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Abstract

The conservation of biodiversity is an important socio-scientific issue, often regarded as a precondition to sustainable development, and the foundation for citizens' understanding of conservation issues can be laid down in formal school education. This research focuses on decision-making discussions about biological conservation issues among 131 15-16 year old students, to address two main research questions: 1. Can peer-group decision-making discussions, in a normal science lesson setting, help develop students' personal reasoning in relation to conservation issues? 2. Are there features common to high-quality discussions about conservation which might be readily identified by classroom teachers? Findings indicate the positive value of students taking part in these short decision-making discussions, guided by a structured framework, as part of their normal science classroom activities. Students increase their quality of personal reasoning, and modify their solutions to the issues. The study begins to uncover features about students, as individuals and as members of discussion groups, which can be associated with high quality decision-making about conservation issues, and which teachers might realistically identify. The work calls for the need to cultivate these features, and integrate them appropriately with learning about the scientific concepts that underpin the theory and practice of conservation management. Such integration will facilitate the development of teaching strategies for dealing effectively with the complex topic of biological conservation; not just in terms of science content, but also in terms of how students are expected to engage with the issues.

Introduction

With serious threats to global and local biodiversity, education about animal and plant conservation is an important socio-scientific issue, and the ability to make decisions about conservation issues is a prerequisite to making informed decisions about wider issues of sustainable development (Grace and Ratcliffe, 2002). Education for sustainable development is now included in the science curriculum in England, and educators and policy-makers have advocated a move towards considering societal and personal values, and skills of argumentation and decision-making alongside the learning of scientific concepts (QCA, 2004). The rhetoric endorses the well-established STS (science-technology-society) education approach to promoting the integration of science with values when considering socio-scientific issues. It has an emphasis on personal and societal decision-making, and gives prominence to values in society as well as science (Solomon, 1993; Ratcliffe, 2001).

Real conservation management programmes require consideration of all the stakeholders' values (Boza, 1993). They are increasingly expected to fulfil social and amenity roles, and scientifically objective criteria are compromised by the multiple demands placed on the site. Although biological conservation (as a socio-scientific issue) has significant environmental importance, there are signs that the topic often remains delivered in an atomistic, value-free way, as part of unconnected science curriculum topics. There is little published research evidence to support this, but among a group of 23 experienced science teachers in the south of England, Grace (2005) found a wide range of practice in terms of when the topic was taught, how

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much time was spent on studying plants and animals in the field, and to what extent science teachers taught the topic in conjunction with other subjects. Grace and Ratcliffe (2002) found that a minority of science teachers expect their 15-16 year old students to include anthropocentric values in discussions about conservation.

Researchers have stressed the central role that discussion and argumentation should play in science education (e.g. Hacker and Rowe, 1997; Driver *et al.*, 2000). Duschl and Osborne (2002) maintain that an absence of dialogical argumentation from the classroom can result in learning being hindered or curtailed, and a strong case can therefore be made for promoting argument within science lessons. In practice, research has shown that activities facilitating argumentation can also promote thinking and reasoning in science (e.g. Mercer *et al.*, 2004; Simon and Maloney, 2007). However, these approaches are still not central features of science lessons in English secondary schools (Newton *et al.*, 1999; Scott and Ametller, 2007). One of the most serious constraints to teaching controversial issues is lack of timetabled time (Oulton *et al.*, 2004), but creating more time for the science curriculum is obviously not an option, and it is necessary to find ways of integrating STS-type approaches into the existing teaching timetable.

Given an appropriate framework to follow during discussion, small groups of 15 year olds are able to begin to address informed decision-making about socio-scientific issues (Ratcliffe, 1997). The present study seeks to explore how effective this approach can be (within the time and space constraints of a normal lesson) at developing students' thinking about conservation issues.

The research focuses on two main questions:

1. Can peer-group decision-making discussions, in a normal science lesson setting, help develop students' personal reasoning in relation to conservation issues?
2. Are there features common to high-quality discussions about conservation which might be readily identified by classroom teachers?

The study builds on the use of a decision-making framework designed by Ratcliffe (1997) for youngsters discussing socio-scientific issues, itself based on extensive research on normative and descriptive decision-making models (e.g. Aikenhead, 1991; Baron and Brown, 1991; Hirakawa and Johnson, 1989; Kortland, 1994; Ross, 1981). The approach used here draws on characteristics promoted by other authors in two fields of study - personal reasoning and group discussion. In this paper, personal reasoning refers to an individual's view of how a controversy should be resolved, and group discussion refers to verbal interaction aimed at resolving a controversy (after Newton *et al.*, 1999). Personal reasoning characteristics (based on the work of Kuhn *et al.*, 1997) are used to compare students' individual pre and post-test views on conservation issues. Group discussion characteristics are then considered to determine whether they are associated with high quality discussions about specific conservation issues.

Kuhn *et al.* (1997) devised a pre and post-test hierarchical scheme for classifying the quality of reasoning on the topic of capital punishment (although they referred to personal reasoning as 'arguments'). They found that dyadic interaction between peers, without teacher intervention, significantly increased the quality of reasoning in early

adolescence and young adults. Participants completed a pre-test questionnaire stating their opinions about capital punishment, and then took part in a series of five 10-minute dyadic discussions on the topic over a period of five weeks, each time with a different classmate to expose them to a range of views. They were then post-tested, alongside a control group to see how their views had changed. Key factors relating to quality of argument explored in the study were i) consideration of the function of capital punishment, and ii) justification for or against the practice. The resulting scheme presented these 'arguments' in the following hierarchical order of increasing quality:

1. 'Nonjustificatory arguments', which are not justified and consequently have little or no argumentative force. Most reasoning in this category was based on an unsupported appeal to sentiment.
2. 'Nonfunctional arguments', focus on the conditions that make (or do not make) capital punishment justified, but do not consider the functions of capital punishment.
3. 'Functional arguments', where justification for the judgement includes consideration of the functions or purposes of capital punishment. Within this category is reasoning that relates the judgement to other alternatives.

Kuhn and her colleagues found that the range of reasoning increased from pre-test to post-test, suggesting a social transmission of new knowledge, and the present study applied a similar approach in an attempt to develop students' understanding of conservation issues.

Methods and sample

The study had three main components: a pre-test questionnaire about a conservation scenario completed individually, audio-taping of group discussions (each group following a decision-making framework), and a post-test questionnaire completed individually. At each stage, the students were asked to consider one of two real conservation issues, concerning species that these students would be expected to have a relatively strong desire to conserve (Grace and Sharp, 2000). They were given the same very brief outline of the scenario at each stage, one of which focussed on the competition for space between rabbits and puffins (an endangered seabird) living on an island, and the other on competition between African elephants and local farmers (more detail about these scenarios are given in Ratcliffe and Grace, 2002). Four whole classes of 15-16 year olds (131 students in total) were included in the study, and in order to reduce variables, they were of a similar academic background. All were from urban and suburban co-educational state secondary schools in the south of England, and were in the top 50% in science within their own schools. It should be noted that none of the students had previously worked on these scenarios at school, or been involved in discussions about socio-scientific issues in general.

Pre-test and post test. The students were given brief pre and post-test questionnaires (without opportunity to confer) to examine changes in their proposed solutions to the conservation issues following the discussions. They were given 15 minutes for these questionnaires, and all completed them within this time. The pre-tests were given just prior to the discussions, and the post-tests were all completed before or during the following lesson, less than a week after the discussions.

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Deleted: The hierarchical scheme in figure 1 is adapted from that of Kuhn *et al.*, (1997) to relate to issues of conservation rather than capital punishment. The same three criteria are used to identify the most superior solutions: 1. functional reasoning (acknowledging that conservation measures are taken for the purpose of preventing decline and extinction of species/gene pools), 2. justification of views, and 3. consideration of alternative solutions. The quality of personal reasoning about biological conservation provided a useful instrument for identifying individuals who modified their thinking, by coding and comparing pre and post-test written responses.¶

¶ [INSERT FIGURE 1 ABOUT HERE]¶

In both pre and post-tests, students were asked:

What do you think should be done about the problem, why, and how?

The 'why' and 'how' tags on this question were included in an attempt to draw out the justificatory and functional aspects of respondents' decisions, recognized by Kuhn *et al.* (1997) as key features of high quality reasoning. This style of question is also recommended by Slater (1982) in humanities education to encourage students to explore their opinions and become more aware of the values underlying their choices. From the very beginning it was stressed that there are not necessarily right or wrong answers, and that professional conservationists also find these issues difficult to resolve. In the pre-test, the students were also asked to rate their interest in wildlife on a three point scale, how often they watched programmes or read articles about wildlife, and whether they belonged to any wildlife groups.

Peer-group discussions.

The decision-making discussions lasted 30-40 minutes, and the students' task was to attempt to come to a group decision on what should be done about the issue, why and how? Twenty-four groups (four to six students per group) were provided with a decision-making framework (figure 1). They were within a normal science classroom setting, and in their usual, mainly self-selected peer groups to avoid disruption caused by regrouping them. They were asked to consider any scientific and non-scientific factors they thought important in making these decisions. The researcher/teachers did not intervene during the discussions other than to address any procedural matters. This was partly to facilitate consistency of approach, but also due to an awareness that there is sometimes a tendency for the self-directed nature of student talk to disappear when the teacher arrives (Harwood, 1989). Cohen (1994) argues that there is thus a need to minimize teacher intervention by providing sufficient structure to guide pupils through the task, but not enough to stifle their opportunities to think for themselves and gain the benefits of interaction.

[INSERT FIGURE 1 ABOUT HERE]

The conversations were audio-taped and quantitative data from each questionnaire were entered onto a spreadsheet. Open-ended responses were listed and coded using emerging themes. The transcripts of the group discussions were examined for common features underpinning high quality discussions using an iterative approach. The coding was validated by two researchers coding a sub-set of the data and discussing discrepancies.

Students' individual pre-test and post-test views on the conservation issues were ranked using the hierarchical scheme in figure 2. This is adapted from a similar scheme designed by Kuhn *et al.*, (1997) for ranking views on capital punishment. The same three criteria are used to identify the most superior solutions: 1. functional reasoning (acknowledging that conservation measures are taken for the purpose of preventing decline and extinction of species/gene pools), 2. justification of views, and 3. consideration of alternative solutions. Coding and comparing pre and post-test written responses, in conjunction with the hierarchical model in figure 2, provided a useful instrument for addressing the first research question (i.e. how individuals had modified their personal reasoning as a result of the discussions).

The second research question (identifying features common to high quality discussion groups) was addressed by identifying characteristics previously promoted by other authors, and seeing whether these applied to the high quality discussion groups in the present study.

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Using a pre and post-test approach and using the hierarchical model in figure 1 was a rapid means of

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[INSERT FIGURE 2 ABOUT HERE]

Findings and discussion

It is not possible to establish with certainty that the differences between an individual's pre-test and post-test statements were the direct result of the discussions, so the responses must be regarded as a sample of the possible wide range of comments each student could have given. The sample was large enough to create a picture of how their thinking had changed, and the timespan between the pre and post-tests was considered short enough to minimise the possible impact of other external influences such as television programmes. General changes evident as a result of the discussions were as follows:

Modified solutions to conservation issues

Although the decision-making discussions were no more than 40 minutes long, they had a marked impact on students' proposed solutions to the conservation problems. Changing or modifying one's mind is a feature of good quality argument recognized by Osborne *et al.* (2001). About three-quarters of the students modified their proposed solutions to the conservation problem following discussion (76% over rabbits; 73% over elephants), and there was no statistically significant difference between girls' and boys' responses. These modified views ranged from a complete change in the proposed solution, to a slightly modified view such as moving from suggesting putting a fence round the farmer's crops, to erecting a fence and controlling the birth rate among the elephants.

Increased acceptance of culling

The issue of culling is at the heart of many conservation management programmes; it featured in all discussions in this study, and was used as a discussion impact indicator, i.e. to show how much students changed their views as a result of discussions. Both before and after discussion, the majority of students suggested a solution other than culling (e.g. constructing fences, relocating or sterilising animals). A minority advocated culling before discussion, but after the discussion there was a marked increase (statistically significant at $p < 0.05$) in advocating culling among both boys and girls (table 1). There was no statistical difference between genders.

[INSERT TABLE 1 ABOUT HERE]

These changes in attitude support Solomon's (1992) suggestion that group discussion can assist attitude change, and is consistent with the assertion by Zoller *et al.* (1990:33-34) that STS (Science-Technology-Society) courses can:

...substantially change the viewpoints/position of senior high school students...

It contrasts, however, with Aikenhead's (1989) hypothesis that, in resolving conceptual conflicts, group decisions emerge from members' original choice preferences, rather than from their interactions during discussion. Aikenhead indicates the difficulty in identifying factors which contribute to viewpoint change, but in the present study the peer group friendship seemed sufficiently robust to allow disagreement without much personal conflict. There are signs in this study that discussion of the issues reduces the rigidity of views and brings students towards a compromise view. However, the students' individual post-test responses did not necessarily reflect their group's decision.

Increased quality of personal reasoning

Using the scheme in figure 2, it was possible to identify individuals who modified their thinking and moved up to the highest level of personal reasoning (level 5) from a lower level following the discussions. At level 1, students merely provided a single solution:

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

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

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

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

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

There was a substantial number of students who partially justified their decisions using tautological statements.

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

or statements relating to biocentric values

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

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

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

e.g. *We have to put the elephants in game reserves protected by people with guns to stop poachers getting in.*

Introduce a natural predator to control the rabbits

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

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

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

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

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

To stop the puffins dying out we need to put a fence round them to stop the rabbits using their burrows. If the rabbits still go under the fences

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we might have to catch as many as possible and move them somewhere else.

A comparison of pre and post-test comments revealed a general shift to higher-level responses following the discussions, with a noticeable increase in the number of students at levels 4 and 5 (figure 3), thus suggesting that these brief decision-making discussions can have an immediate, although not necessarily long-lasting, effect on students' ability to reason about conservation issues.

[INSERT FIGURE 3 ABOUT HERE]

Most students (54%) exhibited an increased quality of response; 40% remained at the same level, and eight students (6%) dropped down a level (later informal talks with four of these students revealed that the main reason for this was that they resented having to complete the questionnaire for a second time). Almost 20% of students moved from level 3 to level 4 following the discussions. The key difference here was that their post-test comments included mention of alternative solutions.

Identifying 'high quality' discussions

In addition to the positive outcomes of discussion outlined above (i.e. modified solutions, increased acceptance of culling, and increased quality of personal reasoning), this study sought to explore other factors common to high quality discussion groups – factors that might be readily identified and nurtured by classroom teachers.

Modifying one's thinking is a product of rational thought, which is a feature of good quality argumentation (Osborne *et al.*, 2001). It could therefore be reasoned that the group discussions of high quality were those containing students arguing at level 5, and more particularly (if we are searching for 'changing thinking') those containing students who modified their thinking by moving to level 5 from a lower level. Groups containing these individuals, could then be investigated to see whether these supposedly 'high quality' discussions exhibit any readily identifiable common features. Five of these 'high quality' discussion groups were identified in this study (groups 1, 3, 5, 10 and 11). Between them they contained eleven students (asterisked in figure 3) who moved up to reach a level 5 response in the post-test. Of these, six moved from level 4 to level 5, and five from level 3 to level 5. The activities of these groups were then followed more closely, as analysis of these interactions was most likely to shed light on factors contributing to quality discussion and decision-making.

Factors present in all high quality discussions (table 2)

The aim of the study at this point was to investigate whether these high quality discussions exhibited common features. Pre-test questionnaires indicated that at least one member of each high quality group appeared to have an elevated interest in wildlife. Although the samples are fairly small, 30% (seven) of the pupils in these groups were 'very interested' in wildlife, compared with the 17% across the whole cohort. All but one of these wildlife enthusiasts claimed to watch TV wildlife programmes or read wildlife articles at least once a week, and initial interest may therefore be a factor leading to high quality discussion, and ways of promoting interest may need to be explored. One of the seven 'very interested' students was ranked at level 5 at pre-test and post-test, and the others either increased their ranking after

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discussion from level 3 to 4, or level 4 to 5. This finding does not necessarily represent a causal relationship between wildlife interest and quality of decision-making discussions, but they seem connected, and if first-hand experience of conservation can promote interest this could be a route to enhancing the quality of argument and decision-making about conservation issues, although the wildlife enthusiasts were not the only contributors of science knowledge within the groups.

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Each of the high quality groups also contained at least one high quality reasoner (i.e. at level 4 or 5) prior to the discussion. This suggests that when arranging groups, teachers might consider including a level 4 or 5 reasoner in each, but this needs to be weighed against any detrimental effects created by altering the dynamics within existing peer-groups. With minimal guidance, teachers could identify such students quite rapidly by conducting a pre-test about the issue, as performed in this study, and levelling students according to the scheme for personal reasoning presented in figure 2.

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Students in discussion groups adopted recognisable individual roles of the kind described by other authors as those that promote reasoning processes. Hogan (1999) regarded promoters of reflection, and contributors of science content knowledge as important roles in this regard. Among students considering socio-scientific issues, Ratcliffe (1997; 1999) identified individuals she referred to as information-vigilant who used readily accessible information to clarify the advantages and disadvantages of particular options.

There were students in all the high quality groups in the present study who exhibited these three key roles:

1. Promoters of reflection were present as those who asked thought-provoking questions, e.g. Peter (Group 1): *...right what's more valuable, an elephant's life or a human's life?*, and those who made thought-provoking statements, e.g. Nigel (Group 11): *We haven't talked about creating a puffin-friendly environment; make them separate; like fence them in.*
2. Contributors of science content knowledge, e.g. Isobel (Group 11): *Puffins are a natural British species, rabbits aren't*
3. Information-vigilance was often shown by following the decision-making framework, e.g. Isobel (group 11): *Look we're going off at a tangent here – right, advantages of sterilisation?*

Another notable feature was that most members of each group contributed to the discussion not by playing one of these roles, but by frequently and subconsciously swapping over roles. Furthermore, none of these groups had a clearly identifiable leader. Gayford (1992) described groups like these as 'democratic teams' in his categorisation of the styles of group behaviour. He identified this style as resulting in better understanding and motivation than in other types.

In adopting Toulmin's argumentation pattern (Toulmin, 1958), Osborne *et al.* (2001) identified levels of quality among students discussing scientific issues, highlighting the importance of multiple rebuttals as criteria for the recognition of quality in argumentation, (rebuttals being statements which specify the conditions when a claim made by someone else will not be true). Each of the high quality groups here engaged in a series of extended arguments with multiple rebuttals, and were hence operating at

1
2 the top level (level 5) in the group argumentation scheme proposed by Osborne *et al.*
3 (2001). Rebuttals can be difficult to identify, but research into recognition of levels of
4 argumentation has resulted in productive teacher-training (Osborne *et al.*, 2004a) and
5 associated training materials (Osborne *et al.*, 2004b).

6 None of the above features was as prevalent in the remaining nineteen groups.
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8 [INSERT TABLE 2 ABOUT HERE]
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10 Factors not present in all high quality discussions (table 3)

11 Even among this small number of high quality discussion groups, it is interesting to
12 note that some features, previously suggested by other authors as indicative of quality
13 discourse, were not consistently evident. It is possible of course that a study of a
14 larger number of such groups might reveal a stronger pattern, where some indicative
15 factors might emerge as being more prevalent, but not necessarily universal, features
16 of high quality discussion.
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19 The main focus of the discussions varied to the extent that they did not appear to be
20 specific indicators of quality discussions. The discussions in groups 1 and 3 (both
21 discussing elephants) tended to focus on practical concerns, with comparatively little
22 consideration of ecological information. Group 1 spent a high proportion of time
23 discussing fence-construction matters, whereas group 3 focussed on the education of
24 local people, and a feeling of uncertainty about the issues featured on occasion.
25 Groups 5 and 11 (both discussing puffins) concentrated more on ecological
26 considerations, with some values considerations. Group 10 (discussing elephants)
27 focused on values, and were particularly economics-oriented, especially around the
28 issue of the ivory trade.
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31 The final group decisions also varied; there was disagreement about culling, and three
32 groups failed to reach a decision, which might suggest that the process of the
33 discussion has more value than the outcome in terms of strengthening argumentation
34 and decision-making skills. Of the elephant discussion groups, group 1 opted not to
35 cull but to build a fence, group 3 decided not to cull but to educate people, feed
36 elephants then try relocation and fences, and group 10 did not make a firm decision
37 but agreed to cull if absolutely necessary. Neither of the two puffin discussion groups
38 came to a decision.
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41 The time the groups spent 'off-task' varied considerably, ranging from 4% to 21% of
42 the total discussion time, indicating that off-task conversation did not appear to be
43 directly related to quality of discussion. Mercer *et al.* (1999) identified 'long
44 utterances' as a factor indicating high quality argumentation. When working with ten
45 year olds they arbitrarily defined these as being at least 100 characters in length when
46 transcribed. In a similar arbitrary way, for the present selected groups of 15-16 year
47 olds, long utterances of at least 150 characters were sought. Between two and nine
48 such long utterances were recorded among the high quality groups, and a similar
49 range of occurrences among all the remaining groups, indicating that this was not a
50 reliable measure of high quality discussion in this study.

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52 In terms of how students interacted and the nature of the argument in which they
53 engaged, there was no discernable difference between genders. This contrasts with a
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suggestion made by Swann (1992) that whereas boys are likely to adopt a more dominant role, girls are more likely to play a supportive and exploratory role, and avoid competitive behaviour. Such stereotypical behaviour was not evident in this research.

There were examples of boys and girls talking confidently and taking leading roles within arguments, at all levels of argumentation. There was no general pattern of gender-related participation, as indicated by the number of times each person led the conversation by contributing at least a three-word phrase or sentence.

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Group size is another potentially important factor. A study in a Greek secondary school for example, reported that students progressed significantly more in their physics reasoning after working in groups of four rather than in pairs (Alexopoulou and Driver, 1996). In the present study, there were high quality discussion groups of four, five and six students, showing that even groups of six can lead to improved reasoning. These groups were self-selected, but their size was largely determined by the space and number of tables in the science classroom. Students' willingness to contribute may also be influenced by other factors which can be recognized but not easily controlled. These may include scientific knowledge, communication skills, self-esteem, students' worldviews (Slater, 1996), and their particular feelings and emotional condition at the time. These are aspects worthy of further research.

[INSERT TABLE 3 ABOUT HERE]

Conclusions and implications for teaching

Findings in this study indicate that personal reasoning can be developed rapidly within a normal classroom setting (figure 3), and has revealed some characteristics common to high quality discussions about these conservation issues (table 2). Further implications for teaching have also emerged from the study:

The relative importance of group decision-making processes and outcomes

Despite supplying constructive ideas, some students in pre and post-tests were unable to come to a definite decision about the issues. Likewise, several of the discussion groups (including some high quality groups) failed to reach a final decision. This is not necessarily a problem, Aikenhead (1985) and of De Jager and Van der Loo (1990) hold the view that the quality of the decision-making process is more important than the quality of the decision itself. A further small but interesting finding in this study was that students' individual post-test responses did not necessarily reflect their group's decision. While the process of group decision-making may have benefits such as modifying thinking and developing decision-making skills, the group decision itself may be less informative to educators in terms of identifying learning gains among individual students. Providing a decision-making framework, which encourages students to note down their views as they progress through the discussion, can reinforce the required skills and assist teachers in reviewing students' engagement with the process (Ratcliffe, 1996).

The structure of conservation discussion lessons

There are of course many approaches to decision-making, such as dramatic interpretations, story-telling, and critical reading and writing activities, each of which encourages the development of particular skills. Role-play remains one of the most popular approaches used in the teaching of controversial issues (Oulton, *et al.*, 2004).

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2 However, students sometimes need opportunities to consider and argue their own
3 positions on an issue rather than always being asked to adopt a role (Slater, 1982).
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5 A whole scheme of work on the unifying theme of conservation could help
6 consolidate students' understanding of science, but this is not practical within the time
7 constraints of the present curriculum. Any proposed model needs to recognize that
8 there is a trade off between complexity and manageability. However, this study has
9 shown that it is feasible to generate positive outcomes, in terms of improving personal
10 reasoning about these particular conservation issues, by discussing the issues in one
11 40-minute lesson in a 'normal' science classroom setting, i.e. with minimum
12 disruption to existing timetabled activities. A recommended approach would therefore
13 be a lesson structure that includes components explored in this study, namely:
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15 i) A brief overview and pre-test question about the issue as a starter exercise to
16 encourage students to explore their own opinions and become more aware of the
17 values underlying their choices (Slater, 1982).

18 ii) Group discussion using a guiding decision-making framework to keep students on
19 track and to help balance the consideration of science and values (Ratcliffe, 1996).
20 Guidance on appropriate ground rules for collaborative discussion may be valuable in
21 helping students organize their discussion; but if this is too prescriptive it may reduce
22 spontaneity and inhibit the flow of the conversation. The presence of the teacher
23 might also influence the nature and direction of the arguments. Naylor *et al.* (2001)
24 suggest that argumentation is more likely to be effective in small groups than teacher-
25 led whole class discussion, and teachers may be able to promote effective
26 argumentation if they are more aware of how their presence and intervention might
27 influence on the nature of discussions.

28 iii) A brief post-test question about the issue of the kind used in this study (perhaps as
29 homework), that would enable students to reflect on their views, and appreciate the
30 value of group discussion, while providing assessment opportunities for the teacher,
31 using the personal reasoning scheme proposed in this study.
32

33 Implications for teaching conservation education

34 Although most students exhibited an increased quality of personal reasoning
35 following the discussions, relatively few (eleven) reached the highest level in the
36 hierarchical scheme – by demonstrating an attempt to justify the decision, with
37 explicit consideration of the function or purpose of biological conservation, and of the
38 comparative effectiveness of alternative solutions. Although many of us have an
39 intuitive understanding of the term conservation education, it is difficult to define in a
40 few words, largely due to the complexity of underpinning concepts and values.
41 Conservation can be viewed as a unifying 'super-concept' providing opportunities for
42 students to draw on their existing knowledge of biological concepts and appreciate
43 how they interrelate. An understanding of conservation issues requires knowledge of a
44 wide range of underlying and interlinking values and biological concepts. However,
45 given that the term 'conservation' does not appear explicitly in the science national
46 curriculum for England it is difficult to define learning outcomes for conservation
47 education.
48

49 When students focus on the concept of conservation as a measure for countering
50 extinction, they generally demonstrate positive attitudes towards conserving
51 organisms, especially intelligent or visually attractive animals (Stanisstreet *et al.*,
52 1993). The impact of humans on the environment is a well-established attainment
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target in the science curriculum, and lends itself to the inclusion of conservation issues. Findings presented here indicate benefits of using case studies of conservation decision-making, which incorporate social and personal values as well as the underlying science. Particularly useful are human-oriented scenarios to elicit more anthropocentric values from students (Grace and Ratcliffe, 2002), preferably based on widespread human activities which students do not readily regard as in conflict with biological conservation, such as intensive farming and commercial forestry. Such approaches could thus serve to help students appreciate the social construction of conservation management practices.

Closing comments

In this study, most students' knowledgebase and awareness of values concerning these specific conservation issues increased after peer group discussion during the course of one lesson. It highlights the value of using a scheme for measuring personal reasoning, and also reveals some features that teachers could look for in recognising high quality decision-making discussions about conservation issues.

The enquiry purposely draws together two important aspects of science education which are both often overlooked in English schools – conservation education and small group discussion. The method described here is a means of addressing both aspects simultaneously. This approach is not necessarily transferable to discussion of other socio-scientific issues, or even other conservation issues, and it focuses on a small sample from which to draw reliable conclusions. However, it does provide an indication of the kind of features common to high quality discussions about these conservation issues, which teachers can readily recognize, promote and assess.

There may be a concern among science teachers that values considerations might dominate discussions about such issues at the expense of the underpinning science, and this is where guidance such as a decision-making framework becomes invaluable in keeping participants on track and engaged with the science. Values and scientific ideas can sometimes be difficult to separate. For example, competition between organisms is a scientific concept; competition between animals and humans can be regarded as a values issue, depending on one's biocentric-anthropocentric viewpoint. Biological conservation is often taught as a value-free scientific discipline, and this may impede learning. The challenge to curriculum developers is to develop models integrating science and values, which explicitly demonstrate the reasoning behind the integration to teachers and students. A further challenge is to help science teachers to justify promoting discussion of conservation issues within the constraints of the school curriculum and timetable. This involves helping teachers appreciate the merits of discussions about conservation as a unifying component of the science curriculum, facilitate delivery, and draw on interdisciplinary research to establish a valid and reliable mechanism for identifying and evaluating appropriate learning outcomes.

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Table 1. Percentage of students (n=131) advocating culling as a solution pre and post-discussion

	<i>Pre-test view</i>	<i>Post-test view</i>
Cull rabbits	22%	34%
Cull elephants	13%	24%

For Peer Review Only

Table 2. Factors present in all high quality discussions

	<i>Group 1 (elephants)</i>	<i>Group 3 (elephants)</i>	<i>Group 5 (puffins)</i>	<i>Group 10 (elephants)</i>	<i>Group 11 (puffins)</i>	<i>Mean % of students in high quality groups</i>	<i>Mean % of students in the other 19 groups</i>
Number of students 'very interested' in wildlife	1	1	1	2	2	30%	17%
Number of pre-test level 4 or 5 personal reasoners	3	3	2	1	3	52%	20%
Number of promoters of reflection	2	2	3	3	3	56%	37%
Number of contributors of science content knowledge	2	2	2	2	3	48%	32%
Number of information vigilant students	2	3	2	3	4	61%	48%
Number of identifiable leaders	0	0	0	0	0	0	7
Number of multiple rebuttals	3	3	7	4	4	4.2	2.3

Table 3. Features not showing a pattern among the high quality discussion groups

	<i>Group 1 (elephants)</i>	<i>Group 3 (elephants)</i>	<i>Group 5 (puffins)</i>	<i>Group 10 (elephants)</i>	<i>Group 11 (puffins)</i>
Main focus of discussion	Practical concerns (fence construction)	Education of local people	Ecological considerations	Economic considerations (ivory trade)	Ecological considerations
Time spent off-task	21%	4%	7%	8%	9%
Total number of long utterances	6	9	7	8	2
Number of oral contributions made in the discussion*	Male 48 Male 35 Male 27 Male 14	Female 28 Male 23 Male 22 Female 14 Female 5	Female 45 Male 41 Female 36 Male 19	Female 44 Female 24 Male 23 Male 17	Female 34 Male 28 Male 23 Male 10 Male 10 Female 8
Final group decision made	yes	yes	no	no	no

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Note: * an 'oral contribution' in this case was arbitrarily considered to be an instance where someone led the conversation by contributing at least a three-word phrase or sentence.

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4 **Figure 1.**
5 **Outline of the decision-making framework given to peer groups** (after Ratcliffe, 1997)
6

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

8 **1. OPTIONS**

9 What are the options?

10 (Discuss the possible solutions to the problem and list them in the table overleaf.)

11 **2. CRITERIA**

12 How are you going to choose between these options?

13 (Discuss the important things to consider when you look at each option, and add them to the table.)

14 **3. INFORMATION**

15 Do you have enough information about each option?

16 What science is involved in this problem?

17 What extra scientific information do you need to help you make the decision?

18 **4. ADVANTAGES/ DISADVANTAGES**

19 Discuss the advantages and disadvantages of each option, and add them to the table.

20 **5. CHOICE**

21 Which option does your group choose?

22 **6. REVIEW**

23 What do you think of the decision you have made?

24 How could you improve the way you made the decision?
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4 **Figure 2.**
5 **Hierarchical scheme for the quality of personal reasoning about biological conservation**
6 **(based on principles proposed by Kuhn *et al.*, 1997)**
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8 **Level 1. Nonjustified arguments.** Decisions that lack any supporting justification.

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

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

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

19 **Level 5. Functional, justified arguments considering alternatives.** There is an attempt to
20 justify the decision, with explicit consideration of the function or purpose of
21 biological conservation, and of the comparative effectiveness of alternatives.
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23 *Note: Level 5 could be divided into two levels – a lower level without consideration of*
24 *alternatives and a higher level with consideration of alternatives. In this study, all*
25 *respondents who gave functional arguments mentioned the effectiveness of*
26 *alternative solutions.*
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Figure 3.
Overall changes in all 131 individual students' written responses following the decision-making discussion (line width relates directly to number of students)
 (* indicates the eleven students identified as being in 'high quality' discussions as they were at level 5 after a positive change of response)

