality. The examples he gives are: creating a nature reserve; littering and dumping waste; and what he terms, 'breaking it up' in a way that does not destroy or mistreat nature. He qualifies the latter by stating:

I'm not sure why, but I don't see road building as destroying it, 'cos they build the trees up the banks and it's kind of working with it – trying to hide the road in the nature instead of . . . it's not like dumping and destroying parts of it.

Michael freely uses the term 'nature' as he talks and, when encouraged to define this term, he suggests this is 'actually quite difficult to pinpoint'.

I dunno, it covers a lot - so it's animals and areas that aren't touched, but also areas that are looked after by councils and are [*air quotes*] 'natural areas' even though they might be man-made to look like that. So it's hard to define.

As he continues, he observes that managed environments that appear natural slip into what he terms, 'a grey area of transition'.

I just think it's kind of hard to define what nature is because . . . we've got so much presence on the planet that it's hard to define. There's no set area if you know what I mean?

As this line of thinking unfolds, Michael reasons that humans are animals – a scientific idea - yet, he considers that human activities are 'too different' to be regarded as natural.

Actually, I just thought about that now as I was talking – we're animals as well, but . . . I wouldn't consider . . . the differences *we* do as nature. Um . . . I don't see it because we seem to be different. Where animals will make their own nest, they're still using the same materials and . . . we seem to be making more harm to it around us and not clearing up and everything. So I don't see us as part of nature. I see there's quite a line between humans and animals and wildlife.

As he continues to think aloud, Michael makes further observations relating to human behaviour and attitudes:

I would think that the way we behave is more advanced away from the wildlife and it makes a big difference how we . . . act and how they act. So, I think that's what the difference is, because when they say wildlife, or nature, or animals, you wouldn't immediately think of humans. I just think it's the big difference between us and what we see as other animals. We think that we're the superior race and so we're better, different, further away, from wildlife and other creatures.

However, when asked, Michael is unable pinpoint any specific source(s) of this awareness.

I'm not sure . . . it's just what I've kind of picked up . . . I don't think anyone's said that. Just thinking about it now - I think it's just how I see the difference between the two.

CS4.2.2 Human imprint

As he begins to explain his thoughts on *Human Imprint*, Michael establishes his definitions for the terms ‘preserve’ and ‘conserve’.

Um . . . well, ‘conserve’ would be like keeping a place alive, like a nature reserve.

‘Preserve’ is like keeping something that has lived for us to see . . . for our heritage.

Relating these definitions to his project, Michael explains that he wished to convey an idea of how humans interact with wildlife. Therefore, he initially explored the idea of killing an animal in order to preserve it. To represent this idea, he chose a ‘preserved’, mounted barn owl as the subject of his photoshoot for *Capturing/preserving nature*. However, he chose not to carry out any specific research on barn owl behaviour or habitat. When asked if he knew anything about barn owls, his response is indicative of superficial awareness.

Um . . . only general stuff like they usually hunt at dusk or dawn . . . um . . . and they’re called barn owls ‘cos they like, high up, safe nesting. . . and that’s about all.

Michael has indicated in his work journal that he intended to put the owl ‘back in its natural setting’. Yet, he photographed it in a local woodland environment. In explaining this decision, Michael acknowledges that woodland is not typical barn owl habitat:

Well it’s not usually that usual – it’s more like fields and edges of fields and hedgerows, they . . . normally go around, ‘cos it can see more and it’s got . . . it follows round the edge where the prey would be – round the edge of the field . . . but, I don’t think it would go into a woodland naturally, but I thought it would probably make the picture simpler to understand because if it was just sitting at the edge of a field or something it would be less of an impact.

Michael wanted the setting to be as important as the main subject in the composition and felt it would make a better visual statement if the owl was in, or beside, a tree. His justification for this was that ‘when you think of birds, normally you’d think of woodland’. This suggests that Michael’s thinking is dominated by his visual awareness and what he judges would make a striking image, rather than his ecological awareness and what might reflect reality. His final comment adds further weight to this idea in that it reveals an entirely pragmatic basis for choosing a barn owl:

I picked it because (*laughs*) it was the only stuffed bird we had!

A similar pragmatic reliance upon the familiar and the available is evident as Michael talks about his other two ideas. He indicates that he chose the Humber Bridge to represent his second

idea of *Competing with/dominating nature* because of its unusual size and the way it spans a natural river feature surrounded by other natural features such as woodland. He is familiar with this location and he had also photographed the bridge before.

When we used to live there, I used to stand on the flat roof by the side of the fire escape and get . . . great sunsets and I've got quite a lot of pictures taken from here and from the edge of the Humber down to the bridge, so it is something I like taking pictures of 'cos I like the sunset.

Again, Michael chose not to support this idea with additional research on the grounds that he considered himself sufficiently well-informed. By way of example, he cites statistical information on size of the Humber Bridge and indicates that it no longer holds the world record as the longest single-span suspension bridge. He is however, unable to identify any specific source(s) of this awareness and attributes it to, 'Bits I've picked up'. He then adds:

We've moved quite a bit and lived in the area at one time . . . like, when you hear about it from people who helped build it and stuff like that (*laughs*) you seem to meet these people with my parents running a pub!

Michael does not view the development of the Humber Bridge as being destructive to the environment because he believes that it has improved transportation for the local communities. He does, however, feel the structure dominates the landscape and, to represent this idea, he photographed the bridge at sunset with the river at low tide. When asked if an image taken at any other time of day might have conveyed the same idea, he observes:

I don't think so . . . no. It's only when it's starting to get dark that this area starts to look nice enough to look like a natural setting. It's not very good when you're showing a structure against nature when the water's brown!

This is an interesting observation in that Michael appears to suggest that a natural setting only looks natural when it is aesthetically pleasing. This perception was perhaps influenced by the context of photography and looking at images of picturesque and dramatic landscapes. However, it facilitated discussion of Michael's views on the aesthetic qualities of landscapes wherein he suggests: (i) people respond differently to environments based on appearance; and (ii) that this behaviour is peculiar to humans. He reasons that animals choose habitats that meet their ecological needs whereas, humans choose appearance over practicality. He then relates this idea to managing environments for wildlife conservation:

You see, for nature reserves and that, it could look very nice, but it might not be the best place for animals to live in. It's nice to us, and we think it's pretty 'cos it's got little

bridges and things to look at . . . and like, leaving wild areas in a garden - it looks untidy, but for animals there's more variety and areas to hide in.

This observation says something about Michael's perceptions of the way aesthetic values are influential even when humans aim to act in the interests of other species.

Additional references to values become evident as Michael discusses his third idea of *Human Imprint*. He suggests an image of a shopping trolley half submerged a ditch is a 'very direct, stereotypical way' of conveying an idea of *Destroying nature*. He then observes a general human 'disrespect' for their environments:

It's like, if you think of animals, they generally look after their own habitat and it's part of their survival, but it's not in ours 'cos some people destroy what's around them, even the area they're living in, so it's something that's part of us as well . . . that shows complete disrespect for our things as well as for other areas.

CS4.2.3 Human interactions with environments

Michael reinforces his idea that there are both positive and negative impacts under the heading of *Human Imprint*:

You see, where I live, there's this one road and at one end there's a train station that every week gets the glass smashed out it, and the council keeps coming back and replacing it with more and more of this expensive tinted glass. At the other end, you've got a nature reserve and a marina and they're constantly working . . . on improving it down there - they're just building a visitor's centre which is again another impact on the nature reserve.

During this discussion of localised patterns of behaviour Michael observes that, other than some joy riding in the car park and dumping his brother's stolen car, there is noticeably less vandalism at the nature reserve 'even though it's the same sort of people who will vandalise the train station'. Michael is unable to pinpoint any specific reason for this other than, 'maybe they prefer breaking things that break'.

As the exchange continues, he offers a further detailed example of local attitudes and behaviours as he describes how the nature reserve was developed. Michael describes how 'toxic waste' from a disused fertilizer factory was removed, and how the clean-up operation had resulted in conflict as some residents objected to the transportation of the waste past their homes. Michael recognises competing priorities as he explains:

Every route they chose to take these lorries, people complained that they didn't want this stuff transported past their house. So it took years to get it sorted where they could take the lorries. So, (*laughs*) they had to do it in the middle of the night! But that's another thing, everyone wants this area to be clean and everything, but they don't want to help in their own way by letting these things come past their house.

Prior to this exchange, Michael had suggested that he had not carried out any kind of environmental project before. However, as he recounts this story, he is suddenly reminded of a Summer School experience at the nature reserve. Michael does not say who organised this, but describes the experience as, 'a slightly more advanced combination of biology and nature'. His description of outdoor investigative activities which involved measuring and collecting data is characteristic of biology fieldwork.

We did things with quadrats and pond dipping and all that stuff and we got a visit down to the old site. This was just after they'd started cleaning it up and they had all the fences round. There were some parts that they'd already cleaned and we were looking at what life there was – and there wasn't that much to be honest, but it had improved.

CS4.2.4 Environmental awareness

Michael talks confidently about his photography project and of human interactions with their environments. Yet, he expresses uncertainty regarding his environmental awareness.

It depends how you define environmentally aware. It depends how you say that, 'cos 'environmentally aware' means that you're aware of like, the damage it is possible for you to do - which I can see what can be done, and it's being aware that you're not doing it yourself as well – not damaging the environment yourself. If people see it as really important they would have already considered an answer, so it shows that it's not something that is actively on my mind a lot of the time.

Michael believes that he has adopted what he describes as a 'middle' position in the way he acts towards nature. This means that he is neither deliberately destructive of environments, nor particularly pro-active regarding conservation. He is aware of, and dislikes, vandalism, and even offers an economic argument as to why this behaviour does not make sense. Yet, he indicates that environmental issues are not one of his main interests. He is unable to identify why he thinks this way and explains:

I'm really not sure how that's been picked up . . . 'cos I know it's like influences you get like friends, family, parents . . . I mean my parents are pretty much like I am really, they're not really active about it but they wouldn't mistreat it on purpose.

CS4.2.5 Sources of environmental information

Michael identifies three sources of information that he might potentially access if he wished to extend his environmental awareness. For global concerns, he talks about Greenpeace on the grounds that, 'they're major and concentrate on more major things'. For national and local issues, he suggests local conservation groups in Britain and organisations such as the National Trust. Finally, he recommends Internet research accessing local council and other websites that offer statistical and other information. However, in evaluating the effectiveness of the Internet as a source of environmental information, Michael indicates that generic Internet searches are too vague to be productive. As such, he suggests he would usually browse through books first to identify specific factors to aid information retrieval. When reflecting on the reliability of Internet sources of information, Michael observes:

I'm not sure, 'cos the writing is all different people's opinions so if you agree with it . . . then . . . [*shrugs shoulders*].

Michael's mention of Greenpeace led to him to recall a recent encounter with a Greenpeace representative:

He wanted five pounds off me a month - something I can't afford - and I was wondering how much it had cost them to make that glossy booklet?

On encountering further representatives in the same area of town, Michael eventually found this aggressive promotion both distasteful and counter-productive.

They made me feel uncomfortable, so I don't want to give them money!

On being asked if he felt people needed to become members of environmental groups in order to become environmentally aware, he replied:

Well no - it's more like everyone doing their own bit. If everyone did their own bit then it'd be fine. It's just that all the people that don't means that other people have to do more to try to counteract what's been done elsewhere.

CS4.2.6 Experiences of compulsory education

Although talking freely about his environmental awareness and sources of environmental information, Michael did not refer to any experiences from his compulsory education. On being asked if he felt his school science had prepared him to engage with environmental issues real life, his response is unenthusiastic:

I don't know . . . it teaches you to a degree, but I think it's more what you pick up yourself in the real world that's more important, because . . . yeah, 'cos if you pick it up yourself it's more like what you think. How you learn to treat nature yourself is better than what you are taught.

As he continues, he compares his experiences of primary and secondary education.

M: 'Cos at primary school they teach you to look after nature anyway, and they teach you to make bird bells and thing like that to help nature and everything, but then in - I dunno - in secondary school it's more [*pulls face and laughs*] maybe I should stop now?

I: (*laughs*) Please feel free to be absolutely honest.

M: I think it . . . well, I dunno . . . I don't think they really went for the environmental! You see my primary school was Church of England so it was . . . more educational like to the environment and God's creatures kind of thing, but secondary school really wasn't like that and . . . I don't think . . . environmentally . . . they didn't really teach much to be honest. I don't really think they taught . . . really . . . that was never an emphasis.

When asked if he felt anything from his science education was relevant to EE, he observes:

Perhaps . . . to a degree, but I just didn't like the lessons. I wasn't . . . I did well in biology, but that was a bit easier, but chemistry and physics kind of just went [*gesture to show content went straight over top of head*]. I used to be quite good at maths and the academic subjects like science, but somehow when I got to GCSE, it's like my learning capability for them kind of . . . stopped . . . and I couldn't take all this extra information on board. But biology was a bit easier to understand.

When shown examples of NC science content Michael recognised, and commented on, elements of *Life processes and living things*. In doing so, he offers a wry observation that the two things he could remember from five years of biology were photosynthesis and osmosis. By way of explanation, Michael suggests that there was 'a lot more emphasis on processes than on variation'. He links 'variation' to 'asexual breeding' and, in doing so, either demonstrates a lack of understanding that asexual reproduction results in clones, or is accurately recalling NC content covered under the label of *Variation*. He then observes that the environmental causes of variation were not covered as much. Yet, was able to say something about how plants adapt to the environment and can mutate in response to soil conditions. At this point he mentions 'GM crops' and implies that variation also applies to animals.

Michael's example relating to food chains is abruptly curtailed as he recognised the statement: *The impact of humans on the environment depends on social and economic factors*. At this point he declares, 'Hey - that's more geography!'

I: Are you say you associate the impact of human activities on the environment with geography?

M: Yeah . . . and yeah, sustainable development, we're doing that now in geography!

I: Are you talking about your AS level geography?

M: Yeah . . . and that's definitely more . . . I'd say it's more geography related because it's also human environment.

When asked if he had encountered SD at school, Michael replies:

No. That's been here [*reference to college*]. The geography here, that's been . . . um . . . settlements and developments and everything. It's only recently – the last six months that that's been taught to us.

From Michael's description, it appears that he perceives SD as a new and human-centred concept that has emerged in response to 'an industrial revolution in the sixties'. His comments suggest that SD been taught in geography in terms of national and/or local authority initiatives based on creating self-sufficient, sustainable local communities. However, he makes it clear that this account constitutes *his* understanding of SD.

CS4.3 Case study findings

CS4.3.1 Experiences of compulsory science education

RQ1 Finding 1 [Experiences of science education]: There are no spontaneous references to experiences of compulsory science education in this case study.

RQ1 Finding 2 [Perceptions of the relevance of science education to EE/ESD]: Michael associates secondary science education with learning about 'processes', and believes that there was less emphasis on content such as variation and diversity. He did not enjoy secondary school science lessons and, with the exception of biology which he found easier to understand, Michael found GCSE science difficult. Yet, in spite of his aversion to secondary school science, his voluntary participation in a Summer School project at a local nature reserve, adds weight to an idea that it is not science education *per se* that Michael feels unable to engage with, but that there is some other factor relating specifically to its form or delivery in secondary school that he found off-putting. Thus, his overall judgment is that secondary school science is relevant to EE

‘to a degree’, but that it is not as valuable and effective in developing environmental awareness as real world, first-hand experience.

RQ1 Finding 3 [Tacit evidence of content consistent with NC science]: Although Michael did not enjoy aspects of science education, he has demonstrated that he is able to draw upon his understanding of science in context of discussing human interactions with their environments. Subjects arising from his exploration of human interactions with nature presented opportunities to draw upon science content in the following contexts:

- CS4.2.1 Perceptions of humans and nature
- CS4.2.2 Human Imprint

Tacit content drawn upon in these contexts is consistent with NC science *Life processes and living things, Application of science and Communication*.

CS4.3.2 Experiences other than compulsory science education

RQ2 Finding 1 [Formal education]:

Compulsory education: Michael identifies geography as the main NC subject associated with EE. Yet, he does not associate any aspect of his compulsory education with facilitating awareness of SD. He is the only student in the sample to mention his primary education in relation to EE. In doing so, he links the development of awareness of caring for environments to his primary school’s Church of England ethos and spiritual values relating to human attitudes towards other living things. His perceptions of compulsory education imply that primary education facilitates awareness of caring for environments and other living things in ways that secondary education does not.

Post-compulsory education: Michael links his familiarity with SD to his experiences of AS level geography. There is also a tacit connection between his media awareness and his AS level media studies course.

RQ2 Finding 2 [Other life experiences]:

Family and upbringing: Michael links his familiarity with local environments to his parents’ career choices, their values and attitudes, and his family lifestyle. He suggests that he ‘picks things up’ through family relationships, and indicates that his values and ‘middle’ attitudes on environmental issues reflect those of his parents. Michael’s parents are hotel managers and his experiences of being brought up in ‘a pub’ are evident his familiarity with local environments.

There are several examples of how Michael has drawn upon this familiarity to inform his photography project:

- i His experiences of relocation have facilitated awareness of different communities and of the social, economic and environmental impacts of: (a) local development projects; and (b) localised patterns of environmental attitudes and behaviours.
- ii Living in a service industry environment had brought him into first-hand contact with construction workers and local people who had talked about aspects of the development of the Humber Bridge. He had also experienced community life before the Humber Bridge was opened. Therefore, he was familiar with the need to board a ferry to cross the river, and of the issues caused by this. As such, Michael is able to talk knowledgeably about the benefits of the Humber Bridge in terms of improved transportation.
- iii He was able to draw upon his first-hand visual awareness to know: (a) when the Humber Bridge looks at its best; and (b) where there were particular examples of environmental damage such as the abandoned shopping trolley dumped in a ditch.
- iv The barn owl used to illustrate his ideas on *Capturing/preserving nature* was a leftover from the interior furnishings of one particular establishment.

Personal experiences: Michael believes that the best way to learn about environments is through first-hand experience. He also attributes the development of environmental attitudes to social interaction with friends. He is observant and notices local attitudes and behaviours in relation to individual respect for environments and individual reactions to environmental issues. This appears to underpin his awareness of conflicting and competing priorities in relation to development projects. His participation in a Summer School activity is an experience that has developed his awareness of some of the issues involved in reclaiming industrial land for wildlife conservation. This practical activity presented opportunities for engagement with an outdoor environment in ways that forms links with compulsory science education - especially biology [ecology; measuring; recording data]. This is learning *in/through* the environment. This is also consistent with Michael's interest in geography

Institutional experiences: Michael is familiar with a range of sources of environmental information and advocates using electronic media with two provisos: (i) a need to identify what to search for; and (ii) awareness that Internet website information reflects the opinions of the authors. He views environmental organisations as potential sources of information on particular environmental issues and recommends Greenpeace as a voice on global issues. However, his

recent encounter with Greenpeace representatives had left him feeling that this organisation placed an unacceptable emphasis on recruiting new members solely for fundraising purposes.

RQ2 Finding 3 [Non-specified experiences]: Michael demonstrates awareness of economic, social, aesthetic, media and ecological factors that he is unable to attribute to any particular experiences. The sources of this awareness are explained in terms of something 'picked up'.

CS4.4 General observations

Michael's choice of subject to explore through photography created opportunities to draw upon science in relation to main theme of *Human Imprint* and discussion of his perceptions of the human relationship with nature. As Michael initially talks about his ideas for this project, he demonstrates a sense of what he terms 'good and bad' environmental attitudes and behaviours. He supports these perceptions through ecological understanding as he compares human needs and behaviours with those of other animals. Michael understands that humans are animals - a scientific idea - and yet, is aware that humankind is somehow 'different' in both behaviour and attitude from what he identifies as 'nature', 'animals' and 'wildlife'. Scientific awareness drawn upon to support this view relates to resource use and habitat. Michael reasons that animals use available materials - implying that this is a simple, natural process that does not damage habitat. In contrast, he believes that humans are more 'advanced' and have limited regard for the consequences of their actions. He observes something innately destructive in human behaviour that is not apparent in other animals. Thus, he suggests that some human activities are harmful to environments, and some actions are deliberately destructive, regardless of the subsequent environmental, social and economic costs.

Michael's values are evident as he observes a human sense of 'superiority' that separates humankind from all other living things. This perception relates to cultural anthropocentrism. Michael demonstrates awareness that it is difficult to define the human relationship with nature since there are many factors and values that influence the way humans think about themselves. Based on Michael's descriptions, humans appear to be a mass of contradictory attitudes and behaviours. He recognises conflicting opinions caused by competing priorities and observes that, even within a single community, people can choose to work with, improve, or destroy their surroundings.

Michael continues to draw upon his awareness of habitats and wildlife behaviour as he explores his idea of *Capturing/preserving nature*. Yet, this time his ecological understanding is offset by

his visual awareness. Throughout the project, Michael exploits his awareness of cultural stereotypes and assumptions (e.g., birds live in trees; natural environments are beautiful; green spaces constitute nature) to manipulate the content of his images. As such, these images are symbolic and designed to attract attention rather than being representational. A combining of ecological and visual awareness is also evident as he discusses the aesthetic qualities of landscapes. Once more, there is a tacit link to compulsory science education as he draws upon his awareness of habitats and links his understanding of animal behaviour to his observations on human social and cultural behaviours. He suggests that: (i) the ‘pretty’ appearance of environments is more of an issue for humans than other animals; and (ii) these values not only influence how humans adapt environments to suit humankind, but also how they manage environments for wildlife. Michael gives an example of how managed environments – and even nature reserves, are relatively tidy places. He observes that nature reserves are often managed aesthetically, and for the comfort of people, rather than in the interests of wildlife.

As he discusses the main theme of *Human Imprint*, Michael demonstrates the influence of the context as he prioritises his visual awareness and aesthetic values. For example, in CS4.2.2 he demonstrates that he is sufficiently well-informed on barn owl behaviour and habitat to know that barn owls are not woodland birds. However, he indicates that he was not interested in conveying any kind of ecological reality to the viewer and had previously made it clear in CS4.1.1 that he had no wish to act in a documentary capacity as a nature photographer. His intention was to create a thought-provoking image through the deliberate act of exploiting and challenging the viewer’s assumptions about birds and human behaviours towards wild animals. Therefore, under these circumstances, his awareness of historical cultural values and behaviours towards wildlife, combined with his understanding of photography and image-making, allowed Michael to disregard his scientific understanding in favour of communicating his creative ideas.

CS4.5 Case study conclusion

Michael’s responses in this case study suggest that his compulsory science education does not feature highly amongst the experiences he associates with developing his awareness, understanding and respect for environments. He appears uninspired by his experiences of science education and believes that there was ‘never much emphasis’ on EE in secondary education. Michael is clearly aware of subject demarcation in the way that he separates the content of NC science from content in geography. His actions suggest that he does not recognise science education as being relevant to understanding human interactions with their environments since he clearly associates this content with geography. Yet, in exploring issues

arising from Human Imprint, Michael has drawn upon his awareness and understanding of: (i) scientific, cultural, social, and economic factors relating to human interactions with environments and other living things; (ii) scientific understanding relating to conservation; (iii) aesthetic values relating to the impact of human activities on the environment; and (iv) cultural values in relation to defining the human relationship with nature. The language and structure through which he has communicated this, suggests tacit links to elements of NC science. This scientific content is interrelated with:

- other formal knowledge [literacy and ICT skills, geography, history];
- social, cultural, economic, and aesthetic awareness;
- personal, social and cultural values.

Michael's supporting written commentary for his project is articulate and proved useful in stimulating and supporting his contributions in the interview. He frequently turned to examples in his work journal to illustrate points being made. Michael's responses suggest that he is able to communicate his views on complex environmental issues in an interesting, articulate and confident manner. He freely admits that the environment is not one of his main interests or priorities. Yet, his values favour respect for environments. He believes that individuals should take responsibility for their own actions and that failure to do so puts the onus on others to compensate for their disregard.

Michael presents himself as an observant young man who is interested in, and clearly connects with, his local environments. He conveys a keen sense of community and this, together with his ability to notice things about his surroundings, means that he is able to talk confidently and knowledgeably about the places he has lived in and the attitudes and behaviours of members of these communities. The most overriding influence on the direction of Michael's project has been his reliance on his familiarity with his local environments – something he links to his family and upbringing. His honesty about his approach to his project also provides some insight into how practical factors can influence decision-making and content. With a delayed start and an imminent deadline, Michael needed to act quickly to identify ideas. Therefore, he chose environmental subjects that were familiar and available to him, as opposed to environmental issues that would have required more detailed research.

Chapter 5: Case study results and discussion

The purpose of this chapter is to draw together the findings from each individual case study into a summary and discussion of outcomes across the sample. Tables summarising data from the individual case studies are presented in Appendix 3.5. These data are drawn upon to support the reporting of the case study outcomes. The findings for RQ1 are presented in 5.1. The findings for RQ2 are presented in 5.2. This is followed in 5.3 by a discussion of outcomes in relation to ideas presented in previous chapters.

5.1 Experiences of compulsory science education (RQ1)

Data presented in Table 1 (Appendix 3.5) shows that there are no spontaneous references to experiences of compulsory science education in any of the individual case studies. However, tacit content drawn upon appears consistent with: (i) *SC2 Life processes and living things*; and (ii) *General requirements across the programme of study*. This is demonstrated as follows:

SC2 Life processes and living things (DfE 1996):	
Content	Tacit evidence in
<p>3. Green plants as organisms <i>growth and nutrition</i></p> <ul style="list-style-type: none"> ▪ plants need light and water to grow ▪ plant growth is affected by the availability of light <p><i>reproduction</i></p> <ul style="list-style-type: none"> ▪ plants produce seeds which, in turn, produce new plants 	CS1
<p>4. Variation, classification and inheritance <i>classification</i></p> <ul style="list-style-type: none"> ▪ classifying living things into the major taxonomic groups 	CS1; CS2; CS4
<p>5. Living things in their environments <i>adaptation and competition</i></p> <ul style="list-style-type: none"> ▪ different habitats support different plants and animals ▪ factors affecting the size of populations include predation and competition for resources ▪ the impact of human activities on the environments is related to population size, economics, industrial factors and levels of consumption and waste <p><i>feeding relationships</i></p> <ul style="list-style-type: none"> ▪ food chains ▪ how toxic materials build up in food chains 	CS1; CS2; CS3; CS4

General requirements across the programme of study (DfE 1996):	
Requirement	Tacit evidence in
2. Application of science <ul style="list-style-type: none"> ▪ evaluating the benefits and drawbacks of scientific and technological developments ▪ relating science to the care of living things and the environment 	CS1; CS2; CS3; CS4
4. Communication <ul style="list-style-type: none"> ▪ using a range of scientific vocabulary 	CS1; CS2; CS3; CS4

More specifically, this content relates to: green plants; variation; habitat; adaptation; food chains; accumulation of toxic materials in food chains; predation and competition. This overview of tacit content is now interpreted as follows:

It appears that all students have acquired some formal knowledge consistent with content in NC science. This knowledge has been drawn upon spontaneously in relation to other awareness and understanding as students have described and explained their ideas on human interactions with their environments and other living things. Yet, the amount of tacit content draw upon varies across the sample. For instance, science content most frequently drawn upon relates to ecology. However, this is not demonstrated equally in all the case studies. For example, references to ecology occur in the following case studies and contexts:

CS1 [James]:

- CS1.2.2 Rubbish as an environmental issue
- CS1.2.3 Landscapes
- CS1.2.4 Human interrelationships with environments
- CS1.2.6 Familiarity with SD

CS2 [Suzanne]:

- CS2.2.3 Effects of woodland clearance
- CS2.2.5 Sustainable development

CS4 [Michael]:

- CS4.2.1 Perceptions of humans and nature
- CS4.2.2 Human Imprint

This suggests that: (i) individuals draw upon a relatively narrow content from a common programme of study for science; and (ii) that science content is drawn upon as-and-when it is deemed relevant to informing aspects of subjects being explored. In this particular instance,

science content has been drawn upon to name, describe and support student perspectives on environments, and their individual perceptions of human interactions with their environments and other living things. This content been drawn upon in relation to:

- values [social, cultural, family, personal, aesthetic];
- other factors [social, cultural, economic, political, historic; aesthetic, spiritual];
- awareness of world events;
- media awareness.

However, tacit content drawn upon is not fully representative of the NC science programme of study. For example, students do not appear to have drawn upon much content consistent with *SC3 Materials and their properties* or *SC4 Physical processes*. There is some suggestion in CS3.2.6 that Ciaron has recognised that energy resources and renewable energy might be relevant to, yet not specifically indicative of, SD. There is also a cost-benefit consideration in CS1.2.2 whereby James touches on ideas relating to energy in context of presenting his views on recycling. However, aside from this, students only mention physics and chemistry in context of direct questioning on their experiences of science education.

Student perceptions of their experiences of science education vary from James' reasonably positive comments in CS1.2.7, to Suzanne's open antipathy expressed in CS2.2.6. Yet, no student appears overly enthusiastic about their school experiences, and there is a general sense that science education makes a fairly limited contribution to developing awareness and understanding of environments when compared to: (i) other curriculum subjects such as geography; and (ii) other life experiences. Perceptions of individual science subjects varied. A common perception across the sample is that biology is 'easier' than physics and chemistry. Most students associated biology with EE and indicated that they had enjoyed and/or achieved well in this subject. In contrast, where physics and chemistry were mentioned, perceptions were more polarised and students stated that they had either preferred, or felt unable to understand, these subjects – especially in key stage 4. No-one openly associated physics and chemistry with supporting EE.

Compulsory science education is not an experience associated with facilitating familiarity with SD. Ciaron suggests that he might have heard the term SD 'in science, in passing'. However, no other student makes this connection and, with the exception of James, the level of familiarity with SD across the sample is demonstrably poor. For example, Suzanne had not heard of the term, Ciaron was unsure of its meaning, and Michael had only recently encountered learning relating to SD in his AS level geography course. James expressed some

sophisticated views on SD, and tacit content drawn upon in CS1.2.6 shows that his reasoning was largely informed by his understanding of science. However, in response to direct questioning in CS1.2.7, he talks about his experiences of geography rather than science.

5.2 Experiences other than compulsory science education (RQ2)

5.2.1 Experiences of formal education

a) *Compulsory education:* There are few spontaneous references to compulsory education in the case studies. Yet, data in Table 2 (Appendix 3.5) show that individual reflections on experiences of compulsory education include the following observations:

- School is good and starts a learning process about things that might not otherwise be encountered. Yet, formal assessment disadvantages students who have difficulty writing [CS1.2.7].
- School teaches things like ‘wildlife’ means animals [CS2.2.3; CS2.2.6].
- There is a certain pragmatism underpinning the choice of subjects to study at GCSE, i.e., weighing aptitude and potential grade against how interesting and/or enjoyable the subject might be [CS3.2.6].
- Primary education facilitates a sense of care for the environment and other living things whereas, secondary education is not overly concerned with EE [CS4.2.5].

In terms of espoused evidence, all students who had studied GCSE geography in key stage 4 (n=3) spontaneously identified geography as the main school experience they associated with EE. Two students made remarkably similar observations:

James: Well you were asking me about science, but I think it was geography that was the main subject for teaching me something about the environment [CS1.2.7].

Ciaron: Um . . . we’ve been talking about science stuff, but when I think of environmental stuff, I always think about the geography we did [CS3.2.6].

James, Ciaron and Michael all demonstrate awareness of curriculum subject demarcation as they describe similarities, differences and overlap in content between geography and science. James clearly recognises a link between the two subjects and yet describes them in terms of distinct fields, i.e., science education teaches about life processes and living things, whilst geography teaches about human impacts on environments and environmental issues. James describes a linear curriculum relationship in support of EE whereby the ‘technical’ content in science education informs learning in geography which, in turn, shows ways in which human and environmental systems interact. In contrast, Ciaron appears much less clear about the

curriculum relationship and observes a blurring of the dividing lines between the two subjects. He characterises NC geography as, ‘Science of the environment’ and offers examples of how some biological content in science education, corresponds to, and overlaps with, human content in geography. For example, factors affecting birth and death rates. He concludes that factors affecting plants and animals are probably covered in biology, whilst geography applies the same types of determining factors to human populations. There is a strong suggestion across all the comparisons that science education does not address learning related to human interactions with environments. For example, Michael is surprised to find that content relating human impacts on environments to social and economic factors exists in NC science. This is content that he recognises and classifies as geography rather than science.

In addition to espoused references to geography, there are tacit indications that students have drawn upon other formal knowledge in this informal context. For example, all have:

- communicated their ideas, observations and insights in writing [English/literacy]
- drawn upon speaking and listening skills in discussion [English/literacy];
- drawn upon information and communication technology [ICT] skills as they have searched for, retrieved, evaluated and presented information.

There is also an individual link to content in NC history. For example, in CS1.2.6, James refers to Roman technology as he talks about the impact of human activities on environments.

b) *Post-compulsory education:* Influences from AS level photography are evident in an emphasis on visual awareness and the aesthetic qualities of environments. This factor, together with reasons for exploring environmental subject matter, underpinned each student’s individual interpretation of the MML brief. With the exception of James, who only completed one photoshoot, the content and quality of images recorded, together with first-hand observations at the time, also had some bearing on ideas taken forward from one photoshoot to the next. This is especially evident in Ciaron’s case where his dissatisfaction with the outcomes of his initial photoshoots led him to change the direction of his project and revise his intentions for his final piece. All students indicate that they gained something positive from their experiences of exploring environmental subject matter through photography. James expressed the most enthusiasm and Suzanne had certainly appreciated the opportunity to express her feelings. However, she was unsure as to whether this experience had left her feeling any more informed about human interrelationships with environments and other living things. In contrast, Ciaron and Michael both indicated that, although environmental issues are not a main interest or priority in their lives, the photography project had presented them with

an opportunity to think about, and express, their views on human impacts on environments, and to notice their surroundings in new and unexpected ways.

There are two espoused links to other aspects of post-compulsory education. In CS2.2.4, Suzanne suggests that her General Studies course highlighted issues relating to the Kyoto Protocol, and in CS4.2.6, Michael links his AS level geography course with teaching about SD. There are also some tacit links. For example, James' awareness and understanding of groundwater resources and urban environments in CS1.2.4 is consistent with content in AS/A level geology, and Ciaron's thinking on the visual impact of images in CS3.2.5 is consistent with aspects of his AS/A level media studies course.

5.2.2 Family and upbringing

Experiences of family and upbringing featured strongly across the sample. Students mention a range of factors relating to: (i) their parents' experiences; (ii) family relationships; (iii) shared values and interests; and (iv) the role of upbringing in developing respect for environments. Students describe these experiences as being influential in various ways. For example:

- James links his preference for outdoor environments to his parents' interests and their general outdoor lifestyle [CS1.1].
- Suzanne links her interest in environmental issues to her parents' formerly active membership of Greenpeace [CS2.2.2].
- Ciaron suggests that his grandfather's career involved European travel that facilitated his father's 'educated' worldview which, in turn, has influenced the development of Ciaron's worldview [CS3.2.5].
- Ciaron and Michael both attribute their familiarity with different environments to their first-hand experiences of family relocation [CS3.2.5; CS4.2.2].

There are also references to extended family. For example, James links his awareness and understanding of managed environments to the farming expertise of his brother-in-law, and Suzanne links her awareness of woodland environments to the residential area, and interests, of her aunt and uncle.

The development of respect for environments, i.e., environmental values, attitudes and behaviours, was mostly linked to experiences referred to in general terms as, 'the way people are brought up'. This notion is particularly apparent as students talk about factors influencing human ignorance, negative environmental attitudes, and destructive behaviours. These are attitudes and actions assumed to stem from a failure of parents to encourage their children to be

aware of their surroundings, to think about environmental issues, and to take responsibility for their own actions. From students' descriptions of parental interests, values and attitudes, it would appear that each student's mindset on environmental issues is broadly in line with that of their parents.

5.2.3 Personal experiences

A general perception across the sample is that the best way to learn about environments is through first-hand experience. All students allude to a general interaction with the world that facilitates a subconscious absorption of knowledge from a variety of sources such as, everyday encounters with people, places and media information. All suggested that experiences gained from living in particular places, travel, talking to people, and being somewhere and noticing things, contribute to developing awareness of different surroundings and the associated environmental issues. There are two examples in CS4 of how close proximity to local development projects has facilitated Michael's awareness and understanding of environmental issues. He is able to give examples of how changes to landscapes can improve the quality life for local communities [CS4.2.2]. He is also able to describe and how conflict can arise within communities when there are competing priorities and opinions on what is desirable and how this should be achieved [CS4.1.2.3]. These examples lend support to Littleddyke's (2004) observation that discussion of a local bypass building scheme had increased pupils' understanding of the key environmental issues.

There is some evidence that social interests have played a role in facilitating awareness and understanding of environments. For example:

- James links his understanding of environmental issues to his enjoyment of discussion and debate on current affairs [CS1.2.2].
- Suzanne's interest in music increased her awareness of issues surrounding the Kyoto Protocol [CS2.2.4].
- Ciaron's ulterior motive for visiting local woodland was to consider its potential as a BMX cycle track [CS3.2.2].
- Michael's voluntarily participation in a Summer School at a local nature reserve raised his awareness of the ecology of the site [CS4.2.3].

Finally, there is some individual evidence that personal relationships (i.e., close friendships) influence the way students think about environments and respond to environmental issues. For example, Suzanne's shared experiences at the country park, supported by her boyfriend's anecdotal evidence, significantly influenced the content of her photography project.

5.2.4 Institutional experiences

James' membership of the Scouting Association is detailed in CS1.1. Aside from this, there are no references to institutional experiences of a *free-choice* nature, as defined by Kola-Olusanya (2005). However, all students made spontaneous reference to Greenpeace and suggested that this, and similar organisations, serve as useful sources of environmental information. The influence of Suzanne's parents, as one-time active members of Greenpeace, is detailed in CS2 and highlighted again in 5.2.2. A residual effect of this influence might be Suzanne's belief that environmentalists are equipped to offer specialist expertise on environmental issues. Yet, there is no evidence to suggest that Suzanne, or any other student in this sample is, or wishes to become, a member of Greenpeace. Michael was certainly unimpressed by the representatives who had attempted to recruit him, and Ciaron's stereotyping of environmental awareness as 'Greenpeace, hippie-type stuff' says something about his perceptions of people who join environmental organisations. James believes that organisations such as Greenpeace have insufficient economic power to effect any significant change to human interactions with environments. In his view, 'It all comes down to money in the end.' This notion that powerful institutions choose to put profit before environmental concerns was also noted in studies by Hillcote *et al* (1995) and Connell *et al* (1999).

Other similarities with existing studies relate to media sources of information. All students indicated that educational and documentary television programmes and news broadcasts had contributed to developing their environmental awareness. This supports findings in Palmer and Suggate (1996); Hillcote *et al* (1995); Connell *et al* (1999); Littlelyke (2004). Most advised caution with regard to the reliability of print and broadcast media. Yet, James was the only one to exhibit any deep mistrust of news reporting, expressing a view that all people should strive to become media aware and question information presented. All students indicated that they routinely perform Internet searches when they need details on particular subjects. However, all recognised its limitations, with some suggesting that it is sensible to question the reliability of information presented on websites since authors' views are subjective and the Internet is largely unregulated. Thus, although there is a general perception across the sample that books are less convenient to use, they are judged to contain more detailed and reliable content.

5.2.5 Non-specified experiences

There are a number of unexplained influences within each case study. These non-specified experiences relate to:

- personal values and priorities;

- definitions applied to term used;
- awareness of social and cultural values, attitudes and behaviours;
- awareness that environmental matters involve a range of interrelated factors.

There is some tacit evidence to suggest that these students have drawn upon social, cultural, economic and political awareness in ways that are appropriate and make sense. However, students found it difficult to pinpoint experiences that facilitated this awareness, and so resorted to using general expressions to describe this process. For example, ‘my general interaction with the world’ [CS1.2.3], and ‘it’s just what I’ve kind of picked up’ [CS4.2.1]. Where attempts have been made to expand on this, experiences are again described in broad terms as being facilitated through, for example, media sources of information and people encountered as part of their everyday lives.

5.3 Discussion

The case study findings show that this sample of students has drawn upon a broad range of experiences in relation to their ideas on human interactions with their environments and other living things. Yet, when examined in context of all experiences identified across the sample, compulsory education in general, and science education in particular, does not feature highly amongst the experiences that are *recognised* by these students as being relevant and influential in developing their awareness, understanding and respect for environments. Instead, they afford greater weight to their experiences of family and upbringing, and to personal experiences gained through first-hand encounters with influential people, particular environments, and information in the public domain stemming mainly from media sources. Four main themes emerge from the case study findings and these are now characterised as: the influence of the teacher; the gap between perception and action; the influence of other experiences; and science education and the student experience of EE/ESD. These points will now be addressed separately:

5.3.1 The influence of the teacher

Student perceptions of compulsory science education in relation to EE/ESD lend weight to the idea of the teacher as a motivating/limiting factor in facilitating EE (Kyburz-Graber 1998; Littledyke 2004; Stevenson 2007a; 2007b). In CS1.2.7, James suggests that, amongst other factors, success in science education depends on the teacher. However, although students across the sample refer quite favourably to their experiences of biology, none mentions any particular biology teacher as being influential in promoting EE. In contrast, James

spontaneously identifies his geography teacher as being a significant person in raising his awareness of environments and environmental issues, and Ciaron credits a history teacher with introducing him to world, as opposed to American, history.

Littledyke (2004:229) observed a link between the environmental awareness of primary school children and their teachers' inclinations towards EE. For example, some younger children had demonstrated a better understanding of environmental issues studied in class than some of the older ones. Results also showed that teachers can influence children's environmental attitudes through a combination of providing a good role model, initiating class discussions of current media issue, and including planned environmental projects (ibid. p.230). Michael was the only student in this sample to make any spontaneous reference to his experiences of primary education in relation to EE. In CS4.2.6, he indicates that he had experienced some practical activities in primary school that were designed to facilitate care and concern for nature (i.e., making bird bells), yet he did not mention any specific teacher. Instead, he suggests that this interest in the environment was perhaps linked to a 'Church of England' ethos that encouraged care for what he terms, 'God's creatures' – a tacit idea of stewardship related to spiritual factors that is not present in any of the other case studies.

Individual responses suggest that, if students do not relate to their science teachers and/or cannot engage with the delivery of compulsory science education, then their perceptions of science education are dominated by their negative classroom experiences, rather than their positive achievements in GCSE science. However, there might be additional factors at work here. Firstly, this is a sample of photography students who have chosen not to pursue any further formal study of science. This action suggests that science education is not a main interest, or a prerequisite to support a career path. Secondly, when two students from a sample of four voice issues with their experiences of secondary science, it paints a picture of compulsory science education that might not be representative of responses from a larger sample. It might also be significant, or merely coincidental, that the two students who had least enjoyed their experiences of science education had attended the same secondary school. Further discussion of this factor in this thesis would be speculative. However, Michael's comparison of his positive experiences of EE in primary education with the lack of emphasis on EE in his secondary education adds some weight to Gayford's (1993:99) suggestion that an important contribution to EE 'will come from the spirit and ethos of the school, its pupils and its staff'. This indicates that there is some potential for further research to investigate the relationship between the ethos of the school, science teachers' attitudes to EE/ESD, and the student experience of compulsory science education in relation to EE/ESD.

5.3.2 The gap between perception and action

There is disparity between students' perceptions of their experiences of science education in relation to EE/ESD and the amount of tacit science content evident in their discussion of environmental subjects. Student actions suggest there is a divide between what they think about their experiences of compulsory science education - which is largely ambivalent, and what they do - which is to unconsciously draw upon scientific awareness and understanding in relation to other factors as they talk. Studies highlighted in chapter 2 contain observations on student's perceptions of science education and their wider experiences of EE. For example, Ekborg (2003:131) found that several students had understood very little from their science lessons in school and had found science difficult and boring. However, this finding represents a comparison of student teachers' experiences of compulsory science education with a new experience of learning science in a problem-based learning (PBL) context. As such, these comments relate to the development of conceptual understanding in science as opposed to the ways in which experiences of compulsory science education have supported EE. In contrast, Hillcote *et al* (1995:165) set student experiences of science education within a wider context of school as a source of environmental information. These authors found that 'school subjects most frequently mentioned were geography and biology' - a finding that was supported and extended in the follow up study, wherein:

'School was identified as an important source of environmental information. There was general praise for subjects such as geography, science, chemistry and biology. (Connell *et al* 1999:102)

However, they also found that many young people were critical of the failure of their schools to fulfil their potential in EE and that, whilst some students suggested schools provided the 'basics' for EE which could be investigated further and/or compared with media information and/or their own experiences, others were dissatisfied with a lack of EE in the curriculum and were critical of a lack of up-to-date and relevant information about the environment (*ibid*).

When compared to these previous studies, what emerges in this thesis is a broad representation of what happens when a group of students explore range of environmental subjects, as opposed to how students might draw upon experiences of science education in relation to one prescribed issue. Thus, although starting from the same brief, each environmental theme explored is different. There are however, some commonalities in approach. For example, all students focused to a large extent on the negative outcomes of human interactions with their environments. Two reasoned that portraying human interactions with environments from a negative point of view was visually more exciting, and one felt personally aggrieved by a

particular issue and wanted to portray this development as both damaging and discriminatory. Therefore, across the sample, human attitudes and behaviours were variously portrayed as irresponsible, uncaring, and motivated by ignorance, greed, economics, politics, and a sense of human superiority over other living things. There is also a general perception that, if everyone took responsibility for their own actions and did their bit, things could be different. These attitudes support Connell *et al* (1999) and strikingly similar views are expressed by young people resident in the UK, USA, and Australia. The common factor underpinning this similarity is probably the influence of a predominantly Western-style cultural perspective on human interactions with environments.

Relatively little science was drawn upon as students annotated their photography projects. Instead, they were able to communicate their ideas and views in much greater depth when presented with an opportunity to discuss their work. This elicited a much fuller representation of their thinking. Espoused evidence suggests that students do not perceive science education as being particularly influential in developing their awareness, understanding and respect for environments. In contrast, tacit content drawn upon suggests that they have clearly learned some science and are able to apply this appropriately, albeit intuitively. Therefore, student actions in this context suggest that formal scientific knowledge is, to a greater or lesser extent, embedded in their thinking on environments and environmental issues.

In one sense this outcome bodes well for science education. Yet, the fact that students did not draw upon much content from physics and chemistry might be indicative of a lack of awareness of its relevance to EE/ESD. Alternatively, the way students chose to interpret the MML brief might have restricted opportunities for individuals to draw upon this content in context of their work. For example, the photography brief placed a focus on human interactions with environments and other living things, and tacit science content drawn upon indicates that students have largely equated this with ecology. Though not incorrect, this view is limited in that they do not recognise ways in which biological, chemical and physical processes are interconnected and interdependent. For example, in CS1.2.6, James suggests that humans 'invent' chemicals to control other species and then talks knowledgeably about the ecological effects of DDT. However, in CS1.2.7, although he indicates that he had enjoyed chemistry at school, he does not acknowledge the role of this subject in supporting his understanding of how humans 'invent' chemicals such as DDT, and what chemical changes take place when pesticides are used on other living things. This might be because: (a) James learnt how toxic materials build up in food chains in a biology lesson and thus, classifies this knowledge as

biology; or (b) that his familiarity with issues surrounding the use of DDT is derived from other experiences and therefore, his scientific knowledge is contextualised.

5.3.3 The influence of other experiences

A view examined in chapter 2 suggests that socio-scientific issues are complex and might involve any permutation of interrelated scientific, social, cultural, economic, political, ethical, spiritual and aesthetic factors and values. Thus, what is learned in compulsory science education might interact with, influence, or be influenced by, a range of other factors and values stemming from an individual's life experiences. Therefore, the fact that these students drew upon scientific knowledge in this situated context is not surprising given previous findings (e.g., Ekborg 2003; Solomon 1992; Seely Brown *et al* 1989). However, of particular interest, is the way that formal knowledge is embedded in the way students think and work. For example, as shown in 5.2.1(a), students have intuitively drawn upon their literacy and ICT skills, yet have adapted their language and methods of communication to suit the context. The same might be said of the way students have drawn upon their scientific knowledge. This has been drawn upon as-and-when required. For example, as shown in 5.2.1(b), choices made to support the practical development of ideas determined the direction and content of each project. As such, there is an observable relationship between the interpretation of the MML brief and experiences drawn upon. James and Michael chose themes that offered several potential links to science, whilst Ciaron and Suzanne explored issues which emphasised social and cultural factors. Thus, these choices either presented, or limited, opportunities for individuals to draw upon science in this context. There are also examples of missed opportunities, i.e., the subject matter offered potential links to science, but the student focused on other factors instead. Whilst this might be symptomatic of a lack of conceptual understanding relating to particular issues, it is more likely to indicate that students prioritise other relevant factors. This appears to be an unconscious process driven and refined by interests, preferences and personal values. As such, when questioned about experiences that have facilitated their environmental awareness, students have mainly identified factors that underpin and have shaped their interests, preferences and values. The types and range of these experiences lends further weight to Tanner's (1998) notion that there are observable patterns of significant life experiences associated with developing environmental awareness and attitudes. There are also similarities between the nature of experiences identified in this sample and those detailed in section 2.3.1 (Palmer and Suggate 1996; Hillcote *et al* 1995; Connell *et al* 1999). This is especially so with regard to the influence of family, people, media, travel and personal experiences.

5.3.4 Science education and the student experience of EE/ESD

Science understanding underpins environmental understanding (Littledyke 1996, 2008; Orr 1992, 1994; Capra 2002). Yet, Littledyke (2004:230) found that few primary school children held ‘a perspective of science as an important influence in society and as a factor in environmental issues; either as a contributing element to the problems or as part of the solution’. There is little espoused evidence in this case study to suggest that older students have acted much differently in this respect. Yet, perhaps students’ understanding of environmental issues, and of the science relating to these issues, is simply indicative of their youth and inexperience. Alternatively, perhaps they were not asked the right kinds of questions in the interview. However, in effect, scientific understanding is sometimes drawn upon skilfully and sometimes naïvely in its application to support particular viewpoints. As such, the way students have drawn upon scientific knowledge in relation to particular issues might be variously construed as demonstrating:

- an immature understanding of science;
- a failure to recognise that science underpins environmental understanding;
- discernment as to when and how science is relevant within a particular context.

There is also limited recognition that decision-making on environmental issues is ultimately subject to prioritisation based on values rather than technical rationalism. This lends support to Grace and Ratcliffe (2002) and ways in which values influence the way science is drawn upon in relation to conservation issues. For example, in CS4.2.2, Michael’s comments demonstrate his awareness that some decisions on conservation are based upon aesthetic values. Thus, nature reserves are managed to appear attractive to humans, as opposed to being entirely ecologically suited to wildlife. Grace and Ratcliffe (2002:1166) also note that all but two of their groups of students (n=24) discussed economic arguments. Revenue is needed to conserve environments, and a nature reserve is more likely to succeed if it is seen to benefit the local community (Kwong 1997). Therefore, it pays to make the reserve aesthetically pleasing in order to attract visitors to the site - even if this form of management is not entirely beneficial to wildlife. Yet, Michael does not make this connection between aesthetic and economic values in CS4.2.2. He does, however, recognise the role of economics in context of discussing other issues. This again suggests that knowledge drawn upon is prioritised and context-dependent. However, although all students at some point referred to ways in which economic values affect human interactions with environments, none recognised that this content is present in the science curriculum.

Would a better understanding of science have changed any student's approach to this project and thus, increased the potential to have drawn upon science in this context? This of course depends on what 'a better understanding' of science means. Is the answer to call for more NC science content? No. This would not be a sensible solution. The science curriculum is already content-heavy and this factor, in itself, creates problems for science teachers charged with meeting national targets for attainment. Also, findings in existing research suggest that students develop individualistic frameworks for explaining environmental issues (Connell *et al* 1999) and that they tend to express rigid viewpoints when discussing issues of conservation (Grace and Ratcliffe 2002). However, whilst Grace and Ratcliffe (2002) found that exposure to, and consideration of, the views of others through peer-group discussion was beneficial in shaking rigid views, Ekborg (2003) observed that, where decisions are underpinned by emotion, it is unlikely that a better understanding of science would make any difference. There is some support for Ekborg's view in CS1 and CS2. For example, it is doubtful whether a better understanding of science would encourage James to take a different position on SD. Firstly, he draws upon science to support his existing position against SD and secondly, his enjoyment social discussion is supported by self-directed reading. So, although his views on SD might be rigid, James is well placed to argue and defend his case articulately.

There is only so much that compulsory education can achieve. There is also evidence in this sample to suggest that students view their everyday life experiences as more effective in facilitating environmental awareness than the school curriculum. Yet, young people need some form of experience that allows them to understand that humankind is inextricably (scientifically *and* socially) linked to the environmental systems of this planet. An obvious contender for this role is science education. However, this requires some changes to the way science is taught. So, is there anything in this study that might add to the debate on this matter? Reflecting on the actions of these students, there is something intuitive about the way they have transferred aspects of formal knowledge into their everyday thinking. For example, they have drawn upon their awareness of science to describe and explain ideas, and to justify their attitudes and values. However, their actions in this context suggest that they are not sure:

- i how science education supports EE/ESD (i.e., what content and skills are relevant and useful in different contexts);
- ii how formal knowledge from science education forms links with formal knowledge from other curriculum subjects within interdisciplinary learning.

This outcome adds further weight to arguments in the literature on scientific literacy that call for formal education to do more to enable young people to engage with socio-scientific issues

in real world contexts. One solution might be to call for a National Curriculum remit to facilitating scientific literacy in order to support environmental literacy. Perhaps using the terms *scientific literacy* and *environmental literacy* as goals of compulsory education might have some positive influence on the outcomes of EE. Yet, there is little point in introducing new terms without presenting a clear strategy for learning. This problem has been identified in relation to the lack of progress in implementing ESD in schools (House of Commons Environmental Audit Committee 2005).

There is consensus in the literature on EE/ESD that the only way to make EE more effective in schools is to afford it higher curriculum status. However, there is a risk that EE just becomes another discrete NC subject driven by performance targets and Ofsted monitoring (House of Commons Environmental Audit Committee 2005). Although this would raise the profile of EE in schools, it is still not a solution guaranteed to facilitate environmental literacy. For instance, what would the programme of study look like? How should it be delivered and by whom? The point is that students still need to be taught how to join up content from different sources to enable understanding of issues that are complex and varied. Therein lies a problem – how do students learn to make these linkages? In this case study, some students actually began to make connections between content in science and geography as they described their experiences of compulsory education in relation to EE/ESD. Therefore, one way forward might be to consider the student's voice on what they find useful. For example, Ciaron makes the following observation in CS3.2.4:

I think a lot of my knowledge, I already have. Whether I know I have it already is different! Maybe this just drew out of me a need to use it and say something about it. [].
If anyone asks, you might be able to tell them but, if you've never been asked, how do you know if you know it?

This statement from Ciaron encapsulates the problem. In the UK, children receive eleven years of compulsory education and, whilst frequent testing indicates what pupils know in single subjects, it does not significantly address what they understand in relation to real life issues explored in real world contexts. Ciaron's astute observation implies that the opportunity to explore his knowledge (formally acquired and gained from other experiences) in this informal context presented him with a forum in which he could recognise, and engage with, what he knows and understands in relation to environmental matters.

Chapter 6 Conclusion

This thesis has investigated experiences drawn upon by students in post-compulsory education as they have explored environmental subject matter through photography. This final chapter links the case study outcomes to the research problem identified in section 1.1 and considers the implications of these for NC science where there is an emphasis on EE and ESD. It is important to be clear about what claims can be made from this case study. This thesis is intended to contribute to the literature on the student experiences of EE where there is an emphasis on compulsory science education. Therefore, its value lies in the description of interactions between experiences of NC science and students' other life experiences in this particular context. The research problem, previously identified on pages 1-2, posed three questions which now serve as the guiding framework for considering the implications of the case study in section 6.1:

- 6.1.1: Have young people in post-compulsory education knowingly, or otherwise, drawn upon any experiences from their compulsory science education when exploring environmental subject matter in informal contexts?*
- 6.1.2: What are these students' perceptions of their experiences of NC science in relation to EE and ESD; and what, if anything, might their responses say about the contributions of compulsory science education to achieving the NC aims for EE/ESD?*
- 6.1.3: What can be said about the contributions of compulsory science education to facilitating understanding that enables informed engagement with environmental issues and facilitates environmental literacy?*

Section 6.2 presents an evaluation of the strengths and weakness of the case study design. The thesis concludes in section 6.3 by considering the outcomes of this inquiry in terms of highlighting areas for further research.

6.1 Implications of the case study outcomes

6.1.1 *Have young people in post-compulsory education knowingly, or otherwise, drawn upon any experiences from their compulsory science education when exploring environmental subject matter in informal contexts?*

The simple answer to this question is yes. However, whilst it might be suggested that compulsory science education has played some role in developing knowledge and

understanding of life processes and living things, i.e., it fulfils its NC remit to support education *about* the environment, there is little espoused evidence that students believe this experience taught them how to engage with environmental issues that focus on human interactions with their environments – and especially so with regard to SD. A more positive outcome for science education is that students have intuitively drawn upon their understanding of science in relation to other experiences and factors as they have explored and discussed environmental subjects. Therefore, although students do not talk about their experiences of compulsory science education in terms of teaching them how to engage with environmental issues, they have to a greater or lesser extent, demonstrated appropriate use of formal scientific knowledge within this particular informal context.

6.1.2 *What are these students' perceptions of their experiences of NC science in relation to EE and ESD; and what, if anything, might their responses say about the contributions of compulsory science education to achieving the NC aims for EE/ESD?*

At face value, there is little espoused evidence in this case study to suggest that the experience of eleven years of compulsory science education has been received with much enthusiasm by these students. There is support for Ekborg (2003) in that most students said they found some aspects of their science education difficult. However, as indicated 5.3.1 and 5.3.2, this might be a factor related to using a sample of non-scientists and/or symptomatic of this particular small sample. Yet, unlike Ekborg's findings, no student suggested that science education was boring. Students' overriding perception of science education in relation to EE was that, whilst science education has been positive and influential in developing a biological understanding of life processes and living things, other curriculum subjects (especially geography) and general life experiences are more influential in developing awareness, understanding and respect for environments. They particularly felt that science education was not concerned with teaching about human interactions with environments.

In line with Connell *et al* (1999), some students felt there was a general lack of attention to EE in secondary education. However, this was an observation aimed at compulsory education as a whole rather than being specific to science education.

So, is there any evidence to suggest that compulsory science education does what it claims to do in relation to EE/ESD and in preparing young people to engage with socio-scientific issues in real world contexts? Whilst this case study certainly presents a lukewarm student response to the experience of an NC core subject, could it really be claimed that compulsory science

education fails to fulfil its NC remit to support EE and ESD? The findings are not conclusive in this respect. Students' espoused perceptions of their science education are not entirely reflected in the tacit science content drawn upon. From the former, it appears that that NC science supports EE in a limited way, but does not support ESD. From the latter, it appears that science education has prepared these students to draw upon their understanding of science in an informal context. In addition to this, students' views on their experiences of compulsory science education were examined in response to a narrow focus on their perceptions of its relevance to one particular theme and context. As such their responses are not necessarily indicative of their experiences of science education as a whole, or of their perceptions of its relevance to other environmental issues relating to, say, health or energy. However, overall, it can be concluded that science education has: (a) to some extent, fulfilled its remit to support EE, but not ESD; and (b) that students' perceptions of the relevance of science education to EE might be improved if they are enabled to recognise the wider content relating to *Application of science* and *Communication* that they have intuitively drawn upon in this context.

In spite of NC guidelines stating overall aims for environmental learning, EE and ESD are not curriculum priorities. As shown in 2.1, NC science did not carry a statutory remit for SD prior to 2000 - and even then the required content was minimal. Therefore, it is hardly surprising that these students did not associate their experiences of science education with ESD. This outcome was anticipated in light of the timing of this research. Therefore, at this time, students' failure to link their experiences of science education with ESD can be explained as a policy issue rather than any particular deficiency in the teaching and learning in science. However, whilst this might justify student responses on ESD, it does not explain why they expressed only a limited recognition of science education's relevance to EE. This outcome is symptomatic of wider issues in compulsory education that perhaps should be of concern to science education. The statutory remit for NC science from 1990-1999 was substantial and made explicit in curriculum guidance for EE published by the NCC (1990) and SCAA/QCA (1996). So, why does this appear to have slipped the notice of these students? This refocuses the argument on the curriculum status of EE and issues of competing priorities for what should be taught, how and why. Curriculum guidance on EE only really presents the possibilities for environmental learning by highlighting the elements of statutory programmes of study relevant to informing EE. However, the delivery of this content is discretionary for schools. Therefore, the same statutory content can be taught with, or without, reference to learning across the curriculum. In other words, there is no fixed requirement for science teachers to teach science content in an interdisciplinary, EE context. Furthermore, there is the question of science teachers' knowledge, expertise and attitudes as highlighted in 2.3.1 (Kyburz-Graber 1998).

This is consistent with ideas on the tensions between the nature of formal education and the nature of EE presented in 2.2. If there is no incentive for schools and, by association, science education, to address learning across the curriculum then, with an overcrowded curriculum and pressures on teachers to prioritise learning that is measured by national testing, it is unlikely that students will: (a) recognise EE and afford it status within the things they learn at school; and (b) recognise how subject content and skills from their experiences of science education relate to EE within interdisciplinary and real world contexts.

6.1.3 *What can be said about the contributions of compulsory science education to facilitating understanding that enables informed engagement with environmental issues and facilitates environmental literacy?*

It has been shown that compulsory science education facilitates EE of a certain kind. In terms of the contribution of NC science to the three linked components of EE, most of what these students have expressed, and drawn upon, suggests that their experiences of compulsory science education have equipped them with formal knowledge consistent with education *about* the environment. There were no spontaneous references to science fieldwork, or to the use of secondary sources of environmental information in science lessons. As such, there is no demonstrable student awareness of the contribution of NC science to education *in/through* the environment. There is also little evidence to suggest that these students believe science education supports the development of respect for environments as part of education *for* the environment. This is particularly apparent with regard to ESD.

The National Curriculum and much of the literature reviewed for this thesis states that young people require knowledge and understanding of science in order to comprehend the natural world and engage with issues involving science in real world contexts. Yet, how much of this taught content is actually useful on an everyday basis? Findings in this case study, suggest that relatively little, and very specific, content is drawn upon. This is not because science is irrelevant (although in some cases it is). Rather, it is because its relevance to environmental issues is, as Grace and Ratcliffe (2002) observed, context-dependent and subject to values and emotion. The individual case studies show that different factors influence ways in which individuals respond to issues relating to human interactions with their environments. High on the list are personal values and cultural influences. Therefore, based on this sample, an individual's environmental literacy comprises:

- *formal knowledge* of geography, science, English, ICT, and history;

- *values and cultural awareness* stemming from family and upbringing, personal experiences, social interaction with others, and media influences;
- *other awareness* relating to interests, preferences, first-hand interactions with environments, and self-directed study.

According to these students, school is not as influential in developing awareness, understanding and respect for environments as other life experiences. Whilst this outcome might not be a desirable reflection on the efficacy of EE in compulsory science education, it is realistic given the low curriculum profile of EE. Another factor relates to the complex nature of environmental issues (Palmer 1998). Whilst the shape of scientific knowledge drawn upon in this case study is dominated by biological content, there is evidence to suggest that content drawn upon has been influenced by the focus of the MML brief (i.e., on human interactions with environments and other living things) and the students' interpretation of this brief (i.e., their chosen theme and practical approach to the project). Factors at work in this process are now identified as *interpretation* and *opportunity*.

Interpretation: These case studies show that environmental exploration can be:

- motivated by pragmatic and emotional reasons;
- underpinned by an interest in particular environments or issues;
- driven by progress towards a predetermined or desired outcome.

Thus, as shown in sections 5.2.1(b) and 5.3.3, although the MML brief offered all students the same starting point for their photography project, the way each individual chose to interpret this brief and develop their ideas served to either present, or limit, potential opportunities to draw upon science in this context.

Opportunity: The idea of opportunity reflects the types of things that happen in real life situations where factors other than scientific understanding might be more appropriate to supporting ideas within the particular context of a situation. For example one might have expected Ciaron, as the highest achieving student in GCSE science, to be ideally placed to draw upon his formal knowledge in his project. Yet, of all the case studies, his contains the least science. Why? Because, having moved away from an initial exploration of what he terms 'nature stuff', there was no need for him to draw upon his scientific understanding to develop ideas relating to the visual impact of advertising. This focus highlighted aesthetic, social and cultural issues and so, Ciaron prioritised knowledge relevant to supporting these issues. In this way, Ciaron's interpretation of the brief had served to limit the opportunities for him to draw

upon science in this particular context. In contrast, the ways in which James, Suzanne and Michael chose to interpret the MML brief presented them with more potential opportunities to draw upon science because of the nature of the subject matter explored. For example, they all touched on ideas relating to ecology.

If, as Roth (1992) suggests, environmental literacy includes the ability to understand interactions between human social systems and natural systems, then these students have all demonstrated that they are somewhere along a sliding scale towards achieving a level of functional environmental literacy. However, there is a noticeable variation in the level of confidence with which students discuss environmental subjects. This might be indicative of gaps in their formal knowledge, or of other factors at work, for instance, the influence of the context of AS photography and/or social factors on students' interpretation of the brief. The influence of interpretation and opportunity, as observed in the case studies, is likely to be unpredictable in that it is context-dependent. Yet, this should not free NC science from its remit to facilitate scientific awareness and understanding that enables informed engagement with environmental issues. Instead, it points towards a need to understand more about how students draw upon experiences of compulsory education in informal contexts; and especially if and how factors such as *interpretation* and *opportunity* are influential in this process. However, before considering ways in which further research might inform this, it is useful to consider what things have changed since the photography project took place:

Changes to EE/ESD since 2000: The findings of this case study are based on student experiences of compulsory education between the years 1990-2000. Since this time there have been further revisions to the NC that have affected both science education and EE. By 2002, the seven key concepts of ESD had replaced the previous three-component form of EE. However, the remit for science education to support ESD was relatively limited and uncertain in comparison to its previous remit to support EE, i.e., there was only one strand of the science programme of study forming a statutory link to SD. NC guidelines on ESD published online during the period 2002-2008 indicated that pupils should be taught:

- to relate life processes to animals and plants found in the environments in which they are found;
- about ways in which living things and the environment need protection;
- variation and inheritance;
- adaptation and competition.

Yet, this is a narrow interpretation of how science education might contribute to the development of awareness and understanding relevant to SD. This contribution is entirely supported by content in *SC2 Life Process and Living things* without any reference to relevant knowledge and skills from the other science disciplines. For example, there is no reference to the need to understand the Earth's cycles and content relating to energy.

According to Reid (2002:76), ESD 'is neither fixed, isolated or pure, nor can we arrive at or present and incontestable, 'correct' version of it for all times and places.' This is certainly manifest in the NC response to SD. Introduced in 1995, the direction and frameworks for SD in compulsory education are still being revised and reinvented and, from September 2008, will undergo yet another NC transformation to assume a position within the *Cross-curriculum dimension* under a new designation of *Global dimension and sustainable development*. Yet, after all this time is ESD in schools really effective? Doubts are being raised about this. For example, a review of progress on ESD by the House of Commons Environmental Audit Committee (2005:5) raised concerns over the lack of basic commitment to the principle of SD from those charged with promoting and educating about it. The committee observed some reluctance on the part of DfES to engage with the importance of ESD. They also found that teachers did not have the time to access, read and action electronic guidelines on ESD. These factors, combined with the low curriculum profile of ESD, have created a situation where 'in many schools, ESD is either not known about or is judged to be a low priority'. Yet ESD, and now the *Global dimension and sustainable development*, has displaced EE within learning across the curriculum. Therefore, of wider concern, is what effect the introduction of ESD has had on pupil learning in EE since 2000, and what steps might be taken to evaluate this?

Changes to science education that relate to EE/ESD: NC science has once again been revised in key stages 3 and 4 and the new programme of study will be introduced in schools from September 2008. This programme of study 'should provide opportunities for pupils to recognise the importance of sustainability in scientific and technological developments' (QCA 2007:212). This is accompanied by an explanatory note:

“Sustainability: This relates to the continuity of economic, social and environmental aspects of human society, as well as the non-human environment. It also incorporates sustainable development: meeting the needs of the present generation without compromising the ability of future generations to meet their needs. It could include examining issues surrounding the availability of finite resources, waste reduction and recycling, energy conservation and renewable energy resources, and environmental pollution.”

Based on this statement, the shape of science education that might facilitate learning relating to sustainability would require the acquisition of knowledge and skills across all three science disciplines. This presents an opportunity for science educators to consider how they might address teaching and learning that relates to sustainability as well as SD. Therefore, they might consider ways of teaching about human interactions with their environments and other living things that facilitates awareness of both intra- and inter-disciplinary perspectives on science and environmental issues.

6.2 Methodological issues

The use of an AS level photography project as an informal context in which to examine the outcomes of science education demonstrates originality in the research design. The outcomes of the case study have demonstrated that opportunities to draw upon experiences of science education can be provided through an informal context in a visual arts subject. The research elicited data that has allowed comment on if and how students in post-compulsory education have drawn upon their compulsory science education in a particular context whilst thinking about human interactions with their environments. In this sense, the case study design has fulfilled the purpose of the thesis. Would this research produce similar results under similar conditions? This would be interesting to test. A factor that cannot be overlooked in this research is that this is not a sample of science students. These photography students all achieved within the A*-C standards of attainment at GCSE. Yet, perhaps they are simply not predisposed to an interest in science. Therefore, it would certainly be useful to repeat this research with science students to compare the outcomes. Would science specialists draw upon experiences of compulsory science education any differently from non-scientists given the same photography brief? Would their perceptions of the relevance of NC science to EE and ESD be any more favourable?

Students carry out the practical aspects of an AS level photography project within a fairly formalised structure in order to meet the assessment objectives. However, the content presented in a work journal is always unpredictable since this is mainly reflects: (i) the student's independent research and development of the subject explored; (ii) their interest in, and aptitude for, photography; and (iii) their commitment to the project. Therefore, the case study design involved offsetting risk against potential gain. Yet, the MML brief, with its flexibility for students to diversify within the parameters of the theme, was a calculated risk that proved successful in facilitating observations relating to the influence of *interpretation* and *opportunity* on the way students draw upon scientific knowledge in an informal context. This

diversity is more in keeping with how someone might engage with environmental issues in everyday contexts. In other words, student actions in this context have been subject to their interests, preferences, emotions and values.

The sample provided four different contexts in which to investigate experiences and content drawn upon. However, analysing each situation was complex in that it involved a process of identifying individual experiences and content drawn upon, then observing how these factors interacted in each case, before finally drawing the findings together into a coherent reporting of actions across the sample. There is also more than one story that might emerge from these narratives. For example, in this instance, the narratives are interpreted by a photography teacher with an interest in the outcomes of the experience of compulsory science education. However, these narratives might equally be studied by a science educator with a view to informing professional practice by examining the conceptual understanding of students as they discuss complex environmental issues in an informal context. This is more in keeping with Ekborg's (2003) approach. The key point being made here is that a photography project of this nature provides an informal context which might potentially facilitate a range of insight into the outcomes of compulsory science education.

A key factor in facilitating triangulation has been the role of practitioner. The things students said about their actions in the photography project were not only verifiable through evidence in the ISP and work journal, but I had also been present as the projects had progressed. The things students said about human interactions with environments, and their experiences of science education, are more difficult to verify since these are the students' subjective accounts of their actions. However, the fact that some responses echo those in other studies suggests there might be some common pattern in the student voice on their experiences of EE. This adds weight to the reliability of the outcomes.

The collection of data from multiple sources has been crucial to informing the findings. Being able to cross-reference and verify details and omissions made for a more reliable and valid account of what happened. Analysis of the work journal alone would have provided a limited story, and so would an interview without the stimulus of details contained in the work journal and ISP. For example, evidence in James' work journal would suggest that he has little in-depth understanding of environmental subjects. In contrast, his interview revealed an entirely different story. Presented with an opportunity to talk, rather than write, James demonstrated an unexpected depth of understanding and passion for environmental issues. This provides a key

point for my own professional development in that future planning and classroom practice will include an opportunity to engage students in post-project discussion of their completed work.

The sample selection carried some risk in that the criteria identified Ciaron. The decision to include a student in the case study who had not experienced eleven years of UK compulsory education was based on three factors: the quality of writing in his work journal; the richness of data collected through his interview; and his achievement in GCSE science. A* achievement in science implies that Ciaron knows everything, and maybe even more, than the NC requires for pupils aged 16. Whilst on the one hand, it could be argued that it was not NC science that facilitated his level of achievement measured through UK formal assessment. On the other, perhaps his NC education in key stage 4 was of such quality that it enabled him to fulfil his potential. This argument cannot be settled here. Therefore, Ciaron's inclusion in the case study is now justified on two counts:

- i His actions in this context provide useful insight into how family experiences and upbringing interact with and affect experiences of compulsory science education.
- ii Evidence that an A* science student rarely drew upon this formal knowledge in this particular context is not indicative of a lack of scientific understanding, but rather that other factors and priorities influence if and how science is drawn upon in informal contexts.

Areas for refinement of the design relate to the interview structure and questioning. The interview structure was a little too flexible. Therefore, although it elicited useful spontaneous responses such as Michael's account of competing priorities in local communities, it also elicited much interesting, yet irrelevant, data. This resulted in an overly long process of data reduction in order to find the most appropriate story for the purpose of this thesis. Something to build into a future interview framework would be questions that elicit a more detailed account of students' perceptions of how science content relevant to EE/ESD relates to content in other subjects.

6.3 Further research

Section 2.3 pursued Orr's (1994) observation that it is not *more* education that is required – it is education of the right kind. So, what is the right kind of education? This thesis cannot claim to have answered this question. What it has done however, is to provide some basis for further research into National Curriculum development that might. Therefore, it is argued here that it is not *more* science content that is needed, it is: (i) an improved curriculum status for EE; and

(ii) the development of initial teacher training and continuing professional development to facilitate the knowledge and skills that will enable teachers to educate students to recognise that the natural and social worlds are both interrelated and interdependent. An NC assumption in relation to EE/ESD is that students are somehow instinctively able to join up content from separate curriculum subjects in a way that enables them to make sense of their environments and environmental issues. Barriers to this have been previously identified as: (i) discipline-based, fragmented and decontextualised learning (Stevenson 2007; Orr 1999; Littledyke 2008); and (ii) teaching that does not treat the linkages between scientific and non-scientific content (Ekborg 2003). This case study has shown that students are aware of subject demarcation, and that most do not recognise linkages between environmental content in science and geography until presented with an opportunity to explore their understanding of these connections. This highlights an area for further research within compulsory education in order to inform practice on how students join up content from individual subjects into an interdisciplinary understanding of human interactions with their environments and other living things.

Conspicuous by its absence in this case study is student recognition of the relevance of physics and chemistry to understanding environmental issues. This lends some support to Orr's (1994) view that specialised and decontextualised learning in formal education unconsciously generates messages that some things are not relevant, or connected to, understanding human interactions with environments. When matched against his belief that 'all education is environmental education' (*ibid.* p.12), the experience of compulsory science education appears to have taught these students that knowledge and understanding of physics and chemistry are not relevant to EE. Whilst this is perhaps an unsafe judgement given the size of the sample, the real point being made is one in support of Ekborg's (2003) observation that, to allow students to learn science well enough to use scientific knowledge when discussing a complex issue, the teaching must treat the linkages. As a core curriculum subject NC science holds a unique position to take a lead on EE and sustainability. It has high-profile curriculum status and carries content vital to understanding natural systems. It also has the potential to do more to enable understanding of the interrelatedness of natural and human systems through its three-discipline format. Thus, science education is unique in its potential to treat subject linkages between independent disciplines within its own programme of study. If, therefore, science educators could work towards initiating research to inform creative ways of teaching the linkages between: (a) biology, physics and chemistry; and (b) scientific and non-scientific content in complex environmental issues; then this might perhaps go some way towards facilitating transferrable knowledge and skills to enable interdisciplinary understanding and thus, progress towards a goal of environmental literacy.

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Photography brief

AS photography coursework Unit 2b

Man-made landscapes

Explore your views on human changes to landscapes and/or human interactions with environments. Take photographs of Man-made landscapes and produce images that record and communicate your observations and views about the relationships between humans and other living things in these places.

Man-made landscapes might include:

- Agricultural / industrial / urban landscapes
- Parks / gardens
- Nature reserves / wildlife conservation areas
- Hedgerows / woodlands
- Transport corridors

You might consider as part of your development of ideas:

- the reasons why humans adapt and develop landscapes to meet different needs;
- what happens to wildlife when landscapes change;
- ways in which humans and other living things co-exist and compete for space and resources;
- issues relating to sustainable development, biodiversity and conservation.

Research / work of others

What motivates landscape, environmental and wildlife artists/photographers? What do they choose to record, how do they do this, and what do they seek to convey to the viewer through their images?

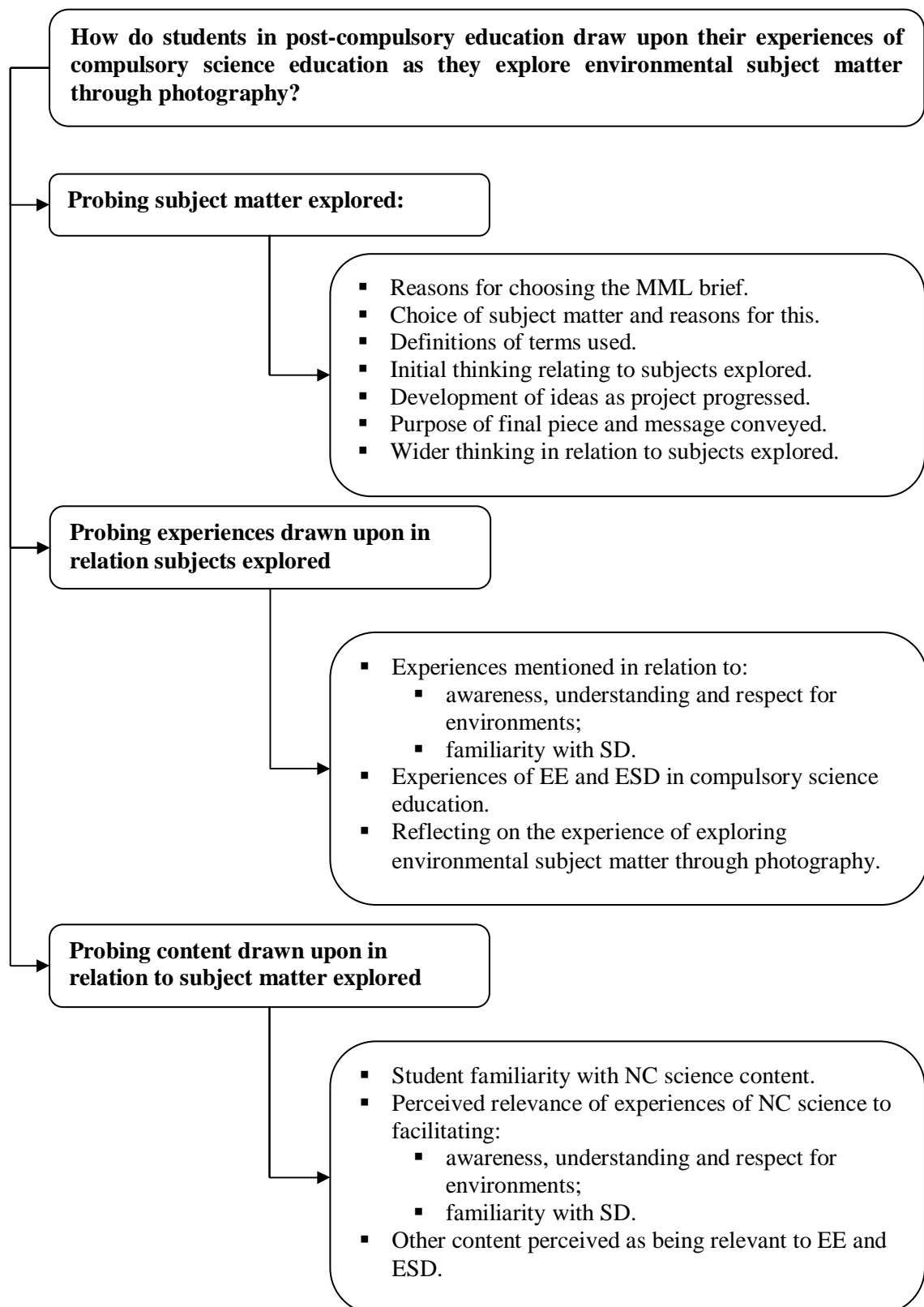
Suggested artists:

- | | |
|-------------------|--------------------|
| ▪ Ansel Adams | ▪ Andy Goldsworthy |
| ▪ Heather Angel | ▪ David T. Hanson |
| ▪ Jim Brandenburg | ▪ Richard Misrach |
| ▪ Fay Godwin | ▪ Frans Lanting |

Processes and techniques

- Film: 35mm black and white / colour photography
- Digital capture and manipulation
- Photomontage /collage / images and text / multiple images
- Experimental techniques /animation / video installation / DVD

2.1 Interview agenda



2.2 Interview framework with examples of questions

Reasons for choosing to respond to the MML brief:

Could we begin by exploring your reasons for choosing to respond to the MML brief?

- ⇒ Have you explored environmental themes before?
- ⇒ Did the introductory presentation for the brief influence you in any way?
- ⇒ Did you know anything about this issue before starting work on your project?
- ⇒ Was there anything you felt you needed to know before starting the project?

Practical exploration of chosen theme [stimulus: 'ideas page' work journal]:

Starting with your initial ideas can you talk me through your photography project?

- ⇒ How did you support the development of your ideas?
- ⇒ What is the purpose of your final piece?
- ⇒ Were you intending to convey any specific statement to the viewer?

Wider thinking on human interactions with environments:

Do the ideas expressed in your photography project reflect your wider thinking on human interactions with environments and other living things?

Experiences of compulsory science education

Can you describe your experiences of science education at school?

- ⇒ Do you think your science education has contributed to your awareness and understanding of environments?
- ⇒ Are you familiar with the term 'sustainable development'?

Reflections on the photography project

Were you pleased with the outcomes of your photography project?

- ⇒ How do you feel about this method of exploring environments?
- ⇒ Has this caused you think any differently about the things you have explored?

Generic questions used to probe and clarify student reasoning:

- Could you expand on this/give examples?
- What are your reasons for this?
- How do you think you have come to know this?
- Has anything in particular influenced the way you think about this?
- What you mean when you say?
- Have I understood correctly what you are saying?

3.1 Tables summarising data for CS1: James

CS1 Table 1: Experiences of compulsory science education [RQ1]

Spontaneous references to science education:

- none

Responses to direct questioning:

- science education is perceived as being not particularly relevant to EE
- science education is not associated with developing awareness of SD
- science education is associated with a ‘technical’ awareness of life processes and living things
- success in science education is judged to be dependent upon the teacher and the interest of the student
- some aspects of science education are better than others e.g., messing about with chemicals is better than written science projects
- science education forms some links with content in geography

Tacit links to compulsory science education:

SC2: Life processes and living things:

3. Green plants:

- ⇒ *nutrition and growth* [plants produce seeds which, in turn, produce new plants; plants need light and water to grow; plant growth is affected by the availability of light]

4. Variation:

- ⇒ *Classification* [classifying living things into the major taxonomic groups]

5. Living things in their environments:

- ⇒ *adaptation and competition* [different habitats support different plants and animals; factors affecting the size of populations include predation and competition for resources; the impact of human activities on the environments is related to population size, economics and levels of consumption and waste]
- ⇒ *feeding relationships* [food chains; toxic materials build up in food chains; factors affecting the size of populations include predation and competition for resources]

2. Application of science:

- ⇒ relating science to the care of living things and the environment
- ⇒ evaluating the benefits and drawbacks of scientific and technological developments

4. Communication

- ⇒ use of scientific vocabulary

CS1 Table 2: Experiences other than compulsory science education [RQ2]**Spontaneous references to compulsory education:**

- none

Responses to direct questioning:

- school is good and starts a learning process about things that might not otherwise be encountered
- geography is the main subject associated with EE and is tentatively associated with developing awareness of SD
- geography facilitates a broader understanding of environments and environmental issues than science education.
- geography teacher influential in facilitating awareness of environmental issues
- assessment in compulsory education favours those who can write

Tacit links to compulsory education:

- English [literacy and communication skills]
- geography [environmental change; population];
- history [Roman Britain];
- ICT [computer skills; sharing views and experiences of ICT]

Other life experiences:**Family:**

- relationships with immediate family [mother, father, sister]
- extended family [brother-in-law]
- parents' career/employment [farmer; joiner]
- shared interests and values
- preference for outdoor lifestyle
- sense of individual responsibility

Personal experiences:

- personal and aesthetic values
- self-directed reading linked to media awareness and personal responsibility
- first-hand interaction with environments
- social interaction with others

Institutional experiences:

- post-compulsory education in a post-16 setting [AS level photography]
- membership of a youth organisation [Scouting Association]

Non-specified experiences:**Relate to:**

- personal values
- cultural, economic, social, political, media and ecological factors

3.2 Tables summarising data for CS2: Suzanne

CS2 Table 1: Experiences of compulsory science education [RQ1]

Spontaneous references to science education:

- none

Responses to direct questioning:

- science education is not associated with EE
- science education is not associated with developing awareness of SD
- science education is perceived as being something different from science
- science rather than science education is relevant to EE
- science education was not a good experience
- science teachers are critical rather than encouraging of student efforts

Tacit links to compulsory science education:

- **Life processes and living things:**
 - ⇒ **Variation:**
 - ⇒ *classification* [classifying living things into the major taxonomic groups]
 - ⇒ **Living things in their environments:**
 - ⇒ *adaptation* [different habitats support different plants and animals; the impact of human activities on the environments is related to economics]
 - ⇒ *feeding relationships* [factors affecting the size of populations include predation and competition for resources]
- **Application of science:**
 - ⇒ relating science to the care of living things and the environment
- **Communication**
 - ⇒ use of scientific vocabulary

CS2 Table 2: Experiences other than compulsory science education [RQ2]

Spontaneous references to compulsory education: One [school]

Responses to direct questioning:

- school linked to understanding of term ‘wildlife’

Tacit links to compulsory education:

- English [literacy and communication skills]
- ICT [computer skills; sharing views and experiences of ICT]

Other life experiences:

Family:

- relationship with parents
- extended family [aunt and uncle]
- parents’ interests [environmental campaigning]
- shared values relating to conservation

Personal experiences:

- first-hand interaction and familiarity with environments
- personal values
- self-directed research
- media [broadcast and print media; nature programmes]
- personal interests [music; computer games]
- aesthetic values
- boyfriend

Institutional experiences:

- post-compulsory education in a post-16 setting [AS level photography]
- post-compulsory education in a post-16 setting [General studies]
- parents’ membership of Greenpeace [Greenpeace]

Non-specified experiences:

Relate to:

- personal values
- aesthetic, cultural, economic, social, political, media and ecological factors

3.3 Tables summarising data for CS3: Ciaron

CS3 Table 1: Experiences of compulsory science education [RQ1]

Spontaneous references to science education:

- none

Responses to direct questioning:

- science education is perceived as being not particularly relevant to EE
- science education is tentatively associated with developing familiarity with content that might relate to SD
- some aspects of science education are better than others:
 - preferred physics and chemistry owing to aptitude to ‘facts, figures and numbers’
 - found biology easier than physics and chemistry
- science education forms some links with content in geography in topics such as population

Tacit links to compulsory science education:

- **Life processes and living things:**
 - ⇒ **Living things in their environments:**
 - ⇒ *adaptation* [the impact of human activities on the environments is related to economics]
- **Communication**
 - ⇒ use of scientific vocabulary

CS3 Table 2: Experiences other than compulsory science education [RQ2]**Spontaneous references to compulsory education:**

- geography

Responses to direct questioning:

US Education: Parents' perception that American schools are 'bad'

- elementary school [only preparation for the next stage of education]
- private education [History teacher introduced aspects of world history]
- home schooling [relaxed way of learning; preparation for change from US to English curriculum]

English NC: Many similarities between the US and English curriculum

- geography is perceived to be the main subject associated with EE
- NC geography different from US geography in its EE content
- geography is viewed as the 'science of the environment'

Tacit links to compulsory education:

- geography [people and places; settlement]
- English [literacy and communication skills]
- ICT [computer skills; sharing views and experiences of ICT]

Other life experiences:**Family:**

- relationships with immediate family [mother; father; brother]
- parents of US and British nationality
- values and sense of responsibility [parents' knowledge, worldview and values]
- parents' career/employment [relocation owing to father's job; mother a teacher]

Personal experiences:

- preference for urban, especially city, environments
- general 'subconscious' way of absorbing information
- general knowledge and personal values
- discussion of ideas [with mother; with photography teachers]
- first-hand observation and experiences gained from living in different places

Institutional experiences:

- media awareness [general media coverage of environmental subjects]
- AS/A level media studies [tacit]

Non-specified experiences:**Relate to:**

- personal values and priorities relating to the environment
- social and cultural awareness
- awareness of environmental organisations such as Greenpeace

3.4 Tables summarising data for CS4: Michael

CS4 Table 1: Experiences of compulsory science education [RQ1]

Spontaneous references to science education:

- none

Responses to direct questioning:

- science education is perceived as being not particularly relevant to EE
- science education is not associated with developing awareness of SD
- science education is concerned with learning about ‘processes’
- secondary school science is difficult and not enjoyable
- found biology easier than physics and chemistry

Tacit links to compulsory science education:

- **Life processes and living things:**
 - ⇒ **Variation:**
 - ⇒ *classification* [classifying living things]
 - ⇒ **Living things in their environments:**
 - ⇒ *adaptation and competition* [different habitats support different plants and animals; the impact of human activities on the environments is related to economic and industrial factors]
- **Application of science:**
 - ⇒ relating science to the care of living things and the environment
- **Communication**
 - ⇒ use of scientific vocabulary

CS4 Table 2: Experiences other than compulsory science education [RQ2]**Spontaneous references to compulsory education:**

- none

Responses to direct questioning:

- geography is perceived to be the main subject associated with EE
- geography is considered to have facilitated a broader understanding of environments and environmental issues than science education
- primary school more relevant to facilitating care for the environment and other living things whereas secondary education is not overly concerned with EE

Tacit links to compulsory education:

- English [literacy and communication skills]
- geography [settlement; environmental change]
- ICT [computer skills; sharing views and experiences of ICT]

Other life experiences:**Family:**

- relationships with immediate family [parents]
- parents' career/employment [hotel managers]
- relocation
- shared interests, values and attitudes
- sense of responsibility

Personal experiences:

- first-hand interaction with environments
- social interaction with others
- media awareness
- values [personal; aesthetic]

Institutional experiences:

- post-compulsory education in a post-16 setting [AS level photography]
- environmental organisations [Greenpeace; National Trust]

Non-specified experiences:**Relate to:**

- values [human; environmental; cultural]
- economic, social, aesthetic, media and ecological factors
- cultural awareness

3.5 Tables summarising data across the sample

Table 1: Experiences of compulsory science education [RQ1]

Spontaneous references to science education:

- None [CS1; CS2; CS3; CS4]

Perceptions of science education's relevance to EE and ESD:

- Science education is not particularly relevant to EE [CS1; CS3; CS4]
- Science education does not develop familiarity with SD [CS1; CS2; CS4]
- Science education might contain some content relevant to SD [CS3]
- Science rather than science education is relevant to EE [CS2]

Attitudes to science education:

- Science education is not a good experience [CS2; CS4]
 - ⇒ science teachers are critical rather than encouraging [CS2]
 - ⇒ secondary school science is difficult and not enjoyable [CS4]
- Biology is easier than physics and chemistry [CS3; CS4]
- Science education is a good experience [CS1]
- Success in science education is dependent on the teacher; the interest of the student; the ability of the student to learn [CS1]
- Some aspects of science education are preferred to others:
 - ⇒ practical work preferred to written projects [CS1]
 - ⇒ physics and chemistry are preferred to biology [CS3]
 - ⇒ biology is preferred to physics and chemistry [CS4]

Perceptions of science content relevant to EE and ESD:

- Science education's contribution to EE is teaching about plants and animals [CS1; CS2; CS3; CS4]
- Science education is associated with a 'technical' awareness of life processes and living things [CS1]
- Science education is concerned with learning about 'processes' [CS4]
- Energy resources and renewable energy might be relevant to SD [CS3]
- Science education content forms some links with environmental content in geography [CS1; CS3]

Tacit links to compulsory science education:

- Life processes and living things [CS1; CS2; CS3; CS4]
- Communication [CS1; CS2; CS3; CS4]
- Application of science [CS1; CS2; CS3]
- Variation [CS1; CS2; CS3]
- Green plants [CS1]

Table 2: Institutional experiences [RQ2]**Post-compulsory education in a post-16 setting:****espoused experiences:**

- AS photography [CS1; CS2; CS3; CS4]
- General studies [CS2]
- AS geography [CS3]

tacit experiences:

- AS/A geology [CS1]
- AS/A media studies [CS3]

Compulsory education:**espoused experiences:**

- School [CS2]
- Geography [CS3]

perceptions of compulsory education:

- School is good; formal assessment favours students who can write [CS1]
- School teaches about wildlife [CS2]
- Primary education is more concerned with facilitating care for environments rather than secondary education [CS3]

tacit experiences:

- English:
 - ⇒ literacy and communication skills [CS1; CS2; CS3; CS4]
- ICT:
 - ⇒ computer skills; sharing views/experiences of ICT [CS1; CS2; CS3; CS4]
- Geography:
 - ⇒ environmental change [CS1; CS4]
 - ⇒ settlement [CS3; CS4]
 - ⇒ population [CS1]
 - ⇒ people and places [CS3]
- History:
 - ⇒ Roman Britain [CS1]

Other institutional experiences:**Membership of youth organisations:**

- Scouts [CS1]

References to environmental organisations:

- Greenpeace [CS1; CS2; CS3; CS4]
- National Trust [CS3]

Table 3: Other life experiences [RQ2]**Espoused experiences:****Family and upbringing:**

- relationships with immediate family; shared values [CS1; CS2; CS3; CS4]
- parents' career/employment; sense of responsibility [CS1; CS3; CS4]
- extended family [CS1; CS2; CS3]
- parents' interests [CS1; CS2]
- preference for particular environments; shared interests and lifestyle [CS1; CS3]
- parents of different nationality; parents' upbringing [CS3]

Personal experiences:

- personal values; first-hand interaction with environments; familiarity with particular environments [CS1; CS2; CS3; CS4]
- social interaction and discussion with others; media awareness [CS1; CS3; CS4]
- aesthetic values [CS1; CS2]
- self-directed study; shared information [CS1]
- boyfriend; music; computer games [CS2]

Sources of environmental information:

- people [CS1; CS2; CS3; CS4]
- broadcast media; internet; books [CS1; CS2; CS3; CS4]
- environmental organisations [CS1; CS2; CS3; CS4]

Non-specified experiences related to:

- values and priorities [CS1; CS2; CS3; CS4]
- social, cultural, economic, political, aesthetic awareness [CS1; CS2; CS3; CS4]
- ecological awareness [CS1; CS3; CS4]