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ABSTRACT

This paper reports on a research study that describes the actions of students and teachers when addressing socio-scientific issues and provides some practical advice for handling learning activities. The study involved four classes of 14-year-old students who participated in small group discussions designed to elicit their opinions about the applications of science and the use of science in social contexts. The framework used for the student discussions consisted of six steps: (1) list options; (2) consider criteria; (3) collect information; (4) evaluate each option; (5) make a decision; and (6) review the process and the decision. Other data collected include all written work and teacher contributions in whole class and small group discussions. The data indicate that students are able to analyze the advantages and disadvantages of an issue but not in a systematic way against the criteria that they identified. The outcomes of this study suggest that a careful examination of the purposes of discussing socio-scientific issues is needed. Those purposes can include those related to relevance, motivation, communication, analysis, and understanding. (DDR)

Discussing socio-scientific issues in science lessons - pupils' actions and the teacher's role.

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Introduction

The preamble to the Science National Curriculum Programmes of Study (Sc0 as some people call it) stipulates requirements for pupils to relate their study of science to real world problems, particularly in social and environmental issues [1].

This is not an easy area to teach. The complexity of the issues; the demands on generating and evaluating evidence; coping with different value positions can make great demands on the teacher in providing and managing suitable learning activities. This article seeks to describe pupils' and teachers' actions in dealing with socio-scientific issues and to give some practical advice in handling learning activities.

The scenario:

Four classes of fourteen year olds in a boys' comprehensive school followed the Salters Science GCSE course. During lessons, besides being introduced to scientific concepts and relevant skills, they may have formed opinions about the applications of science and use of science in social contexts.

In class they were faced with such questions as:

What are you prepared to do to reduce energy consumption?
What can we do about the world food problem?
How should we transport potentially dangerous chemicals?
What materials should we use to make domestic fixtures and fittings?
Should land development take precedence over habitat conservation?

In order to help teacher and pupils structure their deliberations I provided a framework for small group discussion (fig 1). This was based on models of how we **should** (*normative*) go about making decisions [2] and how **in practice** (*descriptive*) we make decisions [3]. Pupils also had relevant information about the problem.

Small group discussions were audio-taped; all written work was collected and teacher contributions in whole class and small group discussions were examined.

Fig 1 Framework for pupil discussions

Options
Make a list of all the things you could do/ think of relevant to the problem
This is phrased appropriately for each different problem

Criteria
How are you going to choose between these options?
Make a list of the important things to think about when you look at each option

Information
Do you have useful information about each option?
What do you know about each alternative in relation to your criteria?
What information do you have about the science involved?

Survey
What are the good things about each option?
- think about your criteria
What are the bad things about each option?
- think about your criteria

Choice
Which option do you choose?

Review
What do you think of the decision you have made?
How could you improve the way you made the decision?

Pupil actions

From analysing the wealth of detailed data collected, a number of key points emerged concerning pupils' actions [4] [5]. Some aspects of decision-making were not problematic: identifying options; identifying a basis for the decision. Other important features were lacking: search for and evaluation of information; systematic consideration of options against criteria; critical review of the decision made.

In particular:

i) Pupils were able to analyse the advantages and disadvantages of an issue, but not in a systematic way against criteria they identified.

ii) Few pupils were information vigilant. Those that were, sought and used information across all tasks and interviews. Pupils used little information about the underlying science.

iii) Pupils used a few dominant criteria as the basis for the decision. These included economics and perceived effectiveness of the proposed solution. Ethical and environmental considerations, although appropriate to the contexts, did not feature frequently.

iv) Adolescents can have decision-making strategies which are persistent over time. Some pupils, when interviewed individually, had a constant underlying rationale for views on a particular issue. However, group discussion could moderate their opinion.

Teachers' behaviour

It is interesting to examine to what extent teacher behaviour in managing activities influenced pupils. Discussions of socio-scientific issues are value-laden. As teachers, we have our own viewpoint on an issue. The extent to which we expose this may depend on how we view the teacher's role:

- as a 'neutral' chair [6]
- in inculcating particular values
- in assisting moral development
- in helping pupils clarify their value positions [7].

Our influences on pupils' views may be deliberate or unintentional.

In this study, there was evidence that teachers have strong influence over **procedures** in class but far less influence over pupil **attitudes**.

Teachers' actions examined

Discussion lessons each had a similar format:

A teacher introduction to the whole class

B small group discussion

C teacher review of pupils' opinions.

A Common features of teacher introduction were:

suggesting organisational aspects e.g. having a group chair, scribe etc.; reference to the decision-making framework; some reference to recent science content; explanation or amplification of the context of the problem as a social issue.

B Teachers did not intervene much in small group discussions. Pupils came to their own views. If pupils sought teacher intervention it was to clarify procedures rather than to discuss opinions. When the teacher initiated the intervention it was to check the pupils' actions and views.

C All teachers completed the lessons by asking groups to report their deliberations to the class. Teachers made few judgmental comments on the nature of pupils' views, although a tension was apparent between trying to adopt a non-judgmental stance and wishing to influence attitudes.

Teacher framing may influence pupils' action, particularly if intervention is high. Pupil experience in this study was characterised by teacher framing which:
i) respected the different ideas and viewpoints of pupils
ii) encouraged pupils to indicate and justify their own views
iii) did not discourage small group work and pupil collaboration
iv) had limited teacher intervention in exploring and explaining the decision-making framework as a whole, particularly in reviewing the nature of the processes undertaken [8].

Teacher action assisted pupils in values clarification but not necessarily attitude change. It is perhaps difficult for us to both respect pupils' viewpoints and challenge them without some inculcation of values of our own. We may genuinely wish to adopt a role of neutral chair in examining the issue and in collecting pupil views. If this is pursued then every pupil opinion may be considered acceptable even if we have an informed contradictory view. Pupils may either be left feeling that theirs is the 'correct' opinion or be confused by the variation in views which results from analysis of the same problem by different groups. One way forward is for us to give more consideration to the evidence base for the opinions generated. Here a systematic framework of cost-benefit analysis can depersonalise the issue and assist in evidence-based decision-making. It can also indicate how the complexity of the issue can legitimately lead to different opinions.

Classroom implications

The outcomes of this study suggest we need to look carefully at the intended purposes of discussing socio-scientific issues and Sc0. Purposes can include:
i) Relevance - encouraging pupils to relate their experience of school science to real problems and developing social responsibility [9]
ii) Motivation - for exploring the issue further [10]
iii) Communication - assisting pupils in verbalising, listening and argument [11]
iv) Analysis - assisting pupils in skills of systematic and thoughtful reasoning [12]
v) Understanding - learning science concepts [13]

There was potential for achievement of the first four purposes, but also some limitations. Socio-scientific issues have relevance to a real problem. Pupils were prepared to spend considerable time discussing the issues, but sometimes appeared to view the problem as distant from their personal involvement. Pupils were highly motivated by discussion but this may stem not from the issue itself but from encouraging and valuing peer group discussion in its own right. However, this valuing of pupil discussion seems an important element in assisting pupils' development of responsible attitudes.

The discussion framework helped pupils in communication skills of verbalising, listening and arguing coherently. The extent to which the framework was able to assist pupils in analysis is indicated by the pupil actions above. Pupils need a good understanding of the expectations and purpose of the task, helped by the teacher clarifying the uses of different parts of the framework. This is important if pupils are to spend more time discussing and analysing the issue than in clarifying procedures.

The fifth purpose of trying to use the tasks to teach 'new' science concepts was not an expected aim of the decision-making discussions. It was clear that pupils did not learn 'new' science by carrying out the tasks, but did clarify their understanding of some relevant science on a few occasions. Modification of the decision-making framework, in particular examining the reasons why the issue is raised, may provide a vehicle for learning science.

Table 1 indicates the strengths and weaknesses of using a framework for discussion of issues.

Table 1 Purposes for discussions of socio-scientific issues: strengths & weaknesses of use of a decision-making framework

Purpose	Strengths	Weaknesses
Relevance	- assists in attitude development - gives a real context to 'school science'	- pupil ownership of the issue is limited
Motivation	- provides an activity in which pupils' views and skills are valued	- pupil contributions are left unevaluated unless the outcomes and process are reviewed
Communication	- clear opportunities for pupils to verbalise and present coherent arguments - framework prevents common problems of group discussion	- a limited amount of 'off task' talk happens unless motivation is sustained
Analysis	- provision of a framework assists in systematic analysis - pupils become aware of the skills involved in analysis	- teacher has to explain purposes & steps in analysis and evaluate the process if the analysis is to be seen as systematic and valued
Understanding Science	- pupils can consolidate some existing understanding with teacher help	- not a vehicle for teaching 'new' science as it stands

Providing a framework for discussion can prevent some common problems of peer group discussion [6]:
- discussions allowed value to be placed on pupil contributions
- there was little evidence of dominance by particular pupils
- combative factions were rarely seen
- group members all contributed in some way
- pupils regarded group discussion as an aid to learning.

One problem which Cowie and Rudduck [6] identify was observed in some discussions: the acceptance of an over easy consensus in the face of complex issues. Despite the framework given, some individuals were willing to concede easily to the views of others without evaluation.

Recommendations for practice

If we want pupils to examine the nature of complex socio-scientific issues - a target in the National Curriculum - then there are a number of steps we can take which will allow for informed debate:

* Clarify with pupils the specific purpose of the activity. The important goal may not to get to a final decision but to understand the complexity of the issue and support analytical skills.

* Make the science base of the issue overt, indicating what principles or ideas may be important

* Highlight the need to clarify the basis on which comments are made - is this a 'top-of-the-head' opinion or one based on a particular piece of evidence. It can be helpful to spend some time with pupils asking about the nature and accessibility of the information needed.

* Use a framework for analysis which is systematic and evaluative rather than relying on unfocused discussion in which the personality and strength of character of individuals may come through more strongly than evidence.
Besides the framework shown, other possible frameworks include consequence mapping; cost-benefit analysis; goals, rights and duties [14].

* Value pupils' opinions but encourage pupils to open them to scrutiny through a suitable framework

* Group pupils so that there is a mixture of skills and good peer relationships Some pupils seek information and evidence more naturally than others. These pupils seem better able to handle a systematic framework.

* Review the activity. This is an important process, often overlooked. It may be at the heart of developing analytical skills for pupils to see the quality of analysis and that different opinions on a complex issue may be legitimate. If the teacher helps in identifying the criteria and evidence behind the decision and in producing a cost-benefit summary for the different opinions, this may help pupils in reinforcing the skills involved in thoughtful decision-making.

Some of these recommendations may be obvious, others more difficult to carry out. I am well aware that involving pupils in such activities can be stimulating but very demanding. Unless we are prepared to assist pupils in understanding the complexity and evidence in forming opinions, they may fail to realise the relation of 'school science' to real problems.
I welcome correspondence over any of the issues raised in this article.

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