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# Pupils' and Parents' Views of the School Science Curriculum

**A study funded by the Wellcome Trust**

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# Executive Summary

The aim of the research reported here was to document the range of views that pupils and their parents held about the school science curriculum, the aspects they found interesting, and their views about its future content. As such, the research aimed to articulate their views as a contribution to the debate about the school science curriculum.

This report provides the findings from 45 focus groups conducted with pupils, parents and teachers in London, Leeds and Birmingham between September 1998 and September 1999. 20 focus groups, split both by gender and whether the pupils intended to continue, or not, with the study of science post-16 were conducted with 144 pupils; a further 20 focus groups were conducted with 117 parents, split similarly by gender and whether they were engaged in science-related work; and 5 focus groups were conducted with 27 teachers to ascertain their response to pupils' views.

The principal findings were:

- All pupils and their parents considered science to be an important subject of study and that it has a legitimate place on the curriculum. Science was seen as a prestigious subject and valued for the understanding it offered of the natural world. Parents felt that the present school science curriculum no longer had any inherent gender bias that was a feature of the separate sciences offered to their generation.
- Pupils valued science education for career aspirations rather than as a subject of intrinsic interest. Those that they associated with science qualifications were still those traditionally associated with science. There was little recognition that a science qualification may be as valuable a generic qualification as one in mathematics or English.
- There were many aspects of their experience that pupils found off-putting. The subject that attracted the most antipathy was, surprisingly, chemistry. This was seen as abstruse and irrelevant to contemporary needs. Pupils found too much of the latter years of science education to be an experience that was rushed; dominated by content; repeated too much of material that they had previously encountered; required too much 'copying'; lacked opportunities for discussion; and was fragmented leaving them without any overview of the subject.
- There were also aspects that pupils found interesting. Amongst the sciences, biology was well-received, particularly by girls, but also for boys, as its relevance to their own personal lives was easily recognised. Chemistry was enjoyed when involved mixing and combining chemicals. The one topic that generated universal enthusiasm was any study of astronomy and space.

- Science was also interesting when it offered opportunities to engage in practical work, when it offered challenge and stimulation whilst not becoming too difficult or complex, and when it stimulated a sense of awe and wonder.
- Both pupils and their parents felt that teachers and their style of teaching were very important determinants of pupil interest in the subject.
- Pupils expressed a keen interest in a range of contemporary scientific or socio-scientific issues. Parents argued that this was an important aspect which they expected the school science curriculum to cover.
- Pupils found it hard to make the connections between school science and their everyday lives but valued school science for the insights it provided and the contribution it made to their own self-esteem as educated individuals.
- There were many aspects of school science for which pupils could perceive little relevance to their everyday lives. In chemistry, topics such as molecular and atomic bonding and industrial applications were mentioned often. Much of the work in physics lacked relevance, particularly for girls. For many topics, the value of the knowledge lay simply in its instrumental value for passing an exam.
- A wide range of suggestions were made for change. Pupils suggested that there was a need for more contemporary examples so that school science appeared, at least occasionally, to address the same issues as science in the media; the curriculum needed to have some of the repetition eliminated and rethought so that there was a less rushed experience in the final years; there was a need for more work such as practicals, extended investigations and opportunities for discussion to enhance the variety of experience and opportunities for personal autonomy. All groups – parents, teachers and pupils felt that there should be some element of choice in the curriculum at age 14.
- Teachers acknowledged that much of the pupils' dissatisfaction was legitimate but felt that they were the product of a content-dominated and overloaded curriculum. Working in a context were pupil performance was monitored ruthlessly as a measure of both their competence and the school's achievement, the limited time forced them to focus on essentials and eliminate any extraneous elements which added the 'fun' to school science. They felt, however, that complaints about excessive copying were overemphasised and that pupils' failed to see the importance of repetition for the purposes of consolidation and elaboration of their knowledge and understanding.

These findings lead us to conclude that there are a number of discontents with current practice in science education, predominantly at Key Stage 4. These dissatisfactions are the product of a curriculum framework that is content-dominated, assessment driven and too homogeneous. The result is that science teachers rush their pupils across the scientific landscape and offer an unvarying experience from the latter stages of primary school to the final days of secondary school, often repeating material, and eliminating any time consuming activities such as practical work or the discussion of contemporary science. Another factor is a curriculum which privileges pure science over technology when pupils, and their parents, do not distinguish between the two, and when technology is a vital link that provides the essential component of relevance which, for the pupils, often appears missing. Physics and chemistry lack much of the relevance that biology offers. A curriculum weighted towards biology would, therefore, have more appeal. In conclusion, we therefore recommend that:

1: *An approach that uses technology to introduce new topics and then develop the science content should be used in the teachiing of science, rather than the obverse.*

2: *The study of some issues raised by contemporary science in any science course post-14 which should be an integral part of the curriculum.*

3: *A curriculum post-14 that should consist of a core course plus further optional modules which would provide an element of choice, both for teachers and their pupils.*

4: *Whilst any post-14 course should contain elements of all physics, chemistry, biology, Earth sciences and astronomy, the requirement that it should be balanced is no longer appropriate to the interests of all pupils.*

5: *The curriculum at Key Stage 2, Key Stage 3 and Key Stage 4 should be clearly differentiated from each other both in their aims and content.*

6: *The recruitment of effective science teachers is vital to sustaining the subject and requires urgent and immediate attention by the science education community.*

# Introduction

Pupils' and parents' views of the school science curriculum presents the findings of a two-year study funded by the Wellcome Trust. The work began in January1997 and its aim was to explore and gather, through the use of focus groups, the views, comments and attitudes that 16-year-old pupils, and their parents, held about the value of science education. The research was undertaken by Dr Jonathan Osborne and Dr Sue Collins of the School of Education, King's College London. This report presents the principal findings of that study.

The need for the report was driven by a view that the school science curriculum was possibly in need of some radical revision. The past half-century has been an era of change – both in the structures and traditions that govern individuals' lives, and in the technology that surrounds them. For instance, in the post-war era, employment, once gained, was often seen as secure and tenable for life. Skills acquired as an apprentice or trainee would be both valued and valuable for the rest of one's employable future. Similarly, 'the white heat of the technological revolution' promised an insatiable demand for skilled scientists and engineers. Such a vision failed to foresee a number of changes – the demise of manufacturing industry, the growth of the service sector, the loss of secure employment, the changing structures of society and the emergence of what has been characterised as a 'risk' society where science is seen not only as a source of solutions but also a source of risk (Beck, 1992). In addition, and perhaps ironically, advancing technologies have left both industry and individuals less dependent on scientific knowledge to engage with, and use, contemporary artefacts and machinery.

The consequence is that the instrumental value of science education has diminished. For instance, contemporary cars, washing machines and TVs are no longer reparable by the average person with a basic grounding in science. And, as a result, we have become increasingly reliant on expertise. Science education too, can no longer be justified solely in terms of its importance as an avenue of pre-professional or pre-vocational training as the employment opportunities for scientists in scientifically related careers have remained static or declined.

Moreover, in the past twenty years, the emerging significance of scientific topics on the political agenda through such issues as global warming, ozone depletion, food safety and the genetic modification of organisms has demanded that science education pay more attention to its role in developing a scientifically literate public. Forced to serve these twin masters, questions have been raised about whether it is succeeding at either or both of these aims (Millar, 1996). Other have suggested that it is simply falling between two stools of competing and disparate priorities arguing, instead, for a radically different form of science education that reflects late twentieth century needs (Millar & Osborne, 1998). For in many ways, the science education offered to the pupils of today would remain largely recognisable to the overwhelming majority of the adult population. In short, it has failed to respond or adapt to the changing society in which it finds itself situated.

Proposals for change have been advanced. The report *Beyond 2000: Science Education for the Future* (Millar and Osborne, 1998) argued, for instance, that any formal school science education must be seen as an end-in-itself and, first and foremost, as an education for scientific literacy. Such debates are important to determine what as a society we should expect of an education *in* or *about* science and in deciding the content of the National Curriculum. Absent from the debate, however, has been the voice of the 'consumers' of science education – the pupils and their parents.

In the past twenty years, there has emerged a dominant consensus, both nationally and internationally, that science education is so important that it must be a compulsory part of all pupils' education. If *Science for All* is then, to be a universal requirement, it seems reasonable that we ask of those on whom we seek to impose this experience, what kind of science education would foster their interest, appreciation and understanding of science. There is, for instance, a need to determine those aspects of science that pupils and parents value and use in their everyday lives. Lay people engage with science and technology in a range of contexts (health, nutrition, waste disposal, pollution), and whilst their views cannot be the sole determinant of a science curriculum, it is essential to articulate their contribution to the debate. To what extent is school science responding to pupils' needs and parents' aspirations enabling them to engage with a major influence on their society and culture? What are their expectations of school science, and do they think it has failed or succeeded in meeting those aspirations? This research sought, therefore, to document those needs and expectations.

## Aims and Objectives

The purpose of this study was to determine the views of pupils and parents on:

1. the kind of scientific knowledge, skills or understanding that they need for dealing with everyday life;
2. the aspects of science that they find interesting;
3. the value of the content of the school science education that they received;
4. the future content of the science curriculum for all.

As any suggestions or arguments for change emerging from this research would require the assent of the science teaching community, our fifth aim was:

5. to determine the reactions of science teachers to the pupils' responses and the implications for a future science curriculum for all.

## Research Methods

The intention of this study was to capture the range of views of both pupils and their parents, in some depth, about the kind of science education they would value. Essentially, such aims call for qualitative methods that concentrate on capturing both participants' views and their rationale, rather than producing a statistical sample of the whole populace.

There are primarily two qualitative data collection methods – group discussion and individual interviews. Individual interviews offer greater flexibility and the potential to follow up points that emerge from the respondent's perspective. However, the agenda is ultimately in the hands of the interviewer and, because of the difference in perceived status between interviewer and interviewee, interviews can promote situations in which respondents provide answers that they think the interviewer wants to hear.

In contrast, focus groups are a form of group interview that provide a more open setting, enabling the participants to determine the particular focus of the discussion, to raise issues that the researchers may not have considered, and allow time for individual reflection within the group. They also provide a context in which participants who hold differing views can challenge each other forcing elaboration and justification. Qualitative data of this kind provides rich and detailed descriptions of people's experiences, understandings and views on an issue. Such research seeks to develop a deeper understanding of its central focus exploring not only *what* participants think but *why*. The method chosen, therefore, was based on focus groups.

Participants were then selected to represent a cross-section of the population – in order to ensure that as many views as possible were gathered and that the data was a comprehensive representation of the population. However, data cannot easily be viewed as a measurement of the *proportion* of the population that holds any particular view. Some measure of the extent to which opinions are widely held can be gathered from the frequency with which they emerge in the groups, and the intensity with which they are expressed. However, the principal value of this method is to capture the variety of views, and their rationale, rather than the proportion of the population that agrees with any specific comment.

## Questions

The initial phase of this project from January – June 97 consisted of a pilot phase during which trials were conducted of the methodology and the questions to be used with the group. Questions were derived initially from a consideration of some of the issues discussed above, and the principal themes of concern. These were the value of school science; how participants saw the value of applications of science in their everyday life; their visions of school science in the future; and the appeal and interest of science to them.

Questions were then modified in the light of participants' responses. Initial trials revealed that in discussing an experience (as opposed to a concrete product), it was better to pose to pupils and parents provocative statements that forced a reaction.

Expressions of assent or rejection led easily to their rationale and then a wider ranging discussion between the group. The function of the moderator in a successful discussion was then solely to use questions, where appropriate, as a means of keeping the discussion focussed on the theme, and to ensure that the discussion was not dominated by a subset of the members of the group.

The full set of questions is shown in Appendix 1. The initial questions, as well as addressing one of the principal themes of investigation, served as a valuable ‘ice-breaker’ that easily initiated discussion amongst the group. Group discussions generally lasted one to one and half-hours and always finished with a summarising question asking each participant to identify the most important element of the discussion. This also provided an opportunity for any individual who had been reticent in the discussion to express views that may have been withheld to that point. All of the statements were accompanied by a set of sub-questions that the interviewer used if the issue was not addressed in the ensuing discussion.

## Sample

The recommended group size for a focus group is between 6 and 8 people. Less than this number reduces the lines of communication and opens the potential for individuals to dominate the discussion. More than this number multiplies the possible lines of communication and risks curtailing the group dynamics. In this research the average group size was 7.

The study focussed on year 11 pupils, age 16, and their parents. Both of these groups constitute important sectors of the public with vested interests in science education. For the pupils, the study captured their views at the end of compulsory schooling – a time when their memories are fresh and recent. Parents’ views on the other hand may reflect the views of the adult public at large.

For this research, sub-groups of the sample were composed of participants deemed ‘similar’ along key dimensions. The key attributes of the populations that were considered important in this research were pupils, parents, male, female, scientific and non-scientific orientation. The division by male and female was a decision taken in the light of a substantive body of research that demonstrates that males and females have different responses both to science and science education. In addition, there is research which shows that in mixed groups the discussion is often dominated by men. Splitting the groups by gender therefore enabled disparate views to be explored in a supportive context. With the parents groups, due to administrative and organisational problems it was not possible to sustain a strict gender division for three of the focus groups.

Finally, it was considered very likely that participants’ views would differ markedly depending on whether, in the case of parents, they were employed in a scientifically based profession, or, in the case of pupils, were considering further study of science post-16. Groups were therefore split by this dimension.

These choices produced 8 distinct possibilities. The general view is that a complete sampling of any one sub-group requires a minimum of 3 focus groups. Therefore, to ensure that the views had been comprehensively collected, 5 focus groups of any one sub-group were used, resulting in a total of 45 focus groups. These were held in three locations across the country – Leeds, Birmingham and London to ensure that the data gathered was broadly representative of the whole populace of England rather than a specific sub-culture.

Our aim was to report on the views of the broad majority of pupils participating in state education and their parents. Our sampling technique was therefore based upon avoidance of the exceptional and 20 state schools were recruited whose GCSE scores lay with ± 15% of the national average. In all, a total of 144 pupils, 117 parents and 26 teachers participated in the focus groups. A total of 45 focus groups were held in all consisting of 20 pupil groups consisting of:

5 girls groups *not* continuing with science (referred to as GN in the report);

5 girls groups *continuing* with science (referred to as GS);

5 boys groups *not* continuing with science (referred to as BN);

5 boys groups *continuing* with science (referred to as BS);

20 parent groups consisting of:

5 male groups working in scientifically-related careers (referred to as MS);

3 male groups *not* working in scientifically-related careers (referred to as MNS);

4 female groups working in scientifically-related careers (referred to as FS);

5 female groups *not* working in scientifically-related careers (referred to as FNS);

1 mixed gender group working in scientifically-related areas (referred to as MG);

2 mixed gender groups *not* working in scientifically related areas (referred to as MNG);

and

5 teacher groups of mixed gender drawn from a range of specialities (referred to as T).

All the focus groups, undertaken between September 98–July 99, were taped and then transcribed. Data were then coded reflexively to identify emergent themes and issues. This resulted in a large set of 430 codes grouped under 25 broad themes. A reliability check was conducted by independently coding the same transcript which gave a 79% initial level of agreement which rose to 90% after the differences in coding were discussed. The interviews were then transferred to a qualitative data analysis package. Such software enables preliminary analysis of the frequency of the certain codes; the differences between the sub-groups; and the rapid testing of tentative hypotheses as it can rapidly retrieve any data that lies at the point of intersection of two or more codes. For instance, do the data support the hypothesis that girls' comments about physics are more negative than boys' comments? Hence, the software supports not only the quality of the analysis but also the extent of what is feasible within a given time.

The report that follows is then a detailed presentation of the body of data that was collected. Its implications are discussed both within the report, and in the summary where the final conclusions and recommendations for change are proposed.

# Section 1:

# Pupils' Views of the School Science Curriculum

# one

## Pupils' views of the importance of school science

Pupils saw scientific knowledge as being an important component of their education. Reasons given were that science is 'all around us'; that it helps 'you to understand the world', providing you with a knowledge of 'how your body works', 'how to fix a car' or 'how to wire a plug'. Science is also useful for explaining things to other people. Such rationales were, however, more extensively and clearly articulated by the girls than the boys. Although arguments for the importance of science, typified by the comment below, were not extensive, they were articulated by the majority of the groups with the exception of the boys' non-science groups:

> *Colin[1]:* *It's [science] led to a lot of discoveries that wouldn't have been discovered without science, ....., technology and stuff like that, and.... if it wasn't for science we wouldn't be where we are today. Really, we'd be still living in caves....., so I think it's really important.* *(BS2/379[2])*

The emphasis in the majority of the comments was on the general value of science in society, often illustrated with examples of its instrumental value:

> *Helen:* *I think science is really important because, for example, now in present days, we wouldn't be using washing machines because they were constructed by the scientists weren't they? I mean, because when you use computers and well, it's a bit like technology – everything, everything with cars and trains, actually I think is related to science.* *(GN2/525)*

Such arguments reflect a lack of any distinction between science and technology and a modernist faith in science as a source of solutions. The controversial nature of scientific research was less prominent in pupils' comments, and there was little recognition that one value of scientific knowledge was the facility to engage critically with contemporary scientific issues. Rather what was emphasised was that scientific knowledge offered a point of entry into the discussion:

> *Lucy:* *It's really important for me to learn science to keep in line with everything else, because, if you switch on the T.V., they're always talking about things that they've discovered and new ways they can do things. To understand what they're talking about you've got to know science. And I can, when I see something on T.V.. Like, I*

[1] All names used in this report are pseudonyms.

[2] References are numbered by the type and number of the group, followed by the text unit reference in the transcript ie. Boy's science, group 2, text unit No 379.

*was watching 'Children's Hospital' the other day and they were talking about sickle cells, stuff like that and I know about sickle cells so I could understand it. (GS5/615)*

Hence what was articulated clearly, in all of these comments, was a recognition that *learning science was important* – and that science and scientific knowledge was an important aspect of contemporary life. For science educators, this is an important finding as it suggests that their subject has achieved such a level of significance in contemporary society that its place on the curriculum is unquestioned.

On a personal level, one of the reasons advanced for the importance of science was that the subject was prestigious. Those who could do science were seen to be intellectually able and enjoyed higher academic status:

> *Julie:* *In ten years time when you meet these people and you ask, 'What GCSEs did you get?' If you sit there and say, 'I got a B in Maths a C in English, an A in Art and an A in graphics', they'll sit there and go – 'Oh, that's good, yes'. But if you come out with, 'I've got two A's in sciences, and an A in maths, B in English and an A in art', they'll sit there and think, 'Oh, brilliant, this is someone who we want to know'. (GS3/291)*

The most common argument for the importance of science was its instrumental value for future careers. A closer examination of the comments made by pupils revealed two aspects to these arguments. First, the range of occupations for which science was seen to be valuable was those traditionally associated with science, e.g. medicine, veterinary work, airline pilots. Second, there was a view prevalent among some of the pupils that science is not a core subject in the sense that mathematics and English are. The latter were considered essential for all occupations whereas science still did not have equivalent status:

> *Sam:* *Because no matter what job you do, even if you are a road sweeper, you'll still use maths and English, no matter what form it is you still need it. I don't think science is so much in that category. (BS3/493)*

Many of the pupils felt that there were a large number of posts for which science was unnecessary. Many suggested, in contrast, that for career purposes IT skills were more relevant to a wider spectrum of career opportunities:

> *Paresh:* *I think IT has taken over...., there's a huge amount of computers been used in every job. For science you only use it in certain jobs, whereas IT you use in almost every job. (BN3/445)*

It was argued, for instance, that you did not need science to become a hairdresser, a banker, a rock star, an artist or a lawyer. However, in some instances there was a creeping recognition that science might have import for a wider set of careers than those traditionally associated with science, although this argument was only ever articulated in general terms rather than by reference to specific examples:

> Charlie: *I think most careers that you pursue they've probably got science involved in them anyway, one way or another, even if it's not really in-depth. It could be like basic – just basic science – so I don't agree with what he's saying exactly. But there maybe some, very few but some careers that don't need science.* *(BS5/203).*

> Sam: *But it's needed, nowadays if you want a job it's one of the ones that you need, nowadays in the jobs that you like, sometimes they want a GCSE mark of science.* *(BN1/435)*

Surprisingly, this awareness seemed to be most prevalent amongst the boys who were not continuing with science. What these findings suggest is that science has a marketing problem. If the main value that pupils are placing on science is its instrumental value rather than its intrinsic interest, then science teachers should endeavour to make clear the wide range of occupations in which scientific knowledge is useful, how it might be used, and why it is useful. Whilst there would appear to be a growing awareness amongst some pupils of the general career value of science, the lack of specific examples raised implies that little has been done to emphasise the value of science qualifications in a wide range of occupations – or that science has value as a cultural resource for any 'educated' individual. In short, if science education wishes to make the argument that it is an essential part of the core curriculum, then science teachers must advance arguments for its importance in adult life which are as irrefutable as those advanced for mathematics and English. At the moment, the attitude of too many pupils would appear to be summarised by the view that – yes, studying science post-16 is important, but not for me. Changing this view requires more emphasis to be given to the relevance of science to all occupations illustrating science teaching with contemporary examples drawn from the world of work so that its salience and significance are self-evident.

A closer examination of the many reasons given for the importance of science shows a marked difference between boys and girls in the number of statements offered. Girls had little difficulty in elaborating reasons for the importance of science to themselves and their own everyday lives (67 text units as opposed to 10). A good example, found in the following comment, illustrates the point that everyday life is the context where the salience, or not, of learning in school is realised:

> Julie: *Like a little electric heater ….I remember I was plugging it in and I felt the plug was warm, and I remember learning that warm was faulty. I told my mum and she was so impressed. And if I hadn't learned that it if was warm it was faulty I would have plugged it in and found out.* *(GS1/520)*

Boys, in contrast, had little to say about the importance of science either to themselves or to their everyday lives. What they did say was very similar to the comments made by the girls, although one or two of the examples they offered had a more traditional gender bias of its value for fixing plugs and fixing cars. This would suggest that they held similar sentiments but simply failed to articulate them to the same extent. Another distinction between the groups was that it was the girls' science groups who offered, surprisingly, less qualifying statements on the importance of science. The boys' science groups, in contrast, offered as many as the non-science groups suggesting that they still held residual doubts about the value of science, either to them personally or more generally. The only other difference found in the data was a tendency by pupils from the South to stress the relevance to themselves as a reason why science was important. An examination of the statements shows no reason why this should be so.

However, despite pupils' generally positive view of the value of science, there were many aspects of *school science* that they found uninteresting. That there was a contradiction between pupils' perception of the significance of science in society, and the value they placed on science in school, was recognised by one group at least:

> *Amanda:* *I think we all have this view of science being boring, but if you sit down and you speak about it then you realise it is actually important. It is actually relevant to the things you've got to do.* *(GN4/1187).*

# two

## Aspects of school science pupils found uninteresting

In conducting this research, we had anticipated that the science subject for which there would be most antipathy would be physics. The subject has a long history of being regarded as mathematical, abstruse and difficult. In addition, historically the take-up by girls has been low. The surprise that emerged from much of the data (Fig 1) was that, for many, the subject that attracted the most vehement expressions of its lack of relevance and appeal was chemistry. In particular, boys' continuing science groups, and girls not continuing with science, made more comments about chemistry, whilst girls' continuing science groups commented more on aspects of physics. The other major feature of this data set is that girls in both groups made many more negative comments about physics than boys which would suggest that school physics still lacks content that appeals to girls.

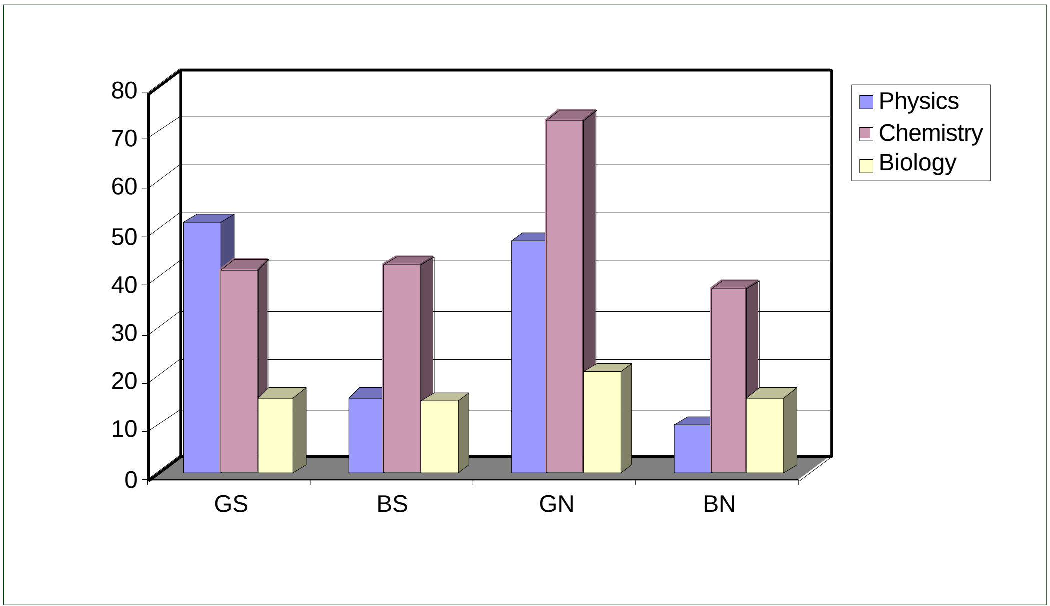


**Fig 1: Chart showing number of comments coded 'uninteresting' for each science subject**

One aspect of chemistry that attracted universal antipathy among non-science pupils was the periodic table. Not only did they experience difficulty in memorising the constituents of the table, but they also failed to perceive its relevance to their everyday lives at present or in the future:

> *Edward*    *It doesn't mean anything to me. I'm never going to use that. It's never going to come into anything, it's just boring.* *(BN2/272)*

Similarly, continuing science groups were unable to see the purpose of the inclusion of the blast furnace in school science:

*Roshni:* *The blast furnace, so when are you going to use a blast furnace? I mean, why do you need to know about it? You're not going to come across it ever. I mean look at the technology today, we've gone onto cloning, I mean it's a bit away off from the blast furnace now, so why do you need to know it? GS5/513)*

The lack of perceived relevance to pupils' lives of such topics was a recurring theme throughout these discussions in all groups, either for continuing education in science and/or career aspirations. For instance, it was argued, 'I won't need to know all the equations or the chemicals' (BN1/388). Without this essential ingredient, sustaining interest was difficult, if not impossible:

*Tamsin:* *A lot of the stuff is irrelevant. You're just going to go away from school and you're never going to think about it again.*
*Jessica:* *Yeah, bonding, you're never going to think 'how do I bond?' (GN1/240-242)*

In the past decade, chemistry education has diminished activities that involve the manipulation of chemicals, chemical combination and analysis. Many of the more 'spectacular' demonstrations have also been excised as a consequence of more stringent safety regulations. In its place, there has been a concentration on more fundamental aspects such as atomic and molecular bonding which are essential for explaining chemical combination. However, the theoretical emphasis on intangible and microscopic entities introduces an element that appears to too many pupils to be abstruse and far removed from their daily concerns. Pupils' complaints about the study of industrial processes which are no longer a mainstay of the British economy, and not readily to hand for organised school visits would seem, therefore, to have some substance.

***Hard or difficult subject***

Amongst all pupils there was general agreement that many aspects of science were 'hard' or 'difficult to understand', which in turn made them uninteresting for some. Points of difficulty mentioned were – the language with its unfamiliar words; the nature of complex concepts such as bonding; and the fragmented nature of the subject. Although challenging work was welcomed, principally by continuing science groups, pupils found sustained difficulty demoralising:

*Julie:* *I think sometimes when we don't understand something that's what makes it boring. But at the same time, if you see something and you want to know why – that's what makes it interesting. If it's something that you want to understand and you can't, it just gets boring after a while. (GS1/492)*

Science itself was seen as being a very logical subject, which in one sense was akin to common sense, and therefore, at the introductory level, relatively undemanding. However, there was recognition that beyond this point science became more difficult. The transition point, where science became notably more difficult was year 9:

*Jane:* *I think the point when it changes is about Year 9, because you've had two years of it and year nine's like...*
*Megan:* *Just after year 9.*
*Jane:* *...when you're picking you're options and...*
*Jessica:* *Everything's more difficult.* *(GN1/310-313)*

Somewhat in contrast, pupils in continuing science groups described science as an 'academic' subject where, 'you can't just memorise it, you have to understand it' (GS3/305) which was part of its appeal for them.

All groups commented on the integration of maths into aspects of physics and chemistry, through the use formulae and equations. Amongst girls and boys in continuing science groups, there was a feeling that a comprehension of aspects of maths was a prerequisite of understanding physics and chemistry. For the small number of girls who experienced difficulty with mathematics, their difficulties with physics were then compounded. There were also a significant number of pupils across all groups who, because of their sustained difficulty in one form or another with some aspects of science – predominantly chemistry and physics – no longer had an appetite for the challenges it offered. Rather they were resigned to the fact that their attainment in tests and examinations would be low.

***Rushed curriculum***

One of the most strongly articulated features, in approximately half of the groups, was the sense that pupils were being frog-marched across the scientific landscape, from one feature to another, with no time to stand and stare, or absorb what it was that they had just learnt:

*Keiran:* *It's all crammed in, and you either take it all in or it goes in one ear and out the other. You catch bits of it, then it gets confusing, then you put the wrong bits together, and if you don't understand it, the teachers can't really understand why you haven't grasped it.* *(BS1/232)*

*Alice:* *And some of our teachers just completely rush us off our feet, I mean not mentioning any names, they take you completely off your feet.* *(GS5/160)*

The basis for these comments was predominantly the pupils' experience of Key Stage 4, GCSE science courses. The points made suggest that the experience of school science is one of a broad syllabus covering physics, chemistry, biology, earth sciences and basic astronomy, coupled with the exigencies of limited time, leaving little space for reflection. Year 11, in particular, was a year in which considerable pressure was applied as a number of topics were covered superficially and in haste, despite the substantial amount of time devoted to science teaching. Some pupils made the point that more advance warning of the forthcoming load would have been helpful.

Surprisingly, blame for this situation, when articulated, was not laid at the feet of the teachers but rather with the nature of the curriculum demands and the subject. The pupils recognised that the curriculum was overloaded and, as a consequence, forced teachers to rush through the syllabus. The result was often practices which were seen as of little educational benefit such as copying – and which had a negative affective outcome on interest in the subject:

> *Phillipa:* *And also the teachers, I think the teachers are worried that there's not enough time.*
> *Amra:* *The teachers are going to think, 'Well I've done my job', because if you look through someone's exercise book you're going to see all the work that had to be covered in there...*
> *Lucy:* *Yeah, but all you did was sit down and copy it down from the board, that's why it's in there, not because you've actually understood it.* *(GS4/733-738)*

> *Rosi:* *But still like this morning we were talking about genetic engineering, and Miss told us about this article, about how they're going to make clones of each baby that gets born. They're going to make a clone of it – so say if it needs a transplant, kidney transplant or whatever he could get it from his clone. And she didn't want to hear that it's wrong. She didn't want to know our opinions and I don't reckon that the curriculum let's them, lets us discuss it further. I mean science, okay you can accept the facts, but is it right, are we allowed to do this to human beings.* *(GS5/88)*

In a situation, where there is a legal requirement to teach the complete curriculum, regardless of whether sufficient time has been allowed, or whether it is educationally appropriate, the impression gained is that some teachers have been forced into transmissive modes of teaching, resorting to greater use of 'chalk and talk'. In part, teachers are being driven into this practice by the use of examinations scores both to measure the quality of their work and the achievements of the school. This finding simply reinforces other findings based on systematic classroom observation (Hacker & Rowe, 1997). Such methods may be efficient for delivering content but all the research evidence, supported by the comments here, suggests that they are simply the least effective method for learning. Thus, an unintended consequence of the national curriculum, and teachers' pragmatic response to its assessment demands, is that it may be having a negative outcome on many pupils' enjoyment of science.

When questions were raised about specific points of interest for further elaboration or justification, the shortage of time was sometimes used as a means of asking pupils simply to 'accept it'. Such appeals to the rationale of authority as a means of justifying the scientific world view to pupils are disturbing for three reasons. First, arguing from authority makes the pupil in the science classroom of the so-called contemporary Western society no different from those cultures that rely on the authority of oral assertion. In both cases the 'the propounders are deferred to as the accredited agents of tradition' (Horton, 1971). Second, it is particularly disturbing that a subject, which claims to be epistemically privileged because of its commitment to evidence as the basis for belief, forces its educators to resort to assertion as a means of convincing pupils of the scientific world-view. Third, to ask of other human beings that they accept and memorise what the science teacher says without any justification leave students bereft of the reasons for belief, and a knowledge that is of little more than superficial value as they are unable to justify their beliefs to others. This unease of relying on authority – essentially an irrational form of argument for a scientist – was sensed by the pupils with teachers teaching outside their 'safe region' who were often reluctant to entertain questions

***Content dominated***

One of the more pervasive comments about school science, mentioned by just less than half the groups, was that science was essentially a body of knowledge characterised by its content, with a particular emphasis on facts and learning, which distinguished it from other subjects:

> *Cassie:* *With science it's solid information and you've got to take it down.* *(GS4/76).*

> *Cheryl:* *...so when they teach you science you know that this is it, okay? There is nothing, you can't prove it wrong,*
> *Leena:* *In what way does that make it different to other subjects though?*
> *Shakira:* *I mean you just have to accept the facts don't you?*
> *(GS5/61-63)*

The difference between science and other subjects, as perceived by a number of boys in continuing science groups, was that school science consisted of facts to be learned. In science 'you've got to print it into your brain' (GN2/83), or learn 'straight facts which you have to repeat in the exams' (BN4/77). In addition, non-science groups expressed the view that maths and science were both 'very set subjects' (GN1/154). The view was expressed that 'there's one answer and you've got to learn it' (BN2/18). This view of science was common to pupils across all the groups.

The negative consequence of the concentration on the 'facts' of science in its teaching for some pupils was also well articulated by one pupil:

> *Claire:* *I think the thing that is making us, everyone having negative opinions of it, is because it's so much, it's because it's so much to learn. And you…suddenly, you're mind is just saying, 'Look this is interesting, but I really don't want to learn it like this, I don't want to pump it into my brain'.* *(GN2/203)*

The poor affective outcome of a course which is dominated by content supports Miller and Tesser's (1986) cognitive-affective mismatch hypothesis which suggests that courses emphasising cognitive outcomes have weak or negative affective outcomes. It is also of concern because affective outcomes are much more enduring than cognitive outcomes (Petty & Cacioppo, 1986) and, if one of the primary residues of a good science education is to be an enduring interest and engagement with science, then school science courses need to change. These comments would suggest that the introduction of a wider variety of pedagogy with less content emphasis would assist.

***Repetition***

A major contributing factor to pupils' lack of interest in science, particularly among continuing science groups, was repetition of work. Repetition was described as taking two forms: first, a number of pupils in non-science groups, and two continuing science groups, commented on the repetition of tests and experiments within given lessons:

> *Asha:* *What's tedious is when the teachers sit there and they'll get a white liquid and they'll say, 'When I pour this green liquid in what colour will it turn?' The point is, 'Oh look it's an acid it's turned red'. And then they'll get the next one, 'This is vinegar, what colour will this turn?' And they won't just do one acid and one alkali they'll do six acids, six alkalis and you have to sit there and it's, like, we've done this about four times already.* *(GS3/247)*

Whilst the repetition here is essentially a rhetorical mean to persuade pupils of the validity of the scientific world view, its use without explicitly addressing why it matters, is clearly a point of disengagement for pupils.

The second dimension of repetition, strongly articulated by continuing science groups, was in topics begun in year 7, or earlier, which had been repeated in subsequent years:

> *Alice:* *Every year I've done science…...I have learnt about photosynthesis. It's not as if I learn it in more depth every year, I just do literally the same thing…...When you get to secondary school it's not that much more advanced and that's it, you learn the same things over and over again.* *(GS5/709-711)*

Solids, liquids and gases were mentioned as another example of a topic in which they perceived no progression. Whilst progression was apparent in some topics in that 'there's a bit more information now' (GS3/257), it was perceived by continuing science groups, to be planned in small stages, where although 'it's more complex, .. it's basically the same' (GS3/259). As the following comment shows, a consequence of an apparent lack of progression in topics, particularly for girls non-science groups, was a growing disenchantment with aspects of science:

> *Claire:* *There's a tiny thing that I want to say about science, which I actually have been in a state about, and I've been complaining about since year 8. We learnt all these amazing things in year 7 that we'd never heard of before, like molecules and atoms and electrons. I don't know about you guys but I got really excited about it, I rushed home and told my mum about it. And then in year 9, we're doing the same thing, year 10, doing the same thing, year 11, doing the same thing….. and it's so repetitive. (GN2-670)*

A number of continuing science groups acknowledged the need to revisit aspects of science. However, the point was made that too much time was devoted to revision and, as a consequence, 'we're never learning anything new – it's just revision and it gets so tedious' (GS5/153). The notion of a spiral model of curriculum planning (Bruner, 1960) in which concepts are revisited and more clearly defined at intervals during schooling, was clearly lost on many pupils. More fundamentally, these comments raise many questions about how this state of affairs can be avoided. The science National Curriculum assumes a steady progression where teachers build on children's previous understandings. There is little doubt that this poses formidable challenges for secondary teachers, partly from a lack of familiarity with the science teaching undertaken in primary schools, and partly from the problem of dealing with the disparate and vicarious experience within primary schools. However, this does not explain or account for the problem within secondary science itself. In part, the solution here lies in asking teachers to think more carefully about students' prior experiences and explicate how any topic they introduce will be both different and build on their previous knowledge. More fundamentally, these responses beg the question whether it is appropriate to sustain the same kind of science education over the 11 years of secondary education – and whether the fare offered lacks sufficient diversity to appeal. One way of eliminating this problem would be to offer a different science course in year 10 and 11, possibly, as one of us has argued elsewhere, a course that emphasised the development of scientific literacy (Millar & Osborne, 1998).

***'Copying'***

Another point was that Key Stage 4 saw a significant reduction in opportunities for engagement in practical investigations. Comments to the effect that 'we hardly do any experiments now' (BN2/67) were made. Instead, pupils commented, that there was an increase in 'copying', 'we're always copying from the board or from a book' (BN3/67), or from photocopied sheets:

> *Tom:* *...if you look at my science book now there are more sheets than there are pages in the book* *(BN4/305)* .

With the exception of girls' continuing science groups, pupils commented on the adverse effects of copying notes from the board, textbooks and so on, on their understanding of scientific concepts:

> *Jake:* *Some teachers just read off a page and you've got to copy it down and they don't say anything about it and you've got a page of writing in your book and you don't know what you're doing.*
> *Marlon:* *It wouldn't be so bad if he explained it at the end, but he doesn't.*
> *Steve:* *No, you just go home and think, 'what was that about?'*

*Vishal:* *Yeah, you're writing things down from the overhead projector, you haven't had time to read it while you're copying it down, it's only when you come back to revision that you think 'I didn't understand that and I wished I'd asked him'. But then you remember that you didn't have a chance to ask because you were that busy trying to copy it down you weren't reading it.* *(BS1/426-427)*

*Terry:* *...when we do experiments you want to know why so you make the effort to read books, to ask the teacher after class and stuff like that. But if you just copy it it's really boring and then when the exam question comes it won't be as set in your mind – you're learning it from your notes and you don't know the experiment. I should be able to see it in my head otherwise I won't learn it.* *(BS5/152)*

As an activity, there is now considerable research that shows that copying or undemanding writing activities are of little educational value. Predominantly, they are associated with transmissive modes of teaching which research has shown to be the least effective in helping pupils to attain knowledge and understanding of the subject (Eggleston, Galton, & Jones, 1976). 'Copying', which in this case may be a euphemism for 'boring writing', is an activity in which little active processing or participation is required by the learner. The explanation for their lack of stimulation perhaps lies in the words of the famous saying, 'lectures are a device where the notes of the lecturer are transferred to the notes of the student, without going through the mind of either'. Such work offers pupils little control over their own learning, and ultimately leads to boredom, disenchantment and alienation (Wallace, 1996). The comments gathered by this work would strongly reinforce her interpretation of the negative educational value of such activities.

### *The Lack of Discussion*

Another consequence of this approach was that there was no time to diverge, no opportunity for the pupils to set the agenda themselves; to pursue topics of particular interest and, most importantly, no time for discussion:

*Tania:* *If you, like, give suggestions they just ignore it and go –'No it's written in the syllabus that you've got to do this'. And it's just kind of fixed upon the syllabus and you're like, 'Well can't we just find a gap for it?' And they're, like, 'No'.* *(GN3/658)*

Pupils in non-science groups, complained that unlike other subjects in which 'you can use your imagination' (GN2/100), in science 'there's no room to put anything of you into it' (GN1/53), and, 'everything else is more creative, even history' (GN4/205). The perceived absence of creativity in science was a point developed among boys' non-science groups and the following comment encapsulates a more widely held view:

*Adam:* *In English you don't have any barriers as such, 'cause in English they mark you on your own knowledge, expressing your own knowledge, not only just reading a story and* *answering questions. Basically it's using what you want to say. But in science it's more strict, 'cause you have to learn and just write it down. Everything's like, ordered, you learn about photosynthesis and write about photosynthesis, whereas in English if you want to write about a flower you can write a poem or something, like that, something creative. It's just not as creative as English.* *(BN4/54)*

Pupils in non-science groups maintained that the freedom to express ideas, views and opinions extended even to the examinations in other subjects, such as English, where there were opportunities to use 'your general knowledge' and to express 'your own opinion' – opportunities which stood in marked contrast to science where it was said:

*David:* *It's more about testing your ability to lean than your ability to do science.* *(BN2/81)*

Part of the problem for science is that the genres of writing it uses – the explanation, the experimental report or description are all unfamiliar genres which children find both alien and alienating (Wray & Lewis, 1997). Writing in science then must be carefully structured and supported if it is to avoid generating such negative reactions.

Science was a subject in which there was 'less margin for error' (BS3/95), whereas in subjects like art, there were 'no boundaries' as 'you can draw whatever you like and still it could be a masterpiece' (BS3/113). Such comments suggest that school science offers little for those pupils who have a creative urge, or are interested in developing their capacity for self-expression. Whilst there are opportunities for a range of activities such as role plays, group-presentations or writing for different audiences, school science essentially deals with established consensual knowledge which is not open to critical examination or reinterpretation. Greater variety of activities within school science would help to break the one-dimensional view of science that such comments represent.

At the root of the pupils' disquiet is the lack of opportunity for control over their own learning experience. As Wallace (1996) has pointed out, in another recent study of pupils' views of their school experience, 'work where pupils had not felt in control of their learning, by definition, had little meaning and failed to engage them'. Opportunities for discussion are then, in addition to practical work, for many pupils, a point at which they regain some control of their educational experience, and a 'point of engagement' with the subject. In short, some personal ownership of a subject. Their excision under the exigencies of curriculum pressure, therefore, may have a high long-term cost in pupils' interest in science.

Moreover, as Shamos (1995) has argued, we live in a humanistic society in which there has been a remarkable growth in 'reflexivity' both personally and within society at large (Giddens, 1990). Thus the authoritarian nature of school science, the tyranny of content and the lack of any plural voice sit ill-at-ease with other subjects which permit, and even encourage, such reflexive and discursive activity. Increasingly, as issues of a socio-scientific nature force themselves into the political spotlight, some pupils would appear to find it strange that school science maintains a hermetic seal between itself and contemporary society.

Making science appealing to such individuals might also require more stress on the creative endeavour that scientific knowledge actually represents. To conceive of the world as being spherical when it appears flat; to see diseases conveyed by tiny microscopic organisms; or to apprehend that all matter is made from a set of 92 elements requires as much creative ability as the work of Van Gogh, Shakespeare or Mozart.

### *Fragmentation*

Two components were mentioned in comments about its disjointed nature: firstly, the disparate nature of biology, physics and chemistry and a failure to see any commonality or unity between the subjects. Pupils found themselves 'constantly chopping and changing' between doing one thing one day and something very different the next day when they 'still haven't grasped' what they did last time. Not unnaturally, pupils found that this made science less coherent and therefore harder to understand, preferring instead the clearly identifiable separate sciences:

> *Elysha:* *Doing them together, that's harder I think.*
> *Alison:* *Doing it separately you can see how they connect as well.*
> *(GS2/119-120)*

Secondly, pupils also complained that the forced unity of the subject disadvantaged them, especially when it was examined and assessed, as those that were able at one science e.g. physics, were penalised by weaknesses or lack of interest in another, e.g. biology. Another frustration for pupils was some of the limited explanations offered by teachers to their requests for more extended explanations:

> *Natasha:* *In history, I mean, certain events, you ask why they happen, sometimes they actually backtrack to why it happened. I mean with science it's just, 'It happened, accept it, you don't need to know this until A-level'.*
> *Amy:* *Yeah, that's often the answer we get, 'You'll do that in more detail when you study the A-level', but like if you're not going to do A-level, you still want to have more of a knowledge of certain things, there's just no time.*
> *(GS5/130-131)*

Such comments suggest that the school science curriculum is failing to construct a coherent picture of the subject, its methods and its practices, leaving pupils with fragmented pieces of knowledge. This is possibly unsurprising given that philosophers and sociologists of science have failed to construct any coherent picture of the scientific enterprise themselves. However, more disturbing is the commonly used rationale that the pupils' queries can be answered at A-level. In one sense, this could be considered an act of 'bad faith' when the teacher knows that only a minority (less than 10% of the cohort (Osborne, Driver, & Simon, 1996)) continue with any one science post-16. In another sense, it is simply the result of a curriculum which has its roots in a foundationalist approach which reserves the whole picture for those who stay the course to the end, and for those only, offering the mystificatory promise of future knowledge as an enticement for recruitment. The effects of delayed gratification on the pupils' genuine curiosity and interest has a negative effect on pupils' interest leaving them lacking an essential overview of the major achievements of science.

As a counterbalance to this critique of their experience of science education, pupils were able to offer many examples of aspects of science they found that engaged their interest.

## Aspects of school science pupils found interesting

Pupils in the majority of groups engaged enthusiastically in discussions about their particular interests in science and, in responding, pupils were encouraged to adopt a long-term perspective of their science education. Some measure of the relative interest in the three sciences can be obtained by from the number of comments coded under this category for each of the separate sciences (Fig 2).

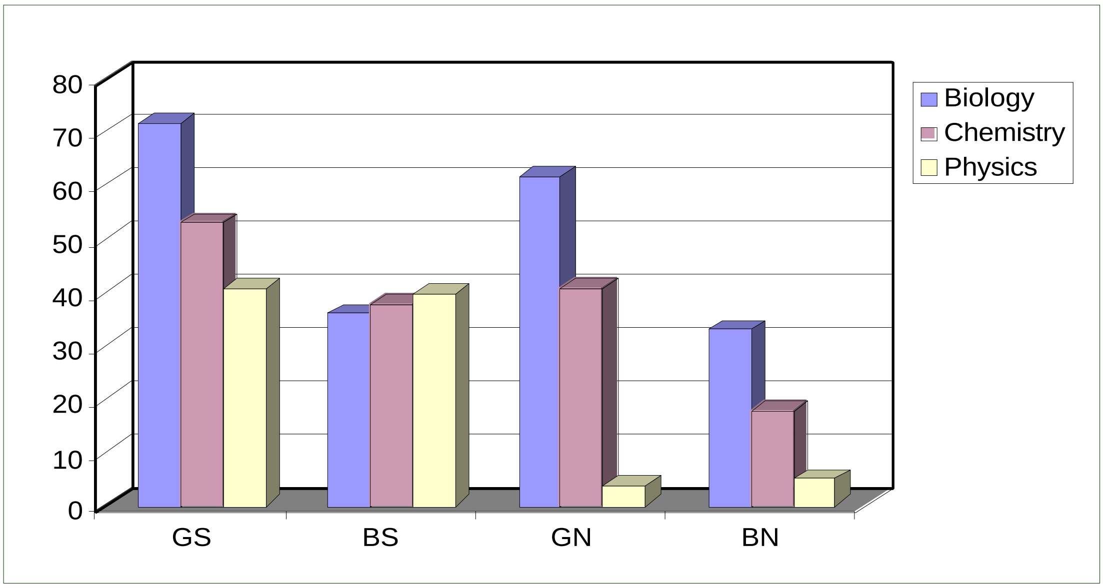


**Figure 2: Chart showing number of text units containing expressions of interest in the three sciences**

Fig 2 shows that both science, and non-science girls' groups, talked more frequently about aspects of biology that interested them, then chemistry, then physics, and that generally they had much more to say than the boys' groups. The preference shown by girls for aspects of biology confirms the findings of other research on attitudes to science (Osborne et al., 1997). The interest shown by boys in biology, however, was unexpected. However, boys in non-science groups, in particular, had difficulty recalling any aspects at all of school science they had found interesting

The distinction between the boys and girls continuing with science post-16 was that the boys talked of their interest in physics and chemistry more than biology, as might be expected. However, the profile of interest for both boys and girls *not* continuing with science was very similar, and distinct from that of those continuing with science post-16. In both groups, biology was the subject predominantly talked about, followed by chemistry with very little enthusiasm for physics. These findings also contradict the view that boys are a homogeneous group who consistently have a more positive attitude to physics than girls (Becker, 1989; Weinburgh, 1995). Whilst the levels of interest shown in chemistry by boys continuing with science was not unexpected, the number of examples offered by girls in both continuing, and non-continuing science groups, was, in the light of other research on attitudes, somewhat surprising.

***Aspects of biology found interesting***

Aspects of human biology generated the greatest number of comments and the least disagreement among girls' groups and boys' non-science groups. As the following comment shows, the attraction of human biology for pupils lay in its relevance to themselves:

> *Sana:* *The main thing is that people relate it back to themselves, like I think most people like learning about themselves, like you said – puberty and everything like that. I mean whereas electrons…* *(GS1/598)*

Pupils developed the importance of relevance further, arguing that they would like to understand the ways in which a healthy body might be achieved and maintained through diet and exercise. These aspects of biology were also of interest because they were 'more modern' (GN4/175) and contained elements of the 'unknown', for example, 'the effects of drugs' (BS3/339) and 'cures for diseases', which made school science stimulating and more relevant to the lives of pupils. An understanding of various forms of illness also interested pupils as this enabled them to offer support and informed advice to members of their family. The sense of self-esteem gained from being able to explain everyday phenomena to their peers or family was a valued aspect of scientific knowledge. Pupils' interest in contemporary aspects of human biology did not appear to extend to aspects of environmental biology, however, where little interest was expressed by any group in this aspect of science, other than it presented opportunities for work outside the laboratory. Given the positive interest in environmental matters expressed elsewhere (section 5), we would suggest that explanation of this disparity lies in the low profile environmental science has in the school science curriculum where it is rarely distinguished as separate entity.

***Aspects of chemistry found interesting***

Across the groups, the features of chemistry that generated interest among pupils were those which were concrete, observable and manipulable. Pupils talked with enthusiasm about 'mixing chemicals', the 'smells and colours' associated with chemical change, and of 'seeing the results for yourself', particularly when opportunities were presented for first hand practical involvement. The interest of continuing science groups was heightened when opportunities for autonomy were presented, such as choosing from a range of tests to be carried out, or in the selection of appropriate equipment. Pupils from all groups were stimulated by an element of danger associated with aspects of chemistry as illustrated by the following exchange:

> *Caroline:* *I was thinking about that one when you put the metal in the water and that. You know when ...*
> *Hannah* *It went on fire.*
> *Suzanne:* *Oh, yeah...*
> *Caroline:* *The alkali metals went...*
> *Asha:* *...yeah, and the magnesium, or something...*
> *Suzanne:* *Put it in water, and the reaction, it was spinning round*

*and it goes on fire, that was good (laughs).*

*Jenny:* *And, like, the first I saw, like, magnesium being lit, it was really bright...*

*Kim:* *Yeah, when that thing sparked...*

*Asha:* *And they were saying, 'Don't look, don't look', it was, like, some sort of exciting moment.* *(GS3/224-232)*

All groups of pupils recalled similar experiences, highlighting the affective aspects of chemistry that made them memorable.

***Aspects of physics found interesting***

Continuing science groups contributed the greatest number of comments on aspects of physics found interesting. Although, gender differences were apparent in the topics that engaged boys and girls, interest was rooted in the concrete and observable features of physics. Boys' interests focused on an understanding of forces in relation to cars and flight, whilst girls expressed a keener interest in aspects of light and electricity.

Despite these differences, an interest in 'space' was the one aspect of physics that united all continuing science and non- science groups. Even those pupils who claimed to have no interest in physics entered into lively discussions on this aspect of science, as one pupil explained:

*John:* *I can remember learning about space and solar system. When you're younger that's something you're fascinated with is space isn't it? As you get older the fascination wears off, but it's still there.* *(BN2/209)*

*Jessica:* *It's one topic that keeps you interested all the way through because it just moves and moves further out and you learn about the stars.* *(GN1/593)*

Pupils expressed a fascination with the Earth and the Solar System, how they were formed and, as the following comment shows, with the unexplored:

*Rajan:* *I think the most interesting things are the unknown because it's stuff that you don't really know and you want to find out about it afterwards. So, if you think there is still more to learn, the more interested you are to learn it .* *(BS3/339)*

Although aspects of the unknown intrigued several girls' groups, they related their interest more directly to themselves and the way it made them feel. For example:

*Hazel:* *..'cause you think how small you are compared to everything in space.* *(GS2/372)*

*Emma:* *Because that affects you. You look up and then you know what they [stars] are and you feel good, you think, 'I learnt that at school'.* *(GS4/375)*

Essentially, what school science offers here is a focus on fundamental, cosmological questions of who we are, what we are and where we are. Such knowledge helps us to construct versions of self, identity and our role within any cosmic order. The universal success of this topic, which is still regarded with antipathy by many secondary school teachers, should not be underestimated as a valuable 'point of engagement' with science.

## Practical Work

Without exception, pupils expressed a greater interest in work that included opportunities for experimentation and investigation. However, the reasons given for this showed differences between continuing science and non-science groups.

As the following exchange shows, the issue of personal autonomy was an important factor for continuing science groups:

*Marlon:* *...you're in control of your own experiment...*
*Justin:* *You're using your own initiative to do things really aren't you?*
*Marlon:* *Instead of being told where to put things.*
*Justin:* *You're independent really.*
*Marlon:* *You're told a baseline and then you can work from that. It just makes it a lot more interesting because you fell you're in control more.*
*Steve:* *You know your own results as well.*
*Justin:* *And your outcome is not something that's processed, you feel like you have to actually accomplish something instead of, like, doing routine.* *(BS1/382-384)*

This finding is supported by the work of Rudduck et al. (1996) who point to the fact that 'the meaningfulness of particular tasks is greater when pupils have a degree of control over the planning and execution of their work'. In the case of science, practical work provides this essential dimension offering pupils a greater sense of ownership.

Although non-science groups did not raise the issue of personal autonomy and decision making, the 'fun' element of some practical work in science was emphasised. The example most commonly given was associated with dissection. Some groups bemoaned the fact that, unlike their parents before them, they were unable to carry out the dissection themselves. They spoke with enthusiasm about opportunities to see for themselves the parts of a pig's heart, kidney and eye, as well as the function of the lungs. Such experience facilitated understanding of the way these organs worked:

*Dipak:* *Yeah, that dissecting a pig's heart. Was that in year 10? Yeah, that was quite interesting*
*Paul:* *We did a trotter. That was quite good.*

*Dipak:* *No we did a heart.*
*Simon:* *It was fun. You get to see what it looks like properly and stuff, and how it works and what the heart's used for.*
*(BN2/214-223)*

Pupils across the groups made the point that scientific concepts were more accessible and more easily retained when supported by practical involvement, even if experiments produced incorrect results:

*Sally:* *Say if you did the experiment and you got it wrong and then you came to the exam, you think, 'Oh I got this wrong because I did this, so this is what really should have happened'. It sort of makes you remember, it triggers what you did before.*
*Lucy:* *Yeah it does.*
*Anne:* *It's like something to remember other things by.*
*(GS1/277-279)*

There was widespread agreement that there were too few opportunities for pupils to engage in practical work or discussion. The point was made by a number of groups that whilst practical work had been an integral part of science in the first three years of their secondary education, fewer opportunities had been presented in year 10 and year 11. The exchange in one group illustrates a more widely expressed view:

*Sumit:* *We all get a month when we all have to do practical stuff and, like, the teacher will bring in a liver or something like that and that will be all right. But you only get that now and again and since we started year 11 I don't think many of us have done a practical yet.*
*Dean:* *I haven't done a practical yet...*
*Marlon:* *I haven't done any practicals at all, no.* *(BN3/61-67)*

For boys' non-science groups, a consequence of the decline in practical work was that subject matter became less accessible and interest waned. The watershed was said to be year 9. Prior to this science had largely held their interest and attention:

*Irfan:* *Before, when I was, like, say sitting in English, and you thought you had science next lesson, and you know you would do something good, and you know you would learn something and do something. Now with science you're sitting in English now and you think, 'Oohh no, science'.*
*(BN3/329)*

## Challenge and Stimulation

A significant factor in the generation of enthusiasm and interest in science among pupils in continuing science groups was personal challenge:

*Jake:* *It's got to be challenging, you can't have something that's really easy that you can do first time, you've got to try something and of it doesn't work then keep trying it.* *(BS1-419)*

Boys and girls in continuing science groups welcomed the challenges presented by the in-depth study of aspects of science. Boys expressed a strong desire to go beyond the basics of science, explained by the following exchange:

*Robert:* *The first time I had a GCSE book I thought, 'Wow, this is incredible'...*
*Anthony:* *Off the wall, you start going, 'Wow', because it's a GCSE book, now they just collect dust.*
*Robert:* *(laughs)...I meant….because it's more complicated compared to what we'd done in year 9 and 10, and I sort didn't understand the book, and I thought, 'I want to learn that book, I want to understand it'. But once you've done it at that level then you want to keep going deeper otherwise it just gets boring, if you keep going over the same things again.* *(BS3/281-284)*

Girls shared this desire for challenge, to 'keep going deeper', but they also expressed a desire to know *why* things happened in science (the causal question) rather than simply learning only *what* happened (the ontological question). The interest of girls in one continuing science group was stimulated by the personal satisfaction that accompanied an understanding of aspects of science:

*Phillipa:* *And I like learning, you know, when it said when you're hot and cold and all the blood went away from your skin? Whenever I get cold, you know, when you're hair sticks up, I always think, 'I know why that happens'.* *(GS4-378)*

*Layla:* *Every day there's something happening, you know, like with the comb and static electricity. ..You've done it and you're thinking, 'yeah, I know why that happens'.* *(GS1-62)*

Allied to these feelings of personal fulfilment, continuing science groups expressed the view that their level of interest was related to their level of achievement. However, this was a more important aspect for girls than for boys. Girls' discussions centred on the premise that, if they were 'good at science' and 'achieved high marks in tests', their confidence was greatly improved and the subject was of greater interest to them:

*Paramjeet:* *And finding out you're good at it as well, it gives you confidence I think so...*
*Nazim:* *Yeah, 'cause when they give you tests and you get the highest mark you can say, 'All right, I'm going to aim again and try to get a high test mark', and you start*

*learning. I think they influence you because if you think you're good at it you get the confidence and you start thinking maybe I could be a doctor or something in that field, a scientist or something.* *(GS1/142-143)*

In explaining the importance of personal achievement and confidence in science, continuing science groups rarely viewed science as a universal entity, but rather, distinguished the separate sciences. Gender differences were apparent in that boys expressed the highest levels of confidence in chemistry and girls in biology.

### Awe and Wonder

Aspects of the subject that 'amazed' or 'fascinated' were limited to those topics that had personal relevance, either to their everyday lives or those that dealt with existential questions of identity such as astronomy and cosmology:

*John* *I think finding out about the human body 'cos you are it really and there are, some things that you don't know.*
*Andrew:* *There's some amazing facts about the body.(BS4/368-369)*

However, given that it might be argued that science is *the* major cultural achievement of Western civilisation, responses that expressed awe, wonder or fascination for the subject and its achievements were not as frequent as one might have hoped. Finally, some sources of enthusiasm for science clearly lay outside the classroom, for example:

*Cheryl:* *I'm going to bring in a quotation here from one of my absolute favourite scientists, Professor Stephen Hawking...*
*Amy:* *My Gran loves him.*
*Cheryl:* *In his book, Brief History of Time, he said...*
*Alice:* *Have you read that?*
*Cheryl:* *Yes.*
*Alice:* *Okay.*
*Cheryl:* *...he said that not all theories can be proved completely, you can only disprove a theory which takes away people's faith from it, but the more you prove it to be correct it puts more faith into it. Some areas of science it can be like a matter of faith.* *(GS5:69-75)*

The last comment, in particular, shows that some pupils are capable of understanding more sophisticated ideas about the nature of science – in this case that faith in scientific theories is based not on their empirical verification but on their resistance to falsification

## Teachers and teaching

Attempts were made during the discussions to limit pupils' comments about individual teachers, as this was not a focus of the research. However, the importance of the role played by teachers in stimulating and maintaining pupils' interest in science was raised unprompted by pupils in every group, attracting the greatest number of comments from non-science groups, particularly from girls. Pupils in all groups identified approaches adopted by teachers that both appealed to them, and heightened their interest in aspects of science.

There was consensus among pupils that their interest was engaged and sustained by teachers who made lessons 'fun', either through their methods of presentation of the material, or through the organisation of work which immersed pupils in practical activities. This was particularly significant for boys' non-science groups as the following exchanges show:

> *Toby:* *I think it's the teachers that are different really, 'cause some teachers you go into, they've been doing loads of experiments, but the other ones just like doing – you sit down and they just say, 'Get on with this, do the writing'.*
>
> *Dan:* *Yeah, you've got your work set out on the board and that's your lesson really.* *(BN1/710-711)*

> *Paresh:* *Mr Bailey he's good.*
>
> *Irfan:* *Yeah, like basically in one lesson you might not do even one line on a page, or even the date.*
>
> *Craig:* *He makes it so funny.*
>
> *Paresh:* *Then he explains it, makes sure you understand it first, then you can do the writing.*
>
> *Irfan:* *Yeah, he gets it into your head. He cuts it short, but then he explains doesn't he?*
>
> *Craig:* *Then when he explains it he says it in a funny way.*
>
> *(BN3/408-414)*

The interest of pupils in continuing science groups and girls' non-science groups was raised by teachers who devoted time during lessons to the clarification of content. Pupils valued individual attention from teachers who were prepared to 'explain' and, when difficulties were experienced, were able to 'help you through it' (BS3/208).

The point was strongly emphasised by pupils that teachers who provided opportunities for them to take an active role in their own learning enhanced their enthusiasm for aspects of science. They appreciated teachers who were willing to engage in 'discussions' and who 'allow you to contribute' (GS4/677).

Girls in continuing science groups highlighted the importance of building a rapport or relationship between pupils and teachers that developed through opportunities to raise questions and discuss aspects of science. Several girls commented on the value of humour during science lessons:

| | |
|---|---|
| *Elysha:* | *With Mr. Forman we ask questions, like, have a good laugh with him, but we do our lesson as well.* |
| *Angela:* | *It's good when teachers can have a laugh with you, 'cause you're learning at the same time as you're having laugh.* |
| *Fatima* | *You get on with them.* |
| *Basra:* | *They treat us more like adults don't they, like students?* |
| *Fatima:* | *You get more respect from them.* (GS2/243-247) |

Boys in one continuing science group made a similar point, but their focus was upon the creation of a 'relaxed environment' (BS2/582) in science lessons which made them more enjoyable and increased pupils' motivation. The point was made that 'when teachers realise that then I think it will all be all right' (BS2/587).

Many of these comments simply reinforce the findings of work found elsewhere on effective teaching that children like teachers who maintain order, make learning interesting through the use of a range and diversity of activities, and sustain an atmosphere of mutual 'good humour' (Cooper & McIntyre, 1996). Humour was valued simply because it helped to sustain a happy atmosphere in the classroom that was conducive to learning. Within these comments also, can be found an evaluation of the teacher's role in their success with the subject – an aspect that increasingly dominated children's thinking as public examinations loom into view. Teachers who simply relied on 'writing on the board' and textbooks were viewed as weaker than those who offered an opportunity to 'do the experiment' and 'to talk about the bits you don't understand in the experiments' which provided a 'better opportunity for learning'.

#### *Differences in responses from North/South groups*

There were few differences in the range of issues raised in this section of the discussion by pupils in groups from the North of the country and those in the South. One notable exception was the significant link made by girls in continuing science groups in the North between their interest in science and their career aspirations:

| | |
|---|---|
| *Alison:* | *...it's because I enjoy it and because I want to become a paramedic as well, in medicine, so I'm interested in it and I want to learn more about it because of what I want to be.* (GS2/426) |

Such links were not made by groups from other areas apart from one boys' continuing science group in the North, where clear career intentions within the fields of medicine and aviation were expressed by some boys.

# four

## Aspects of science found interesting in everyday life

Pupils' interest in the science outside school, what might be termed the science of everyday life, was explored by posing the statement to them that: *the science I read about in the newspaper and see on TV is of no great interest to people of my age.* In response, the pupils expressed a high level of interest in such science. And, although pupils in continuing science groups provided a greater number of examples, even the majority of non-science groups offered an enthusiastic response to the statement. Areas of interest were common amongst pupils across all groups. There were, however, significant gender differences in the science pupils watched on the television, read in newspapers and magazines, and talked about with friends and family.

A number of boys' groups, and two girls' groups, expressed a keen interest in aspects environmental science, predominantly the causes and effects of environmental pollution. This interest was surprising in view of their lack of interest in aspects of environmental science within the school curriculum. A small number of pupils discussed the greenhouse effect, making the point that it 'might actually happen in a few years if we're not careful' (GS4/705), and would have a serious impact on their future lives:

> *Megan:* *Well, the ice cap thing, where they're all melting down.*
> *Jane:* *It's important, like if it carries on doing that, there might be no England left.* *(GN1/597-600)*

Equal concern was expressed by pupils living in the North and South of the country about the growing number of cars, and their effects on the environment. As one group explained:

> *Leah:* *Cause when you think about it, when you think about the number of cars and stuff, you think, in a couple of years it could be, like flooded or something. It makes you think twice when you get in a car.*
> *Shelly:* *Like when you go to get petrol for the car or something, my mum makes a point of getting a particular kind of petrol because she says it's for our grandchildren and their grandchildren and you have to, you know, live on this earth and things like that.* *(GS4/712-13)*

Boys in one non-science group highlighted the role of science in tackling the problems of pollution associated with cars:

| | |
|---|---|
| *Glen:* | *The only science thing recently I've read in the paper is that new models of cars are using scientific knowledge to learn about petrol cars and pollution, making other cars more, like environmentally friendly.* |
| *Barry:* | *Yeah, 'cause if they can do that to most of the cars then I think more people would change, 'cause they know they'll be saving the planet.* *(BN1/658-59)* |

Other boys' groups discussed the pollution of areas of the sea caused by the recent sinking of oil tankers off the coast, which had serious implications for wildlife. One continuing science group was worried about the possible pollution of the domestic water supply:

| | |
|---|---|
| *Matthew:* | *...all the fertilisers and how it affects us. Like in the water, nitrogen could affect us and all that. We need to know. Basically most of us would like reading about such things, not things that have been discovered many, many years ago* *(BS5/318)* |

Boys' continuing science groups also showed some concern about reliance on fossil fuels and the consequent depletion of energy resources. Consequently, they were interested in developments in the use of solar energy as an alternative.

All groups mentioned an interest in events and disasters around the world that had an impact on the environment, including storms, hurricanes, tornadoes, earthquakes, and erupting volcanoes. These were seen to be increasingly common events and were exciting, fascinating and a cause for concern. Moreover, environmental issues, incidents and disasters were current and had a relevance to their lives which was immediately apparent:

| | |
|---|---|
| *Rajan:* | *It's because it's the present and it's...* |
| *Brenden:* | *Because it's now and it's happening, it's not just theory, it's happening….* |
| *Rajan:* | *...it's not A=B, it's things that are relevant to our lives, not like the Blast Furnace.* *(BS3/688-89)* |

A further area of common interest across groups, raised spontaneously, was genetic engineering and cloning. Discussions about the latter showed that, on one level pupils were interested because it was 'new, things that are being discovered that have never been thought of before' (BS3/705). It was also a source of fascination – 'this really weird thing about a mouse with an ear on it' (GS4/648) and it was 'important to know about' (GS1/682). On another level, pupils maintained that the implications of cloning were 'frightening', 'scary' and 'terrifying frankly'. It was seen to be the kind of science that 'they've always done in science fiction films, but now it's not fiction anymore' (BS2/5513). Although there was agreement that it was a 'step into the future' (GN2/807), the questions of whether it was 'a step we want' (GN2/806), or 'is it right that we should tamper with it?' (GS1/679), were posed and led to discussions of ethical issues.

The issue of BSE and CJD was raised by three girls' non-science groups and highlighted a further aspect of science in society which gave rise to pupils' concerns about their personal health. It was an issue found to be both 'interesting and frightening' (GN4/1104). They had 'heard about teenagers who are dying from eating hamburgers' (GN2/816) and this was a cause of great concern because 'it relates to us' (GN4/1104) and 'it could happen to me' (GN4/1112). However, pupils' ideas and views about such issues as genetic engineering and BSE were not informed by their learning in school science:

> *Giles:* *It's like, you don't learn this stuff from school, you learn it from home by reading and all that. Teachers won't go into cloning and how they do it. So if you're watching a programme and they start on cloning, you say, 'oh yeah, I remember that I read that in a book.* *(BS3/726)*

Many of these interests and concerns show that pupils, like everyone else, are not separated from the present discourse in society which sees scientific advances as a source of risk, threat and danger *as well as* a source of solutions. The view was expressed that it would be twenty or thirty years before such issues permeated the curriculum suggesting that pupils saw school science as concerned with the past rather than the present. This would suggest that science education has yet to adapt to the changed nature of the context in which it sits and recognise that the exclusion of contemporary science, and the associated dilemmas it raises, is damaging its own self-interest.

A consequence of this failure of school science to address important socio-scientific issues was that the principal source of information for pupils was television programmes and the occasional newspaper articles. This was an issue of some concern for a number of the parents interviewed in the other component of this study (see section 3). Parents felt that socio-scientific issues and scientific research were often sensationalised by the media and looked to school science to provide better, more balanced information.

Girls once again confirmed their interest in human biology, highlighting an interest in documentaries about the human body and programmes and articles that focused on advances in medical science. The issues that attracted their interest were those that were seen to be relevant to themselves and their lives. A number of programmes and newspaper articles were simply of intrinsic interest, for example, how the body works and reproduction. Others programmes that engaged them were aspects of medical science that directly affected their lives, and were of considerable concern, such as the growing incidence of meningitis amongst young people, and the causes and treatment of anorexia. Broader aspects of medical advances were also of interest to girls, and to a lesser extent boys' continuing science groups. Pupils discussed such issues as organ transplants, the ways in which diseases are transmitted and spread, cures for diseases, 'using gamma rays which are potentially lethal to cure cancer' (BS4/634), and advances in the development of drugs to treat a range of diseases and disorders. The latter were said to be both 'reassuring' and 'exciting' as 'we'll live forever if they keep discovering new drugs' (GS3/510).

***Chemical and biological science***

A number of boys' groups showed a keen interest in chemical science related to bombs and weapons of war. Particular interest was shown in the manufacture and deployment of weapons of mass destruction around the world, which were seen as a potential threat to pupils themselves, 'a bomb could destroy the world... exterminate the human race' (BN5/603). Concern was also expressed about the threat of biological warfare, again seen to have a possible impact on the future lives of pupils.

***Space exploration***

Boys reaffirmed a lively interest in space, though girls offered few comments to support their expressed interest in this aspect of science. The appeal for boys in aspects of space was in the representation of science as 'modern', 'forward-looking' and exciting – 'things that don't have answers to them' (BS5/309) and aspects of science that 'you won't learn about in physics' (BN2/424). They talked enthusiastically about 'finding water of the moon' and 'sending a buggy to Mars', as well as the real possibility of 'visiting other planets' in the future and, as the following comments show, space exploration typified technical advances that science offered for their future:

> *Darren:* *A hundred years ago you'd probably have been thrown in a mad house for saying someone would be on the Moon.*
> *Mundeep:* *Yeah, and they're saying, like in thirty years you could have a holiday on space, like that's amazing.*
> *Simon:* *Science dictates your future really. Whatever happens in science is going to affect you personally, so you'll be interested in it.* *(BS4/616-21)*

Pupils across the groups maintained that television programmes, newspapers and magazines made these aspects of scientific research accessible, through the use of visual images and content presented 'in an interesting way', with a degree of detail, but 'not boring detail, not too complex'.

# five

## Pupils' views on the ways in which school science is useful in everyday life

There was widespread agreement that some aspects of school science were useful to pupils in their everyday lives. There were, however, only limited examples provided by pupils across all the groups. Even continuing science groups, who had earlier asserted that science 'is everywhere' and is 'in everything', were somewhat hesitant in their responses. Although pupils' relatively restricted life-experiences may be expected to constrain the range of examples articulated, the paucity across the groups possibly exposes a failure to link the content of school science to pupils' everyday lives. In this part of the discussion, there were also significant differences of opinion between groups about the degree to which school science was useful,

Perhaps unsurprisingly, it was aspects of human biology that were perceived to be of the greatest personal use to pupils outside school and produced the greatest number of comments. A number of boys in non-science groups pointed to an interest in sport and the value of a knowledge of the body when 'warming up' prior to physical activity to prevent injuries. However, this point was challenged in one group by the argument that, although aspects of human biology might be relevant, teachers did not elucidate connections during science lessons.

Pupils in the majority of groups found it particularly difficult to recall specific examples of aspects of science used around the home, for hobbies, or in conversations with friends and family. Reasons offered by a number of continuing science groups suggested that pupils used their knowledge of science unconsciously:

> *Sudhir:* *My dad was going to paint the garage and he couldn't open the can of paint, so I levered it. So you do use it – even if you don't really know you're using it.* *(BS3/507)*

Discussion of the everyday usefulness of science generated significantly fewer comments from girls and, where examples were provided, notable gender differences were apparent. Boys' groups highlighted the use of aspects of physics, with particular reference to *electricity*. Examples articulated by boys in non-science groups were almost entirely restricted to this area of science. Whilst boys in continuing science groups also showed a preoccupation with *electricity*, discussion was extended to include *leverage principles* in 'opening tins', 'removing nuts on wheels' and in the removal of the inner tube from a bicycle tyre. Aspects of physics associated with fixing cars and bicycles including an understanding of *gears*, *brakes* and *acceleration* engaged the majority of boys' continuing science groups. These aspects of physics were notable for their virtual absence from discussions within girls' groups. The predominant theme across these groups was the use of chemistry for cooking, including the boiling of water, mixing ingredients to the desirable 'consistency' and ‘concentration’ to achieve optimum results in food preparation, and irreversible change in baking bread. Two groups raised aspects of biology related to food safety:

> *Amra:* *And food, I never put raw food and cooked food together. You could be dead couldn’t you?*
> *Darvinder:* *Did we learn that in school?*
> *Lucy:* *No*
> *Amra:* *Yes we did, cooked meat and raw meat, we watched a video.* *(GS4/568-72)*

The lack of certainty about whether examples provided were learnt in school science, reflected in the exchange quoted above, was a recurring feature in discussions across the groups. Challenges were offered to a number of the applications of school science suggested, the main thrust of the argument being that many aspects of science found useful in everyday life amounted to little more than ‘common sense’:

> *Claire:* *Cooking? We don’t do cooking in science.*
> *Sheeba:* *No we - hang on, we do metal conducting heat.*
> *Stella:* *Yeah, that’s to do with cooking.*
> *Sheeba:* *You learn not to touch something hot.*
> *Claire:* *But that’s the simpler form of science, it’s more common sense than...*
> *Aisha:* *That’s basic, basic knowledge.*
> *Claire* *...it’s just basic knowledge we would learn anyway. If a pan is made of metal and the handle is hot, you’re going to learn that the handle’s do get hot when you heat it up, I mean it’s common sense.* *(GN2/724-730)*

A small number of pupils across the groups shared the perception that common sense science and basic scientific knowledge were synonymous. A significant number of pupils, however, did draw a distinction, the consensus being that common sense science was gained principally through experiences outside school and from parents:

> *Shireen:* *It tends to be common sense that’s been drilled into you by your mum telling you not to leave the milk out of the ‘fridge.* *(GN1/488)*

> *Megan:* *It’s also common sense when you’ve got a headache you’re not going to take something to settle your stomach.* *(GN1/499)*

In contrast to this, basic scientific knowledge was associated with school science learnt prior to year 10:

> *Aisha:* *...we’ve learnt the basic knowledge of science, I mean how electricity is dangerous and what conducts electricity, what conducts heat and they do help us in our everyday life. But then we go into such detail, that’s when we start going away from what’s useful.* *(GN2/753)*

A small number of continuing science groups, whilst acknowledging that many aspects of science in everyday life utilised basic scientific knowledge, suggested that the value of school science lay in understanding *why* things worked or happened as opposed to simply knowing *what* actions to perform:

> *Mark:* *...science is really good 'cause you know why it does something, you don't sit there and think,. 'well if I put this together we make a cake'. It's not 'we make a cake', it's 'we make a cake because...' And I think one of the best things about science is the because.* *(BS3/504)*

However, such arguments were challenged in a number of continuing science groups on the grounds that it was not necessary to comprehend the underlying principles of science for much of everyday life:

> *Wayne:* *...you will always use a lot of scientific principles when doing something, but you don't really need to know why that is so to do most things, such as my Martial Arts. I use leverage principles for locks, but I don't need to know why leverage principles work to do a lock.* *(BS4/527)*

One of the features of modern contemporary society is that increasingly sophisticated technology reduces the knowledge required by the user to a minimum. Whilst simultaneously, in the event of its failure, its remediation becomes increasingly dependent on an expertise that no basic science education can provide. The instrumental value of science – an example of which is found in the last statement – then becomes questionable. However, what the pupil above fails to recognise is that an understanding of leverage principles may result in the ability to perform even better locks and that scientific knowledge can inform decision-making and action. For instance, that doubling one's speed quadruples the breaking distance; or that the use of anti-biotic cleaners simply leads to more powerful resistant germs.

Scientific knowledge was also valued by pupils for its contribution to their conception of themselves as educated individuals. This point was made predominantly by girls and boys in continuing science groups. These pupils maintained that the value of scientific knowledge lay more in the augmentation of their general knowledge than in direct application in everyday life:

> *Tony:* *I think it all, like adds up to part of your general knowledge, but you never use a lot in practice. Like molecules and photosynthesis, you know it and it's, you know, part of your information that you know, but you won't use it really.* *(BN5/491)*

Continuing science groups more readily articulated examples of aspects of science that they described as 'good to know'. These supported their understanding of science-related issues affecting their lives and enabled them to engage confidently in informed discussion with family and friends:

| | |
|---|---|
| *Kelvin:* | *I just think it helps you to understand more things that are going on around you. Because people may say, 'oh don't cut down the rain forests because it's making oxygen', and ….if you hadn't done biology then you wouldn't know why you need the trees would you?* |
| *Trevor:* | *You wouldn't know why you needed oxygen either.* |
| *Kelvin:* | *Yeah things like that. And pollution is damaging the atmosphere and acid rain, unless you have actually done it in science, so it just helps you to understand what's happening in the world. (BS2/ 425-429)* |

| | |
|---|---|
| *Jenny:* | *There's some things where I will sit there and if I see a firework, say three miles away and you'll see the flash and then you count 1, 2, 3, then you hear the bang; sometimes I'll think, 'that's three miles away because it's three seconds before I heard the bang'. (GS3/361)* |

The value of human biology in informing decisions about their lifestyle engaged a significant number of girls' groups, particularly the importance of science education. Whilst one boy raised the topic, somewhat nervously, it was not pursued by the group. One concern, expressed by girls non-science groups, was that individuals may not receive relevant information from home and therefore it was vital that it was included in science:

| | |
|---|---|
| *Jaymisha:* | *Like sex education, you don't really learn it from your parents, you learn it from somewhere, and school science is the best place.* |
| *Kirsty:* | *If it wasn't for reproduction in science then you would never know. And you might just one day have sex and then the next thing you know you have a baby. (GN3/496-97)* |

One girls' continuing science group raised the importance of the inclusion of issues related to safe sex in science, and how science enabled them to understand how some of the danger could be avoided.

Work associated with aspects of nutrition and diet was particularly relevant to girls in continuing science groups who explained how a knowledge of nutrition had led to an improvement in their dietary choices. The value of work associated with smoking, drugs and alcohol awareness was mentioned briefly by a number of boys, but was significantly more important for girls:

| | |
|---|---|
| *Anna:* | *When you see that doll with all that black tar, you know that...* |
| *Nima:* | *If you smoke cigarettes ten minutes of your life goes with a single cigarette.* |
| *Kim:* | *You think 'I don't want that to happen to me'. (GS3/375-77)* |

The point was made that, though useful, work associated with smoking, drugs and alcohol was covered too late in school science as, by the time the topic was introduced, many had already been 'smoking for years' (GS4/552). In addition, the view was expressed that these issues were covered only superficially in school science, making an informed decision problematic as pupils were not given enough detail about the effects or the nature of the risks.

Pupils across the groups found this discussion challenging and thought provoking. However, difficulties experienced in recalling examples and, in a number of cases, the need to defend those articulated helped some pupils to consider more carefully, and more reflectively, the uses of science. The outcome was summarised concisely by one pupil:

> *Amanda:* *I don't know, after all this talk I sort of realise now that you don't have to, like, lump everything together. I don't think it is all going to be useful, but I think you have to understand it.* *(GN4/952)*

# six

## Pupils' views of aspects of school science which were not useful in everyday life

Not surprisingly, the aspects of science that were articulated as least useful in everyday life by all pupils were those for which no direct application could be envisaged. In this respect, it was aspects of chemistry and physics that generated the greatest number of comments and the least disagreement among pupils. All groups entered into lively debate during this discussion and examples provided by one pupil were often challenged by another. These interactions were particularly notable in continuing science groups where pupils defended and justified the use and value of aspects of the area(s) of science they intended to study at A level.

*Chemistry:* Pupils made a large number of comments about aspects of chemistry for which no useful purpose was envisaged. Once again, the connection between relevance and interest emerged as pupils found it difficult to see how a knowledge of 'atoms and particles' or industrial processes such as crude oil distillation was relevant to their everyday life as they were 'never going to separate crude oil' (GS3/414).

> *Tom:* *How many carbon atoms are in something doesn't bother you. You don't walk down the street and think, 'I wonder how many carbon atoms are in that car', or whatever, it just doesn't happen.* *(BN4/250)*

*Physics:* Many more comments were made by girls, who perceived little use for aspects of physics including:– forces; potential and kinetic energy, friction; electrons and protons; coulombs of electricity; and electromagnetic fields and transformers. Pupils argued that early work in physics, such as electrical circuits, was of greater use in their lives, but that it was 'taken too far' and the relevance to pupils' lives was lost:

> *Nazmin:* *We're never going to walk around with a voltmeter...we don't need to know that.* *(GS1/608)*

*Biology:* Few examples were discussed of aspects of biology that were not useful in pupils' lives. The principal comments were made by girls' non-science groups who complained that aspects of human biology did not 'go far enough' to be of real use or value in their lives, for example, in dealing with the issue of drugs and smoking. No mention was made of aspects of biology lacking a sense of everyday usefulness by continuing science groups. Boys' non-science groups, however, had problems in identifying the salience of studying photosynthesis and the cells of plants and animals.

A recurring theme, throughout the continuing science groups, was that the relevance of science was identified with its instrumental value – that school science 'doesn't seem to be for yourself, it's for the exam' (BS4/310), or alternatively, a future career.

And that essentially much of the knowledge would be forgotten, as it would have little value for their future lives:

> *Layla:* *The only time it's useful is when it's for the exams, and then after that you're never going to hear about the thing again.* *(GS1/609)*

These findings in this section and elsewhere raise a number of issues. First, there is the irony that a subject which poses, in the words of a recent editorial in the *Independent* (2.1.99), 'the political and moral dilemmas of the next decade', too often fails to communicate its relevance to young people. Second, it would appear that the existing curriculum, and the existing approach to the teaching of science, are failing to convey a strong impression that scientific knowledge is of intrinsic interest – as much a part of our culture as the aphorisms of Shakespeare, the poetry of Blake, or the novels of Jane Austin. Finally, for a subject that is so strongly interwoven with technology, current examples of the connective threads either have little self-evident relevance for contemporary youth, or are not sufficiently foregrounded. This is not to argue that relevance for young people should be either the sole, or major determinant of the content of a curriculum. Rather, what these data convey is that the value of a subject, for young people, lies in its perceived relevance. Currently, it would suggest that the existing curriculum too strongly reflects the scientist's worldview concerned with basic concepts rather than utility, capability rather than critical reflection, and the privileging of science over technology. The consequence is an opening of a gulf between science and its future citizens. Neither is this comment new. Initiatives such as the ASE's *SATIS (Science and Technology in Society)* and *Salters Science* were both a product of a similar perception in the 1980s. Research would suggest that their uptake has been at best patchy (Watts & McGrath, 1998) and, coupled with the findings presented here, suggests that the national curriculum may have simply perpetuated a form of science which may only appeal to a minority.

# seven

## Changes to the school science curriculum

Pupils' ideas about future change in the school science curriculum were elicited by asking for their response to the statement: '*If I had a free hand to decide what young people learnt in school science, I would not change anything'*. Pupils adopted a positive perspective in their contemplation of school science and any proposed changes, and all groups contributed with enthusiasm to the discussions.

***Changes pupils would make in the content of the school science curriculum***

Not surprisingly, many comments called for significant changes. Boys in one non-science group made the point that if they were to be persuaded to continue their studies in science it would need to offer 'something that inspires you' (BN4/210). Behind this lay a concern that school science was essentially retrospective rather then offering 'something new and exciting'. As one boy commented:

> *Marcus:* *...it's not supposed to be like that, it's supposed to be going towards the future isn't it?* *(BS3/235)*

This point was shared by girls' groups who commented that school science needed to acquaint pupils with 'what's going on now in science and how it matters to us' (GN2/893). However, a more balanced perspective, advanced by girls in continuing science groups with no opposition, was that whilst the 'old stuff' had its place on the curriculum, there was a need for it to be 'updated with new ideas' (GS3/544).

The consensus within and between groups was, therefore, that changes were needed in the content of school science. However, there were significant gender differences in the components of school science where change was needed. In these discussions, girls focused on human biology, whilst boys' non-science groups offered examples related to chemistry and physics. Girls in non-science groups called for extensions to aspects of science that were of direct relevance to their lives, for example, health issues that were of concern including anorexia, drug and alcohol awareness and sex education.

Although girls in continuing science groups also wanted to learn more about themselves, 'little things like why you hiccough' (GS1/335), and 'the body system' (GS2/277), their emphasis was upon more study of advances in medical science which were not included in school science. For instance, one commented that 'we don't learn anything about diseases' (GS4/358) such as 'AIDS and things like cancer' (GS2/402), yet these were perceived to be crucial to an understanding of themselves and the maintenance of their physical well being.

Girls in one continuing science group, who claimed that more aspects of medical science in school science might heighten pupils' awareness of careers in this field, raised the need for schools to make more effort to market science. Consequently, more pupils might be become interested in being nurses or doctors.

Discussion amongst boys' non-science groups was equally constructive, though different aspects of science were perceived to be relevant to their lives. One group highlighted the need for the study of nuclear fission and fusion to be included, seen, not unnaturally, to be relevant to the present day:

> *Tony:* *I mean nuclear fission can end the world in an atom bomb, but she didn't even talk about or mention that and, like that's a very topical issue right now. And whether we can harness nuclear fusion power, because then our power problem would be solved* *(BN5/299)*

Whilst the curriculum does contain elements of radioactivity, the peculiar omission from the curriculum of these two important physical processes is extraordinary.

Boys in other non-science groups expressed the view that the study of the way things work in physics had little relevance to their lives. Instead, they simply need to know 'how to use it' and 'to recognise what information it's giving us' (BN4/222). Again, it was felt that too many of the applications studied failed to reflect advances in contemporary science.

A significant number of pupils in non-science groups, and boys in continuing science groups, identified the study of *Earth and Space* in physics as an example of one aspect of school science which required updating and extending, not only to reflect recent advances, but also to capture some of the excitement and wonder that they associated with the subject. Dissatisfaction with this topic was that it was often not developed beyond the superficial introduction provided in year 7. Gender differences were apparent in their views about extending the study of this topic. Girls exhibited a sense of wonder and fascination with aspects of space:

> *Basra:* *Stars. I like to learn more about stars.*
>
> *Elysha:* *Yes, the constellations, 'cause my dad learnt all that in Switzerland and he knows, like all the serious stars and everything and I wish I knew that because that's fascinating.*
>
> *Mary:* *And it's knowledge you'll take with you outside school, that you're going to use. You're going to be all lonely one night, all upset and you look at the stars and you think, 'Oh yeah I learnt that one when I was at school, that's the Big Bear'*
>
> *Fatima:* *Yeah, there's the Bear and it's, like one day it's something you can teach your children.*
>
> *Mary:* *Yeah, that's what I was going to say. It sounds corny but you can sit there with your kids and tell about it.*
>
> *(GN3/430-441)*

Boys in non-science groups offered a somewhat less romantic view of this topic. Nonetheless, they were no less enthusiastic in calling for its extension. Their discussions focused, rather, on space travel – for instance, on the possibility that 'we might be able to go to some other places in the solar system' (BN2/159) or that 'we're probably going to be out there in the future...living on Mars or something' (BN4/145).

***Contemporary science***

There was agreement across all groups that school science was outdated, 'it's like we're always falling back on the past' (BS3/235), and 'it's about old stuff'(GN2/896). It failed to reflect contemporary issues in society, 'what's happening now' (BN5/301), 'modern advances in science' (BN5/525) and 'things on the news everyday' (GS3/550). It had little relevance to 'ourselves and our lives' (GN2/647), there was too little in school science that 'you use in your life' (BN4/217). If, it was said, the subject had more relevance to young people 'more people would do it after GCSE' (GN4/1288).

In contrast, pupils perceived other subjects to 'change all the time' (BN5/229). The failure of school science to provide any opportunity to educate them about events that permeated their daily life was commented on by several of the groups:

> *Paul:* *I like new inventions.*
> *Rishi:* *Yeah, and finding more things in the solar system. They've discovered this new planet, or something like that, outside the solar system.*
> *Edward:* *You won't learn about that in physics will we?*
> *Deepam:* *That's what I mean. The only way we'll learn about things like that is on the TV or in the newspaper.*
> *John:* *Yeah, we don't learn about that stuff in school, the latest stuff that's happening.* *(BN2/418-425)*

> *Leena:* *I think in science if they taught us things that we know like you're going to get a job in, I mean, genetic engineering, I might think that Suzanne, in a couple of years, she might get a degree and become a genetic engineer. But we never get taught this, so she never gets inspired by it. And, like becoming an astronaut, we never do anything about it.* *(GS5/121)*

However, there was not universal approbation for such a position as the comment was made that this was a problem for other subjects as well. However, for a subject that uses its relevance to everyday life and the understanding of technology as one of its principal *raison d'être*, the growing disjuncture between science-as-it-is-taught and science-as-it-is-reported in the media must be a matter for concern. Too often the sentiment expressed was that the connections to technology were simply not made, and that there was a failure to relate school science to everyday life. Contemporary social contexts provide another vital 'point of engagement' for pupils endowing the subject with that essential quality – relevance. Thus, if science education does not take the small step from science to its applications, how can it take the much larger step to the considering the implications of the work of scientists and technologists?

In summary, these comments reveal a desire for a science curriculum that presents a more contemporary face to its pupils – one that offers them more of the topics that they perceive to be relevant to their lives at the end of the 20th century with the inclusion of more current exemplars of applications drawn from medical science and the study of astronomy and space travel. For too many, it would seem, the changes in modern society have simply passed the science curriculum by.

***Changes in the organisation of school science***

Many comments were made about the way school science was organised. This was an aspect of the discussion that engaged non-science groups and boys in continuing science groups. Pupils felt that there was a lack of continuity in school science between Key Stage 3 and Key Stage 4 as the curriculum content was unevenly spread. The result was excessive curriculum content in year 10 and year 11. Even within Key Stage 4, a number of girls made the point that in year 10 they had, 'spent a lot of time going over just a single topic' (GN3/224), and for that reason 'it's all bunched up together now, it's really hard to get the work done' (GN3/224). The result was that things were often explained too quickly without time to assimilate what were difficult or unfamiliar concepts. However, this experience was in direct contrast to other aspects of science that were repeated, with little apparent progression through Key Stage 3 and Key Stage 4. Examples provided were *electricity*, *photosynthesis* and *electrolysis*, which were seen to be 'wasting our time' (BN3/198). Pupils therefore wanted more thought to be given to eliminating repetition and spreading the learning demands more evenly across the five years of secondary school.

***Change in methods and styles of teaching in science***

All groups entered into lively discussion about methods of teaching in science. Although they appreciated that changes needed to be made in the content and organisation of the science curriculum, they were united in the view that teachers had it in their gift to make the existing science curriculum more compelling and stimulating. The comments made by one group captured a widely held view among pupils:

> *Ben:* *No matter what the subject is, if you've got a good teacher it is possible to make it, not very interesting, but more interesting.*
> *Tione:* *… in biology, even though plants aren't great, our teacher is really good, so we're doing better in biology.*
> *Laurie:* *Yeah, we're doing better in biology definitely.*
> *Tione:* *It's got to be taught as opposed to written down and copied.* *(BN5/659-681)*

Girls continuing science groups made the greatest number of recommendations for change about the approach to teaching used in school science. This view was shared by boys in two non-science groups, who maintained that they would 'probably change the method of teaching more than the actual work involved' (BN2/131). These boys expressed the view that the importance of school science was that it 'helps you to think in a logical way sometimes' (BN4/95), however, they went on to say that too much of it was taught in 'a boring way' with 'no enthusiasm'.

Essentially an approach of 'here's a textbook, there's the sheet, off you go and do it' that generated little positive response from the pupils.

Rudduck (1996) suggests that the important concept that describes children's relationships with 'good' teachers is one of 'trust'. Trust, as such, is something that is developed over a period of time and 'is embedded in a willingness of teachers to listen to pupils and respond to their learning needs'. In the latter stages of their secondary school education, children also become more goal orientated and dependent on teachers to develop the knowledge and understanding needed for information, assessment, support and guidance. A change, then, that would possibly most benefit the teaching of science in Key Stage 4 would be the widespread adoption of the Latin motto, *festina lente* (hurry slowly) – remembering that opportunities to engage in discussion and extended talk about the topic at hand not only helps pupil learning, but also raises their engagement and involvement. These issues emerged again in pupils' comments on the changes that were needed to make science more engaging.

### *Engagement with science*

Girls in non-science groups recommended a reduction in curriculum content for science to facilitate the integration of more practical work. All groups had maintained earlier in the discussions that practical work would not only make science more interesting but would improve their understanding. The latter point, reinforced in the discussion here, was raised by non-science groups and by boys in continuing science groups, who both appealed for more practical work to make content more accessible, particularly in physics:

> *Patrick:* *In physics we do the least amount of experiments.*
> *Kelvin* *Yeah, it's mostly writing in physics. (BS2/195-198)*

Boys' groups appealed for increased opportunities for active involvement in practical work, to undertake experiments for themselves in preference to observing teacher demonstrations:

> *Amish:* *More dissecting things*
> *Tione:* *Yeah, I'd like to do that.* *(BN5/311-13)*

Although personal involvement was a matter of some importance to boys in continuing science groups, they did not simply want to see an increase in opportunities to undertake in practical work, but fundamental changes in the way such work was organised, offering greater personal autonomy:

> *Sudhir:* *I'd like it to be less structured, you find out more things for yourself than the teachers telling you that this is what happens. And sometimes you have to accept it instead of them telling you why.* *(BS4/195)*

Boys in continuing science groups also called for a problem-solving approach to the teaching and learning of science, making the case for more open investigations in science where the teacher would 'pose a very general question and get the pupils to investigate into it' (BS4/225). This would be introduced to counteract what boy's science groups saw as the confirmatory nature of much investigatory work in science where:

| | |
|---|---|
| *Trevor:* | *Usually you get told what practical to do and then you get to do your practical but then...* |
| *Gordon:* | *You get told to set it all out in your book and things like that.* |
| *Trevor:* | *...and usually you'll see what's going to happen before you've actually done it yourself...* |
| *Gordon:* | *'Cause the teacher shows you first. (BS2/88-93)* |

One boys' continuing science group expressed the view that practical work was undervalued as an indication of pupils' learning in science and that more assessment of pupils' ability could be based on their practical competencies as 'too much emphasis is put on the exam' (BS4/297).

Although girls did mention a need for more practical work, their emphasis, rather, was on increased opportunities to engage in discussions in school science:

| | |
|---|---|
| *Leah:* | *I would like to see more discussion actually in the classroom, because I don't actually enjoy practicals that much...* |
| *Naomi:* | *Yeah.* |
| *Leah:* | *And you sometimes fall asleep.* |
| *Hayley:* | *That's what it is, because there's no, like, debating in science, no discussions. (GN4/661-670)* |

Discussion and debates were the key to making science more 'enjoyable', particularly for less committed peers who could 'find out how interesting it really is' (GS4/696). For two boys non-science groups the need for increased opportunities for class discussion was linked with requests for a significant reduction in worksheets arguing that they benefited 'more from class discussion than the sheets' (BN4/319) as:

| | |
|---|---|
| *Laurie:* | *If you discuss, say a topic, I think you take it into your brain quicker than if you just copy it down once.(BN5/270)* |

One girls' continuing science group shared this view. Girls in one non-science group recommended 'the use of visual aids including models, more demonstrations, that kind of thing' (GN2/559) to reduce what they saw to be the excessive, writing and copying notes from the board and textbooks. In addition, they called for the teaching of science through 'little stories' (GN2/557) which focused on the human side of scientific discoveries:

| | |
|---|---|
| *Elaine:* | *It would make me enjoy it more if we had to know about people for our exam, if the teachers brought the people into it you'd think.* |
| *Claire:* | *Yeah, science would be...you'd remember it.* |
| *Elaine* | *'Cos when they say, 'Oh this person ages ago did this', you'd think, 'Wow, that's so amazing, they knew that so* |

*long ago', or whatever, and it makes you think, 'Wow, it's a lot more interesting.* *(GN2/196-198)*

Girls in continuing groups shared too this desire for school science to focus on the scientists as well as the discoveries and the advances that they had made:

*Amila:* *What I've always wanted to ask is, why did all these scientists that came up with all these laws, why did they come about? Did they just wake up one day and think 'oh I think I'll find a new law today', or did they decide to do that?* *(GS5/510)*

The example given by one girls' continuing science group contrasted the differing focus:

*Aisha:* *In science you're just learning about what he did, and it doesn't refer that much to him except maybe the name.* *(GN2/185)*

There are many arguments for the inclusion of a historical dimension to the study of science. For the teacher 'appreciating where great minds had difficulty attunes a teacher to where lesser minds might also have difficulty' (Matthews, 1989). For the pupil, it reintroduces a personal dimension – science is an activity done by humans. Individuals acquire first names and wives or husbands. So *Ronald* Ross, whose work led to the identification of the malarial parasite, writes to his wife on the evening of the discovery. Context is added too so that he remembers 'that dark, little, hot office' in which he worked. 1898 is the year in which the Curies 'climbed hills, visited grottoes, bathed in rivers'. After her husband dies, Marie Curie takes a lover, Langevin, much to the consternation of the scientific establishment. Rosalind Franklin, returning from Cambridge after viewing Crick and Watson's first flawed model of the DNA helix circulates black-edged cards announcing the death of the DNA helix. Such stories introduce narrative elements which is a cultural universal whose excision from science makes the subject unnatural to pupils and difficult to relate to.

### *Elements of choice in the study of science in Key Stage 4*

Where continuing and non-science pupils followed integrated science courses there was general agreement that it should be divided into discrete disciplines, with distinct coursework and examinations. Pupils argued that the present arrangement of an aggregated grade for science failed to reflect their capability in the individual sciences and that this was unjust.

All groups debated the status of science as a core subject of the curriculum in Key Stage 4. Opinion was divided and ranged from suggested discontinuance of science as a compulsory subject to retention of one, or two compulsory elements, the remainder being optional. Whilst the majority of pupils expressed the view that they had learnt sufficient science by age 14, the end of Key Stage 3, to make these suggestions feasible, a number of groups discussed the possibility of voluntary modules in all areas of science so that pupils might pursue specific areas of interest. Clearly, the views of the pupils here are at variance with the scientific establishment and their parents who both regard compulsory science to age 16 as a significant improvement in the quality of their science education.

# Section 2:

# Teachers' Responses to the Pupils' Views of the School Science Curriculum

This section of the report provides an overview of teachers' responses to the pupils' comments. Teachers were provided with a summary of their views and then invited to participate in one of five focus groups to discuss the findings and comment. The questions used to stimulate discussion are shown in Appendix 1c. This section of the report is organised around the principal themes emerging from the pupils' comments. Inevitably the focus of this discussion was on those aspects of their school science lessons that pupils found unsatisfactory. It should not be forgotten, then, that there were many positive aspects that were not discussed extensively in this phase of the research. Moreover, teachers responded with many positive comments for possible improvement to the teaching and learning of school science.

# eight

## Pupil dissatisfaction with school science.

Teachers across the five groups showed little surprise, but considerable disappointment in pupils' views of school science. The majority of teachers agreed that the problems identified by pupils, particularly in key stage 4, were legitimate.

The predominant explanation for pupils' disenchantment with aspects of school science was the requirement to deliver a curriculum for science dominated by excessive content, particularly in key stage 4, and furthermore, the necessity to concentrate on enhancing pupil performance in examinations. Their responses to specific points were as follows:

### Decline in the pupils' engagement in science in key stage 4

Teachers across all the groups made it clear that they would welcome a significant increase in opportunities for pupils to engage in practical work. However, a number of inhibiting factors were identified. First, there was said to be an imbalance in the science curriculum between key stages 3 and 4 resulting in fewer topics which lent themselves to practical work in year 10 and year 11. Examples were given of organic chemistry, Earth science and geology, of which it was said. 'there isn't much practical work for them to do' (T5/115)

Second, teachers pointed to changes in the safety regulations which prohibited certain aspects of practical work, particularly in chemistry, which had hitherto been an integral part of the curriculum for pupils in years 10 and 11. For instance:

> *Hugh:* *You're so careful with safety now that some people might not do some experiments with their pupils, especially if you've got a large class with disruptive pupils.* *(T5/184)*

The third point, strongly articulated by teachers in all groups, was the lack of time for science in key stage 4; as one teacher commented, 'time is the biggest issue that we face in trying to teach effectively' (T1/71). The pressure to 'rush through topics so we can concentrate on how to answer exam questions' (T1/121), meant that school science in years 10 and 11 lacked an element of 'fun'. It was no longer possible to offer experiences to pupils in science which were specifically designed 'for their enjoyment, their understanding of certain concepts and science at large in the world' (T5/141); instead, it was said, 'you're just trying to get through the syllabus' (T5/141).

An additional problematic factor was the amount of time allocated for science in the timetable in many schools. The longest reported lessons were one hour and twenty minutes and the shortest were of forty minutes duration, which teachers maintained, 'just isn't enough time to teach the subject' (T3/113). Single periods for science were said by a number of teachers to allow insufficient time for pupils to 'undertake anything worthwhile' and one teacher commented:

*Mike:* *The idea of kids doing investigative science is that they have an opportunity to be creative and explore their own ideas. You try to do that in 45 minutes.* *(T3/172)*

A further impediment to practical work in science was the pressure of examinations. If pupils were to do well, they needed to be able to 'regurgitate facts' and facts were not easily taught or learned through practical work. As one teacher put it:

*Neil:* *Practical work can be a very confused and murky thing because it often lacks focus and pupils come out not knowing what they're doing.* *(T2/37)*

Teachers complained that in science, unlike examinations in other subjects, pupils were required to have committed much of their learning to memory, for instance:

*Tessa:* *You take a question like the carbon cycle. Now for us they are expected to learn every stage of what's actually happening. I saw a geography question where they had exactly the same cycle, with a little tree and they had one missing piece and they had all the words at the bottom and they had to find the right word to put in the box. For science they are expected to know the answer, to learn the equations and formulae.* *(T5/156)*

A further point made by teachers in one group was that pupils' experiences of science in primary schools led to unrealistic expectations of science in secondary schools. It was said that pupils expected to spend their time 'in laboratories, doing wonderful experiments with Bunsen burners every lesson' (T3/287) and the reality was disappointing for many pupils.

### Repetition of work in science

Whilst teachers agreed with pupils that aspects of science were revisited at intervals throughout key stages 3 and 4, in their view it was progressive repetition and an essential part of a spiral curriculum. As one teacher explained:

*Wendy:* *It's all about progression isn't it? I mean if we talk about electrical circuits. Now we know that electricity is probably taught in primary school, then again in key stage 3 and again in key stage 4. And the problem is that even though you've done it before, the concepts are so difficult that very few grasp the more complex concepts well enough in key stage 3 to be able to go on to the more complex things of potential and resistance. Even just the* *idea that the current isn't used up as it goes round the circuit – a lot are still struggling with that at key stage 4. So unless you go over simple circuits each time, you haven't got a hope of teaching them the key stage 4 electrical stuff about resistors and potential difference.(T4/62)*

Teachers who worked with mixed ability classes, whilst not calling for setting or streaming of pupils in key stage 4, identified the particular difficulty of attempting to meet the needs of all pupils in the group when there were some 'who get fed up with it because they don't need the repetition' (T4/66). In contrast, the point was made that there were pupils who would benefit from revisiting earlier concepts but who were reluctant to do so:

*Beth:* *They say, 'we've done this before' and switch off. They couldn't do it before so there's no point in trying now. If they've failed once they're not prepared to try again, because they don't want to fail again.* *(T4/75)*

A further reason for pupils' complaints about repetition was seen to be a direct result of the science taught in primary schools. Here the point was made by teachers, in all groups, that science in key stage 2 incorporated a significant amount of work previously associated with the first one or two years of science in the secondary phase. Whilst teachers made the point that the majority of pupils had 'only a superficial experience' (T3/307) of many aspects of science in key stage 2, and 'have absolutely no understanding' (T5/239) of the majority of topics covered in primary school, primary science nevertheless caused some difficulties for secondary science teachers, for example:

*Jenny:* *You look at what they've done in key stage 2 and it's basically everything that we do in key stage 3, so they just say, 'we've already done this'.*
*Mary:* *But what they're doing is they're adding detail to it, so you say to the pupils, 'we're doing photosynthesis today' and the don't see the added detail, they just say 'oh we've done that' and they switch off.* *(T1/81-82)*

Such arguments, that science in primary schools only develops a superficial understanding of science are contradicted by research which suggests that the Key Stage 2 science SATs are in fact harder than the Key Stage 3 science SATs (Bunyan, 1998).

Teachers in one group discussed possible ways in which needless repetition of aspects of science might be avoided through changes in approaches to teaching that included the elicitation of pupils' existing prior to beginning work on a new topic. Other strategies suggested included 'giving the end of module test at the beginning' (T3/179) to highlight those aspects of the topic which were understood by pupils and those which required greater concentration during the module. A further suggestion involved pupils in identifying 'true and false statements' about a relevant topic from a list compiled by the teacher. The advantages of these strategies were said to be, first, ‘that they get discussion going’ (T3/176), providing the teacher with some insight into pupils’ ideas, and second:

*Liam:* *...if you start off by looking at what they know and you take it on board, perhaps the lessons that you do in the following weeks, you can change them a bit and perhaps go off into something that broadens, or stretches it a bit and make it a bit more interesting.* *(T3/83)*

However, this suggestion was not met with universal approbation within the group:

*Robert:* *I think often we don’t do enough to find out what it is the students know, but the reason for that comes down to a lack of time and pressure to finish the courses. The other aspect is that finding out what they know is one thing, how do you take that though when you’ve got a range of states of progression within a particular class? Taking all that on is not easy, so that a child can progress from their own particular level, it’s not easy….*

*Patricia:* *...in an ideal world I think we would all like to do that, but we know that faced with thirty children who all have different starting points, it’s so difficult to actually organise, particularly in science where, in terms of practical work for safety, you generally need to have all of them doing the same experiments at the same time on the same day, because it’s just not practical to organise it any other way.* *(T3/98-99)*

## Excessive copying in science

Complaints from pupils that excessive copying of notes from the board, overhead transparencies and textbooks affected their interest in school science, were not supported by any teacher in any group.

All teachers encouraged ‘note taking’ during science lessons, ‘because they obviously need something in their books’ (T2/57). However, they were insistent that copying, as described by pupils, was not a feature of their own teaching in science. For example, ‘they certainly don’t spend time in my lessons copying from books or the board’ (T4/48). The majority of teachers suggested that pupils may have exaggerated the amount of copying undertaken in science lessons and were referring instead to any activity that required writing. It was said that ‘anything you put on the board they may call copying’ (T5/85), and as one teacher commented:

*Tom:* *I think it’s important that they do make their notes, you know, and it gives me some feedback as well. But I thought perhaps they were getting copying mixed up with that.* *(T3/231)*

Teachers provided notes to be copied from the board when there were specific 'facts they need to learn' (T1/43). The point was made by a number of teachers across the groups that pupils needed to record information to support revision for tests and examinations, for instance:

> Lynn: *If I've written notes up on the board and they've copied them down, then they've got that, they can revise that when it comes to the test and maybe we feel happy with that idea. Whereas we feel less secure with the idea of getting them to go away and research a particular topic and construct ideas for themselves.* *(T4/118)*

This extract itself, with the specific mention of the activity of copying, suggests that there may possibly be an element of self-denial in teachers' responses. On the one hand, these teachers denied that it occurred in their classrooms but, on the other hand, as the above quote suggests, it was essential to ensure that they have notes for revision. Note-taking was said by a large number of teachers to offer a reliable means of transferring information from the teacher to the pupil. However, one teacher made the point that:

> Roy: *Whatever they are writing that work has to go through their mind and not just from their eye, down their arm and onto the paper; and any way you can make it go through the mind is going to help.* *(T4/143)*

The point was made by a large number of teachers that note-taking was not utilised in isolation, but in conjunction with a range of other activities, for instance:

> Rachel: *I think it's more like, the teacher is talking and you write; the teacher writes something on the board and then you write it down. and then you bring in discussion, you might produce a demonstration experiment. and then you write about it. If they see all that as copying, then it might explain it.* *(T5/107)*

In developing this point, teachers from each group provided examples of alternative strategies to the simple copying of notes. A large number of teachers distributed photocopied sheets which pupils retained for revision purposes after teachers had 'gone through it sentence by sentence and said what this means and discussed it' (T1/58). Other strategies involved pupils in the formulation of 'spider diagrams' (T1/61), responding to 'comprehension questions' (T4/137), completing a 'learning wall' (T3/225) and undertaking 'cloze procedure' exercises (T5/92-94).

# nine

## Recommendations for change made by teachers

In the light of teachers responses to pupils' views of school science, it was not surprising that the principal recommendations made were those which would allow more time for science and greater flexibility within the school science curriculum.

### Reduction in the content of the science curriculum

There was general agreement among teachers that there was 'far too much content in science' (T2/117), particularly in key stage 4. Consequently, opportunities for practical work diminished and the tyranny of content constrained teachers who were eager to digress from the syllabus, to encourage pupils' interest through discussion or debate of socio-scientific issues.

However, teachers were cautious in identifying aspects of the school science curriculum which might be omitted to permit more practical work and the inclusion of more contemporary science. Whilst the majority did not make specific recommendations, others discussed the difficulties inherent in deciding which aspects might be removed. As one teacher put it, 'we'd all complain if our favourite bit was taken out' (T1/195). In direct contrast, a small number of teachers maintained that it was not feasible to remove aspects of the existing curriculum:

> *Diane:* *You can't take stuff out. You can't take stuff on the cells out and then expect to teach genetic modification. You can't understand incredibly complicated things like genetic modification - which is what they said they wanted to know about - if you don't understand the basics of genetics.* *(T1/267)*

Nevertheless, the point was made by a large number of teachers that if the current science curriculum were to be made more attractive to more pupils then additional time would need to be allocated to it. Politically, in a climate where the existing time allocation for science is constantly questioned, the latter suggestion would have little, if any, support. Clearly, the burgeoning body of scientific knowledge, all of which clamours for a place on the curriculum, does pose a dilemma. In one sense, it might be said that the parents' responses (see section 3) show that the change in the school science curriculum in the past four decades has been to present a broader and broader picture which simultaneously becomes more and more superficial. The radical response, which never emerged from the teachers, would be to acknowledge the impossibility of painting a complete broad picture of science, rather as the historians long ago abandoned any attempt to cover the whole of history. History in schools, in contrast to science in schools, seeks to examine in depth a limited set of periods emphasising the process of historical interpretation as much as the content itself.

### Changes in the content of the curriculum for science

There was general agreement among teachers that the present National Curriculum for science was 'overly academic' and lacked material that pupils found interesting and relevant to their lives:

> Jean: *The fact that it's compulsory means you ought to give some thought to how useful it is. People are happy to study things that they find a relevance for. Science is completely irrelevant and too remote and abstract for most of them.* *(T3/446)*

Teachers across the groups endorsed the view expressed by pupils that school science needed to embrace contemporary issues and advances in science. To achieve this the curriculum for science required an element of 'flexibility'. It was suggested that the science curriculum should change more readily to reflect scientific advances. As one teacher explained:

> Tom: *Right now people ought to be informed about genetically modified foods, so they can make an informed decision about it. So genetically modified foods should be in the science curriculum right now.* *(T3/465)*

Whilst it was acknowledged that school science could not realistically be subject to continual change – 'you can't change the syllabus every time a new scientific discovery comes along' (T1/273) – nevertheless, it was thought necessary to allow some flexibility to enable teachers to deliver the content of the curriculum in more imaginative ways. A number of suggestions were made including, for example, a choice of projects in which pupils would be encouraged to explore issues of interest under the guidance of the teacher. Using a current A-level course as an example one teacher explained:

> Lesley: *If you were able to choose topics that interested you then your interest and enthusiasm would be conveyed to the pupils. In A -level physics we gave them a choice and they chose to look at the Hubble Telescope. Topics like that lend themselves to discussion and I know it was an A level group, but something like that could work for GCSE.* *(T4/263)*

A further suggestion involved the teaching of science using 'stories' or 'case studies'. This idea was based upon the approach commonly adopted in the teaching of history and involved an exploration of the 'initial ideas of science' (T4/247) through the study of relevant people in science, such as, Darwin, Galileo and Copernicus. As such, 'scientific theories are more interesting and have more relevance, because they are like stories instead of dry facts' (T4/247).

A final suggestion, put forward by teachers in three groups, was the more extensive use of the *Salters Science Scheme*. One teacher went as far as to suggest that 'everyone should use *Salters*' (T5/359). The principal advantages were said to be that the scheme 'starts from where the pupils are' (T5/368) and the topics were rooted in everyday contexts, for example:

> *Dawn:* *With the transport section the kids stood on a bridge on the Western Avenue and looked for signs on the lorries, those carrying petrol and chemicals. The first thing they do is record all the signs, so they've got them for hazardous chemicals. Then you can do a demonstration showing what all these chemicals are and you can go into the symbols as well.* *(T5/391)*

The approach adopted by *Salters Science* was contrasted with those schemes that presented an abstract, disembodied view of science in key stage 4, and were said to 'start with the science and try to bolt the relevant bits on' (T5/385). However, the *Salters* scheme was not met with universal approval by any group. The integrated nature of the topics was said to be inappropriate for pupils in schools in which the three sciences were taught separately. In addition, there was some disagreement about the extent to which *Salters* provided an adequate foundation for those pupils who wished continue their studies of science at A level. However, those teachers who were committed to its use maintained that it offered the means by which school science might be made more interesting and relevant to a greater number of pupils.

## Recommendations for changes in the structure of examinations for science

A small number of teachers maintained that, 'in an ideal world' they would 'do away with exams altogether' (T2/97), making science a wholly practical subject. Whilst few teachers expressed a desire for such radical change, a number of teachers called for an education in science for all pupils which was not dictated by success in examinations. The pressure exerted on teachers and pupils by the need to prepare for examinations, described as 'constantly pushing for A to C grades at GCSE' (T4/235), inhibited opportunities for diversification and extended practical work in science. The point, made strongly by teachers in one group, was that until there was a move away from the current system where the success of the school was 'measured in percentages' (T4/235), teachers would be 'unable to teach in more interesting ways' (T4/249). As one teacher explained:

> *Yvonne:* *We are driven by the numbers game and trying to quantify education is ruining it. I can understand that you need to see progression in each school, but trying to put it in numerical terms and trying to measure it in this way is not what education is about.* *(T4/240)*

## Reduction in class sizes

Teachers in two groups expressed the view that many of the negative comments made by pupils might be addressed if group sizes for science were reduced from their present levels of 28 and above to 'more manageable numbers' (T1/216). Smaller numbers of pupils would make it possible to provide individual attention, 'making sure they understand these concepts' (T1/216). Practical work would present fewer organisational problems, and avoid the current situation of which it was said:

> *Paul:* *If sitting 32 kids down in seats with a book is easier than 32 kids all chasing round doing practical work, then that's what we're going to do. Because at the end of the day it's survival and I don't think you can get away from that.*
>
> *(T2/119)*

In addition, it was said that with fewer pupils, teachers would be more willing to encourage greater pupil involvement in science lessons. At present it was reportedly, 'impossible to have a reasoned discussion or debate with over 30 kids' (T2/117). Such an argument is, however, contradicted by the commonplace use of discussion in other curriculum subjects which would suggest that the issue is one of an unfamiliar pedagogic technique rather than a principled objection.

### An element of choice in school science courses

There was universal agreement among teachers that science should retain it's status as a compulsory core subject of the curriculum for all pupils to age 16. A number of teachers disagreed with the suggestion made by some pupils that they had gained sufficient knowledge and understanding of science by the end of year 9. As one teacher put it – 'you can't say you've learnt enough English or maths by year 9, so how can you have learnt enough science?' (T4/306).

However, teachers made it clear this was not to suggest that all pupils should necessarily study the same science in key stage 4. Teachers in only one group were in favour of retaining the present model of science in key stage 4, 'with greatly reduced content' (T4/303). The models suggested by teachers across the remaining groups showed a marked similarity. In essence, the majority of teachers recommended the retention of a mandatory 'core course' for science, which would include only, 'the science they all really need to know' (T3/419) and which would be followed by pupils throughout key stage 3.

In key stage 4 it was suggested, by three groups of teachers, that those pupils who had little interest in and aptitude for science would follow a 'vocational', or 'integrated' science course, in which, for example, 'you wouldn't be doing things like moles, you'd be putting it in context, like *Salters*' (T4/53). Certain core elements would be retained, however, to develop pupils' understanding of issues such as 'genetics and pollution' and to enable them to 'have some ideas so they can argue the issues' (T4/300).

For those pupils who showed an interest in, and aptitude for science at the end of key stage 3, teachers recommended a more 'academic' course in science. A number of teachers expressed the view that separate sciences, 'taught by specialist teachers'

(T2/379) were more appropriate for these pupils and were a better preparation for A level science courses. Whilst some teachers were in favour of offering pupils a choice of one or two sciences at GCSE, a small number expressed the view that this might herald a ‘return to the situation where pupils make stereotypical choices’ (T4/299) preferring to ‘keep it broad, but give them enough time for the work’ (T5/567). A variation to this model was offered by teachers in one group, who were in favour of a ‘core course’ for all pupils, with ‘extension courses’ in biology, physics and chemistry for what were described as ‘A to C grade pupils’ (T5/511).

# ten

## Other Concerns

### The exploration of socio-scientific issues

There was general agreement among teachers that school science did not equip pupils to participate in discussion of socio-scientific issues. Several reasons were advanced to explain this. It was said by one group that school science was 'not set up to do that' (T2/193) – that the National Curriculum and its system of assessment did not encourage or permit sufficient diversity of approach for their incorporation. The requirements of an overburdened, prescribed curriculum inhibited their introduction, particularly when such work made no contribution to their assessment. However, it was recognised that pupils did need considerably more time than was currently available to consider socio-scientific issues:

> *Anthea:* *...to discuss, debate and reflect on what they're being taught. But they're not given that because it's, you know, let's move on to the next bit.*
>
> *Hugh:* *Children really enjoy discussing things and coming up with their own ideas and their own theories and trying to argue each other down...but you just have to say, 'Right sorry, got to get back to this', because we've got to get it finished by the end of the term.* *(T4/378)*

Whilst school science was said by some teachers to provide the foundations of an understanding of socio-scientific issues, participants in one group maintained that pupils rarely made connections between science in the media and science learnt in school. It was said that 'there's school science and there's science in the outside world' (T4/421), and pupils rarely showed 'the ability to transfer their learning' (T1/465). Whilst teachers 'hoped' that pupils would transfer their knowledge, many expressed the view that pupils' learning in science was insufficient at the level of GCSE to have any real understanding. An example was given by teachers in one group of television programmes such as *Tomorrow's World* and *Horizon* which demanded a depth of scientific understanding not attained by pupils in year 11:

> *Greg:* *...I remember being at A level and even then you understood only the first ten minutes...They speak too quickly in these sorts of programmes and they give too much information. I think you have to be pretty advanced in the subject to be able to follow some of these programmes.* *(T1/481)*

Essentially, the predominant view reflected here shows teachers clearly identifying themselves with the standard 'deficit' model promulgated by the scientific establishment. From this perspective, the public is seen as lacking sufficient knowledge to make any significant contribution to the scientific debate. This position has, however, been extensively criticised by a body of recent research in the past decade (Irwin, 1995, Layton et al., 1993). However, one group of teachers highlighted the importance of developing an understanding of science related issues before A-level to counteract impressions gained from television and newspaper reports which were said to be 'wildly inaccurate at times' (T5/602). Nevertheless, whilst expressing the view that school science 'does equip them with some knowledge' (T5/608), this group of teachers complained about the 'lack of time to make the links' (T5/609) between the topics studied and science related issues in the outside world.

Teachers in two groups made the further point that scientific issues took some time to 'filter down' to the school science curriculum, for example, global warming which was now part of the science syllabus. Pupils reading about this topic would be expected to have a greater understanding than of 'newer' issues such as genetic modification and BSE. For those it was thought that, 'many teachers don't know enough about them to teach them, they are just being discovered now and we have to wait for them to filter down' (T1/482).

The view was expressed by teachers in one group that, if pupils were to gain an understanding of science-related issues, the school science curriculum and approaches to teaching science required radical change.

## The instrumental importance of science to pupils

The majority of teachers conceded that many pupils viewed school science principally as 'a means to an end' (T1/338), or 'a stepping stone' (T1/339) to a science related career, rather than for its intrinsic value in their lives. One group maintained that in England there did not exist a 'culture of education in the broad sense' (T2/228). Unlike other countries, such as France where 'they even teach philosophy in schools', it was said that, 'in England you've got to be a bit odd if you are interested in things for their own sake' (T2/228). This was said to be especially true of science:

> *Nick:* *I think we're suffering from the fact that science has a tradition of being a minority, low status sort of thing. The idea that you need a lot of science to be an educated person is a very recent thing. You look at people in high positions in society today and an enormous number of them will say they know no science, never did any and were never interested. It goes back to the two cultures thing – arts or sciences. I think those sort of feelings in society take generations to change and the influences are still there in pupils' perceptions.* *(T2/228)*

The principal reason that many pupils viewed science for its career, rather than its cultural value, was said by teachers to be a failure on the part of pupils to make connections between science as learned and science in everyday life. The point was also made that parents were partly responsible for the perpetuation of a narrow, career oriented view of science among pupils, for instance – ‘parents give their children their particular world view, they set the agenda’ (T2/232) and:

> *Julie:* *I think a lot of parents confuse training and education. Giving them a good scientific education is completely different to taking them onto A-level, university, or into some job.*
>
> *Martin:* *I think also parental understanding of science is a strange thing. They might know about English or poetry or history or geography, but science, well it’s only for those people who want to go onto science related things.*
>
> *(T5/638-642)*

Participants in other groups commented that teachers must accept some responsibility for the failure of pupils to view science in cultural terms – ‘we’re not getting over that science is exciting, or part of everyday life’ (T1/358). The point was made that teachers were not given opportunities to spend time in industry or ‘to learn anecdotal stories’ (T3/514) that they could bring into school to ‘make science real for pupils’ (T3/520). Such knowledge was only available to teachers through books whereas to give it meaning ‘you’ve actually got to go outside and experience it for yourself’ (T3/520). Teachers commented that whilst they were adept at transmitting the idea that science is useful for a science-related career, they were not skilful at ‘getting over the idea of science for life’ (T1/391) and its general cultural value:

> *Matthew:* *Science isn’t presented as something intrinsically interesting, something worth doing for its own sake, that’s just not the way it’s ever presented. It’s just a means to an end. You know, you say to the kids they’ve got to have maths, English and science if you want a good job. That’s just the way they see it. You’ve got to get through this drudgery just to try to get a good job’.* *(T1/396)*

The point was made by teachers in one group that science in the public perception was very different to that of the humanities. Whilst these were said to be part of the ‘general knowledge of every individual’, there were few aspects of ‘the general knowledge of science’ (T3/549) that had a similar status. As one teacher explained;

> *Lucy:* *There’s proper scientists and there’s the rest of us and we aren’t really expected to know very much.* *(T3/549)*

In three of the groups, teachers acknowledged that pupils tended to have a narrow perspective of the use of science for future careers. They provided examples of pupils who were unable to make connections between careers in ‘the building industry’ or ‘hairdressing’ and school science. And in four groups, teachers agreed that science was not ‘marketed’ well in schools. Some thought this was the fault of careers departments who were providing an insufficiently broad view of the use of science for a range of careers, whilst others maintained that teachers themselves were ‘complacent’. Unlike teachers in other subjects, those in science departments were said to be unaccustomed to 'selling' the subject to pupils when they were considering their options at the end of year 9; as one teacher put it, 'science is compulsory, we don't have to market it' (T2/213). This 'complacency' was said to extend beyond a failure to communicate the value of science for a range of careers; to a failure to 'market science at A level'. As one teacher explained:

> *James:* *The factors which cause pupils to choose science at A level have very little to do with anything that goes on at school. Very little to do with the courses we offer or the content of the course, or who teaches them and how they teach them. They tend to be to do with what they perceive to be useful either in terms of university courses, or careers.* *(T2/214)*

## A lack of opportunity for creativity in school science

Whilst the majority of teachers agreed that science in the 'real world' was not always a body of certain knowledge, they did think that it was portrayed as such in the school science syllabus, leaving few opportunities for creativity, individual thought and interpretation of ideas. One teacher explained that:

> *Roy:* *...science is about tensions between hypotheses, it's not about finding the truth, it's simply about finding the best explanation. That's what we've got to be much more explicit about, because there's the syllabus and they have to know the right answers in order to be able to pass the exam.* *(T4/452)*

However, a small number of teachers expressed the view that whilst there were opportunities for scientists to be 'enormously creative', it was 'inappropriate' for school science to reflect this way of working. The point was made that pupils needed to understand the 'basic models' of science, such as aspects of atomic structure, forces and gravity, before they were sufficiently well equipped to enter into discussions as 'you can't discuss things properly until you understand the models' (T1/518). This was advanced as an argument in defence of the absence of any discussion of socio-scientific topics in school science – issues such as genetic modification were 'uncertain science' and therefore had 'no place' in the school science curriculum as, 'there isn't a right answer to put on an exam paper' (T1/519).

Teachers in one group contrasted science to other subjects such as history, where opportunities to encourage 'individual thought, analysis, discussion and argument' were said to be, 'built into the history curriculum' (T4/485), but with school science 'there is a right answer all the time, there's a right explanation for everything' (T4/490). Whilst teachers in most groups reportedly attempted on occasions, to encourage discussion and debate they rarely lost sight of the requirements of examinations, for instance:

*Laura:* *I had a class the other day and we were discussing the steady state theory versus the Big Bang theory and they were all putting forward their arguments. Then all of a sudden a little voice from the back introduces God. You know, I was thinking to myself that it was a valid point and we should be able to talk about it. But I thought if a child started talking about God in a GCSE exam question on the Big Bang versus steady state theory, I know exactly what the mark would be.* *(T3/727)*

Rather, it was preferable to provide pupils with information and correct nomenclature to meet the requirement to, 'write an answer on an exam script in two lines, to get three marks' (T3/735). In one group, school science was said to have 'nothing to do with science', it was only a process of gaining the highest marks possible on tests and examinations. Teachers in one group also reported that pupils became 'worried' if teachers introduced discussions about aspects of science not directly relevant to that required for the exams. They were said to be 'ultimately only interested in what they need for their grades' (T4/494). There was seen to be a much stronger concentration on grades among pupils since the implementation of the National Curriculum:

*Andrew:* *They now come up to high school with an expectation. Having gone through key stage 1 and key stage 2 SATs, they're already geared into the idea that in order to achieve things they've got to get certain grades in the exams. So that's what they're looking for from the time they come into high school now – reaching the right level at the right time.* *(T4/497)*

Although the majority of teachers agreed that, 'there is a place for creativity in school science' there was said to be, 'little opportunity for it' (T2/243).

In addition, teachers complained that although the National Curriculum was intended to, 'bring in that element of open-ended, investigative, collaborative approach' (T2/244), the 25 per cent of available time was only sufficient for pupils to undertake one investigation during the year, and 'that's all you need to get through the exam system' (T2/244). In contrast to this, school science in the past was said to have been marked by a more flexible approach to practical work:

*Ian:* *It's been emasculated by the people who desire the thing to be pinned down to get the examination results. We used to do work that was internally assessed and moderated. If you had a bit of interesting work you wanted to do, as long as it was credited as being assessed fairly by the examiner, it was fine. But now you can't do that, you've got to do exactly what it says in the syllabus and it means you have no flexibility basically. Open-ended investigations, wonderful as they may be, get completely wiped out because you've got to get a good mark. So you do it this way because that will get you the best mark.* *(T2/244)*

A number of teachers regretted the limited time available to encourage discussion in science lessons, as one participant commented; 'it would be really good if every three weeks even, you could do a lesson which was just discussion' (T2/280). However, despite the severe limitations teachers in the majority of groups maintained that opportunities for discussion existed in school science and were seized whenever possible, centering on those issues for which there was 'no right or wrong answer' (T1/512), such as the use of nuclear power, abortion and 'test tube babies' (T1/506). Such discussions were said to be almost invariably teacher-led, with pupils offering a point of view and the teacher acting as 'devil's advocate' in putting the alternate view. However, teachers rarely encouraged small group discussions during science lessons because:

*William:* *They need guidance to talk about the right thing, otherwise they'll lose the track and talk about something else. Or they just don't have the information there to be able to converse with each other about it.* *(T1/531)*

A small number of teachers commented on the benefits to pupils of visiting speakers and visits to a variety of places of interest including museums and industry. However, these were 'events' often organised as part of an annual 'science week', rather than a concerted attempt to bring science in the outside world into the classroom. As one teacher commented:

*Bob:* *Science week is positive, but that almost is contrived because it's a science week and we do something new. But then it's just back to your original way of teaching and your way of delivering when it's over. There isn't a follow-up and it doesn't involve all students because they can't all go.* *(T3/780)*

# Section 3:

# Parents' Views of Science Education

# eleven

## Parents' experiences of school science

The experiences of parents varied greatly – both within and between groups. Parents felt they had been the recipients of a received and revered body of high status knowledge, where only the keenest and most able were encouraged to study it after age 14. Failure to continue with the study of science post-14, however, was not necessarily an indicator of a lack of interest in science. For many parents, opportunities to study science had not been available, either because they were unable to combine arts and science subjects at O level, or because they were actively discouraged. Amongst women there were many who had formed the impression, from an early age, that chemistry and physics were 'boys subjects' and, therefore, not 'suitable' subjects of study for them; instead they had been guided towards courses in biology, or domestic science, which were deemed more appropriate for girls. The opposite was true for men. For many men an interest in biology had been discouraged in favour of physics and chemistry, though for men, as for women, the combining of arts and science subjects had often not been possible.

Parents felt that, 30 or 40 years ago, school science, like many other subjects, had been characterised by 'facts and having to cram them in for exams' (FN1/95), where subjects had been prized for their instrumental value. As one parent explained:

> *Steve:* *At that time you were given facts in books, too many tests and asked to regurgitate those facts. That is what education was, and perhaps, science subjects lent themselves to a more structured approach to that method of education than the humanities did.* *(MS3/119)*

History, too had had a similar factual emphasis as events 'happened and you can't alter it' – a world view which was analogous to science where there existed 'basic laws which you just have to accept' (MFS3/75). Similarly, women in one non-science group pointed to the fact that even English in their day had offered limited opportunities for personal expression or interpretation. Amongst the parents, however, there was now a strong impression that other subjects in the curriculum had changed more markedly.

### The appeal of school science

Aspects of school science were identified as interesting by parents across the groups for two reasons. First, like their children, they remembered science lessons that had offered them hands-on, practical experimentation which were 'fun', or 'dangerous'. Second, retrospectively aspects of school science were interesting because the knowledge had proved useful throughout their adult life, either in their career, or in their everyday lives. More specific comments were then made about the individual sciences.

### ***Biology***

As might be expected, women expressed a considerably greater level of interest in aspects of biology than men. Although a small number of men and women from non-science groups recalled interesting work on ‘plants’ and ‘nature study’, the predominant area of interest among women was in aspects of human biology. Reasons offered corresponded to those expressed by their children; principally that it engaged them because it was ‘relevant’ to themselves and their lives:

> *Joyce* — *One of the reasons I went for biology was for the very selfish reason that it related to me. I wanted to learn about me, I mean, what was going on inside my body, and why did this happen, and why did that happen to me and to other people as well. It was a personal thing. (FS1/71)*

Although very few men expressed an interest in any aspect of biology, the one feature that had engaged the majority and women and men from non-science groups was the dissection of animals and their organs. The mental images associated with this experience were strong and persistent, and they were able to recall in graphic detail the dissection of frogs, rats, animal eyes, lungs and hearts:

> *Barbara:* *I know it sounds really horrible and people won’t like me, but I learnt most through dissection in biology.*
> *Wendy:* *Oh, I loved that, I adored that.*
> *Hilary:* *They don’t do that now, but it was a big part of biology...*
> *Julie:* *When we did optics – the marvellous part of the eye – we had to have a sheep’s head and you had to cut through the skull and go through the brain and get to the back of the eye and it was fantastic.*
> *Barbara:* *You were actually handling it, your visual picture, something you could really look at. You can remember the pictures from years and years ago. The memory works in pictures and you can still see dissecting certain animals. But it’s not a nice subject now is it? (FS1/ 207-211)*

### ***Chemistry***

Chemistry had little appeal for the majority of parents in non-science groups, but was enjoyed by a significant number of men and women in science groups. One attraction of chemistry was the practical nature of the subject; mention was made of the ‘excitement’ of ‘mixing chemicals and watching the reactions’ (MN3/109), or the distinctive smells, ‘I can still remember the hydrogen sulphide smell’ (MS3/42). They enjoyed ‘playing around with the equipment’ (MN2/26), which was preferable to the ‘dry old formulae of physics’ (MN2/26). The aspect of chemistry that attracted the greatest number of positive comments among men was ‘accidents and events’. Several anecdotes were related during discussions that described explosions and escaping noxious gases which all added to the enjoyment.

One group of men highlighted the relevance of aspects of chemistry, with particular reference to the blast furnace:

> *Ted:* *I remember the teacher explaining in great detail how a blast furnace worked. I come from Teeside and that was of great interest to people because there was a lot of relevant things you could learn about. Like chemical combinations and temperature and so on. That was about the only thing I can recall as being of particular interest or relevance.* *(MN3/144)*

The stark contrast between this view, and the use of exactly the same example by pupils as an illustration of the *irrelevance* of the curriculum is ironic. Essentially, it is a reflection of the demise of heavy traditional industries, the rise of the 'post-industrial' society dominated by information technologies, and a curriculum that may have failed to recognise those changes. For school science, the message is simply that it is important to locate the applications used to provide relevance in the technology of today rather than that of yesteryear.

***Physics***

Whilst very few women recalled any aspects of physics found interesting, it had considerable appeal for men, especially those in science groups. Two groups mentioned that physics was appealing as it was less *messy* than chemistry or biology:

> *Graham:* *Physics I found so sort of clean and aesthetic, compared to chemistry which I thought was an absolute mess.(MS1/16)*

Physics appealed to those men in science groups who preferred subjects that were 'more factual than abstract' (MS2/29), and included elements of 'problem solving'. Interest in physics had been stimulated by scientific developments of the 1960s and 1970s, for example:

> *Tony:* *I think for me it was maths and physics because it was the sixties and it was an exciting time with the moon landings and nuclear technology coming on stream.* *(MS1/14)*

Likewise, the contemporary growth[3] in the uptake of biology post-16 may have been stimulated by the fact that biology has become the science of the late 20$^{th}$ Century with the innovations and implications of gene technology.

Physics was said to be 'logical' and to encourage 'analysis', which was important for many men in science groups. It had 'the power to explain things far beyond immediate experience' (MS4/38), for example, how planets and galaxies were formed. It also explained aspects of world in which they lived and which 'related to you'.

[3] The percentage of the cohort studying biology has risen from 6 to 9% from 1990-1998. The figures for physics and chemistry have essentially remained static between 5 and 6% of the cohort over the same period.

### *Approaches to teaching that made science appealing*

Teachers had played a fundamental part in stimulating parents' interest in science; 'they could tip your interest in science one way or the other' (MS3/8). Across the groups the single most important attribute of a good science teacher was 'enthusiasm'. Participants remembered teachers who had 'brought the subject alive' through their ebullience and ability to communicate. For instance:

> *Phillip:* *I think it depends how you put it over. I had this young, go-ahead physics teacher who could make you enthusiastic about it. I think the popularity of a subject at school depends very much on the teaching of it. (MN1/87)*

A further recurring theme across the groups was the importance of teachers who exuded confidence in their subject, were willing and able to answer questions and who 'spent time explaining' difficult concepts. Given that both parents and pupils alike emphasised the importance of such teachers for generating an interest in the subject, the current crisis (Constable et al., 1999) in science teacher recruitment does not bode well for the future of school science. In essence, school science's most valuable resource is *not* its equipment or its laboratories but a cadre of *well-qualified , enthusiastic teachers* who are justly remunerated for their skills.

## Less appealing aspects of school science

There were a significant number of parents from non-science groups for whom school science, especially physics and chemistry, had very little appeal. Physics and chemistry, for instance, were said to be 'hard to understand' (FN1/236); other comments included, 'I just didn't get the principles' (FN2/187) and 'it went straight over my head' (MN1/296), and 'it didn't have any meaning' (FN1/302).

> *Mary:* *You went in and you learnt theorems and you stood there doing experiments and you didn't know why you were doing them and what they were leading to. (FS1/301)*

Aspects of biology that were found less appealing by a number of men in non-science groups centred on the 'rote learning of facts' and in the seeming irrelevance of some topics of study, including:

> *James:* *...things like the life cycle of a housefly. It just was of no interest whatsoever. (MN3/250)*

For the majority of parents in non-science groups the relevance of school science had lain in its instrumental value for examinations:

> *David:* *All they wanted to do was get results, get people to pass their O level, you know, that was all that was necessary.(MN3/141)*

Rather, like the pupils, an inability to comprehend the relevance of physics and chemistry to their everyday lives was an important causal factor generating antipathy for women in both science and non-science groups – 'I couldn't see the application directly like I could with biology' (FS1/38). However, a significant number of men, whilst being unable to discern the value of biology in their everyday lives which was said to have been 'just rote learning for exams' (MS3/42), had had little difficulty in perceiving the application of aspects of physics. For instance:

> *Murray:* *I remember going out and testing the speed of sound with a starting gun at one end of the field and a stopwatch at the other and you could relate that to real life, whereas chemistry I couldn't.* *(MN1/145)*

***Approaches to teaching found less appealing***

A considerable number of parents across the groups cited approaches to teaching as the principal reason for their lack of interest in aspects of school science. A common complaint among women was that they not been encouraged by teachers to develop an interest in chemistry and physics, a prevalent criticism being that 'they were much more interested in the boys'.

Whilst enthusiastic teachers had stimulated the interest of men in science groups, those who had 'failed to inspire' were those who lacked confidence or expertise in the subject. As one parent commented:

> *Colin:* *Even now I can recall instances where I could ask a question and the answer that I got clearly wasn't the right one, you know, the teachers weren't several steps ahead of me, they were just a little bit ahead of me and the quality of teaching just wasn't there.* *(MS2/33)*

Only a very small number of parents complained about the absence of opportunities for practical work or recalled science lessons that featured note taking or 'copying from the board' unlike the pupils. However, practical work was said by many parents to have been 'boring' because they 'did as we were told', and 'you didn't have to think for yourself' (FN1/114). There had been too few opportunities for autonomy or decision-making and they frequently failed to comprehend the purpose of experiments that were considered to be largely confirmatory. This contrast between the parents' less than universal enthusiasm for practical work, and the positive value placed on the activity by their children, suggests that there has been a significant change over the past few decades in the form, if not the function, of practical work. Possibly, contemporary practical work, with at least some attempt to be more open-ended, offers exactly that dimension of personal responsibility – an important point of engagement for pupils – that was missing from their parents' experience.

Emerging from these points is a picture of a subject whose form has changed but not its content. No longer is the subject riddled with the inherent gender bias that characterised these parents' experience. The arguments advanced in the 1980s by Harding (1983), Kelly (1981) and others have led to a restructuring of science education so that a similar experience is offered to all, and where girls now do as well as boys at science GCSE's. However, for most of these parents, the subject itself is still easily recognised dealing with well-established and unchanged content.

# twelve

## Parents' views of the value of school science in everyday life

There were notable differences between the groups in the links made between the science learned at school and its use or value in everyday life. All parents in science groups engaged in the discussion eagerly, as did women in non-science groups. However, men in non-science groups found it more difficult to relate their learning to their everyday lives and offered generally fewer examples, or maintained that aspects of science used in their lives had been learned since they left school, either from other people, or from books and manuals, or a as process of 'trial and error'.

***The practical application of science in everyday life***

In responding to the statement – '*the science I learnt at school has been of little use to me in my life to date'*, the discussion focused on utilitarian aspects of school science. Frequent references were made to the need to use science in caring for their children and other members of their families. Women considered it important to have some insight into the causes and prevention of illness, the maintenance of good health, an understanding of nutrition, diet and exercise, and the dangers of smoking. The point was made that it was helpful to be able to make simple diagnoses when their children were ill or hurt, to recognise things like 'torn muscles', 'stomach complaints' (FN3/415) and:

> *Judy:* *If one of the kids comes running up to you and you take a look at the wound and you say, 'well that's not dangerous'. How do you know it's not dangerous? Because you did it in biology at school and you can see that the cut is nowhere near an artery, or whatever. So much is science with a lot of bits hidden away, but you're using them all the time.*
>
> *(FN1/161)*

Some knowledge of biology was considered by women to be helpful in offering reassurance to members of the family who fell ill, as one parent put it 'you can take the fear away from other people, especially your children' (FN2/215).

Aspects of chemistry and physics featured very little in discussions among women in non-science groups. However, once a connection was made, often through an example given by an individual in the group, the remainder of the group quickly realised the extent to which aspects of physics and chemistry were an integral part of everyday life even in the most menial tasks. Women in non-science groups frequently expressed regret that they lacked the type of scientific knowledge that would be useful in their lives; for example, one group commented that their lack of understanding sometimes limited their understanding of the treatments they had to give to their children:

*Maureen:* *One of my boys had an in-growing toe nail and I was told to bathe it everyday with sodium bicarbonate in warm water. I went everywhere but I could only get bicarbonate of soda and I didn't know the difference. One of the boys asked at school and they said it was the same, but it was a real dilemma for me.* *(FN2/245)*

Scientific knowledge is valued, in this respect, because it offers freedom from ignorance, personal independence and a measure of self-esteem. Or, in the words of Thomas Jefferson, 'those who are ignorant and free never have been and never will be'. Science education then, offers a body of knowledge that helps to construct, at least partially, the independent and self-reliant individual.

Men in non-science groups, and one women's' non-science group, pointed out that the connection between aspects of science and its application in everyday life was not made in school science. Women gave examples of work associated with electricity and combustion engines which had been presented as disembodied and 'theoretical' and, therefore, 'didn't relate to anything at all'. In contrast to this experience, parents who had continued their studies of science to age 16 and beyond, had very different views of the value of school science in their everyday lives. These parents had 'learnt a lot of practical applications as we went along' (FS1/134), either for 'changing plugs and fuses' and 'mechanics for fixing cars'(FS/134), or through 'learning the principle, then you could apply it when you were outside school' (FS1/152).

Women in one science group reported that, whilst direct applications were often not apparent in school science, it nevertheless laid the 'foundations' and its value in everyday life was only evident later. For example:

*Kathy:* *You may not learn the specifics in school, but you learnt the basic building blocks...and later on it would become something useful.* *(FS3/227)*

However, all women in science groups did not share this view. Despite their extended education in science, their experiences had been somewhat restricted and reflected a gender bias in science education at the time:

*Beth:* *It's interesting that we were taught how to sew and make cakes, but we weren't taught how to change a carburettor or replace the gasket on a cylinder head, were we?(FS3/262)*

A number of participants in non-science groups questioned the extent to which aspects of science used in everyday life were attributable to school science, or had been learnt from parents or elsewhere – a point that was also made by the pupils. As one parent commented:

*Christine:* *I think the two are confused for us now because we've learnt about the way the things are and we think we learnt them from our mothers. But we did learn the principles behind everyday things, but you don't actually realise it at*

*the time, you think, 'why on earth are we learning this?'*
*(MFN1/213)*

Similarly, a recurring comment across all groups was that much of the application of school science to everyday life was unconscious. Women in non-science groups referred to the use of scientific knowledge in caring for their children, with comments such as, 'you don't realise you're using it, you just do it automatically' (FN1/157). A man in one non-science group typified a more general view of the use of school science in everyday life:

*David:* *I think the analogy would be – can you see the wind? You can't see the wind but you can see the effects of the wind. You can't see science, but you can see the effects of science.* *(MN1/191)*

One parent maintained that school science would always appear to be more useful with the benefit of hindsight:

*James:* *I think you don't appreciate that knowledge is the gradual accumulation of ideas, and probably the foundation of that you sometimes don't realise is being laid.* *(MN2/76)*

Participants in one mixed non-science group also made the point that even if school science had focused on the utilitarian, much would be irrelevant today:

*Edward:* *In my day the only computer was Ernie that drew the premium bonds. That was it. For instance, say a plane. Ordinary people didn't seem to go on planes because they didn't have the money. Cars, again that's all to do with science, how a car works, but not everybody had a car, not everybody had automatic washing machines, and now they're digital.* *(MFN2/291)*

This comment highlights the danger of allowing immediate instrumental value to predominate in the determination of the curriculum. Atwood machines, the triode valve, Fletcher's trolley, Searles' bar, the slide rule, much of botany and other topics have long since passed into curriculum history. One only has to look at the enormous transformations in technology of the past fifty years to realise that the instrumental value of any particular technological application of basic scientific concepts is highly circumspect and may have a short shelf life. Rather, the main value of technological applications for school science is the provision of much needed meaning to what would otherwise be an arid fare – a subject solely of academic interest.

### The value of school science as a way of thinking

The value of school science as 'a way of thinking', for developing 'problem solving skills' and 'presentational skills' was a recurring theme in men's science and non-science groups. The argument advanced was that the value of an education in science was not simply as a preparation for a science-related career, or for its application to everyday life, but that the subject had broader applications in the lives of individuals:

*Peter:* *I still use a lot of the skills of reasoning that one used in science in what I do now. I mean a lot of my work now relates to the law and how to interpret statute law and the reasoning is very, very useful.* *(MN1/177)*

*Gordon:* *In my view the thing that really came from school science was a logical way of approaching problems and I think that's far more valuable than the actual scientific knowledge.*
*Roland:* *Exactly. It's just a way of managing – solving problems. Because engineering is largely about solving problems, where there isn't necessarily a right answer, so it's choosing the most appropriate solution. And a lot of things in life are like that, where there isn't a right answer.* *(MS3/239-240)*

In the light of pupils' complaints that science is dominated by 'right' and 'wrong' answers, these comments, which reflect a valuing of the transcendent intellectual skills inculcated by school science rather than knowledge *per se,* seem somewhat contradictory. They suggest that the factual emphasis has come to predominate even more, or alternatively, that the genuine residue of school science is an analytical mode of thinking which is not developed by other subjects. Thus school science fostered the desire to 'find explanations for things' (FS1/151) with examples such as stripping a car engine to more fully comprehend how it worked, or 'trying to quantify how far a storm is away from the thunder and lightning' (FS/151).

A small number of women in non-science groups also valued school science for instilling in them a questioning approach to aspects of their daily lives:

*Jane:* *For me it became a way of questioning things and I think that's probably what it's useful for in my life. If someone asks you something, like one of my children, I never answer them, I just ask them another question. I think that to me has been the most useful thing it's given me, you want to question things not just accept them.* *(FN4/168)*

A final feature of the value of school science in everyday life, mentioned by parents in science groups, was that scientific knowledge enabled them to support their own children's education. Parents expressed pleasure in being able to explain a wide range of aspects of science to their children. For some parents this went some way towards making up the 'deficiencies' of the current school science curriculum, but for others it was a way of setting their children's learning in context through relating aspects of science to important current issues:

*Maggie:* *I was lecturing my son on physics, which I do fairly frequently. The government had got this campaign to get everybody to obey the 30 mile an hour speed limit because no one can grasp how fast the energy of a moving car moves. It's proportional to the square of the velocity. So a car moving at 20 miles an hour has a force factor of, say 4, if you like. A car moving at 30 miles an hour has a force factor of 9, that's twice as much and 40 miles an hour has a force factor of 16, you know and that's just simple physics... That's why people get killed, by a very marginal increase in speed.* *(FS3/214)*

### Aspects of science parents would have liked to have learned

Parents' responses to the question asking what they would have liked to have learnt in school science differed considerably across the groups and reflecting two distinct aspects of science; those which were of intrinsic interest to individuals, and those which had practical application in their everyday lives.

Perhaps, not surprisingly, parents in non-science groups made the majority of suggestions and these frequently centred on the utilitarian aspects of science:

*Nigel:* *People are saying I wish I done this at school and it's because it's something that would have done you some good in your life...If you'd known a bit more about things like electricity, every time something needs fixing in your house you wouldn't have to pay for someone to come and fix it, you know, because it's simple really.* *(MN3/526).*

In contrast, those parents who had studied science beyond the age of 16 years and had pursued science related careers were unable to identify many areas of omission in their own science education. The exceptions were aspects of science they had chosen to abandon but which had been found to be of intrinsic interest later in life, for instance:

*Ian:* *I gave up biology before O levels and have developed an interest in it since and I wish I had pursued it.* *(MS4/80)*

Women in both science and non-science groups frequently commented that they would simply like to have learnt 'more science' and 'more in-depth science' (FS2/374). A number of women in science groups reiterated earlier comments about the lack of accessibility of science for women, stating that they would have appreciated greater equality and encouragement and thereby have gained a broader education in science. Women in non-science groups stated that they, 'would have paid more attention' (FN3/580) if they had realised the 'significant part to be played by science' (FN4/414) in their future lives. All of these comments reflect a recognition amongst the populace at large that science is now an important component of the cultural life of contemporary society.

Two further significant points arose during this part of the discussion. On the one hand men in two non-science groups complained that school science in their day was portrayed as an unchanging body of knowledge. Its retrospective, rather than a prospective vision, left pupils without:

> *Simon:* … *any sense from the science teachers that it was a living, developing thing. It was almost like it stuck, this is it. This is science and I'm passing it on to you and it's not to do with how the world is changing and how our view of the world is changing. You didn't get that at all.(MN2/178)*

On the other hand there were those parents who reiterated the point that developments in science over the past 20 to 30 years had been unanticipated, therefore, it was unrealistic to expect school science to be prescient. Examples were given of scientific advances in the areas of mechanics and electronics, including computers and household appliances that would have been impossible to predict. However, given that similar points were made by the pupils about the lack of contemporary science, it would suggest that the substance of this criticism is not about the ability of science education to foresee the future, but rather, its obsession with reconstructing an established body of knowledge. The resulting singular focus on its justification – essentially a retrospective vision – rather than its contemporary development, a prospective vision, leaves pupils with no sense that this is a dynamic, ever-changing, present-day body of knowledge.

In summary then, it was clear from the comments made by parents in all groups that they valued their education in science, however limited it might have been. It had instrumental value for fixing things around the home, for offering explanations to themselves and others, and for the development of problem-solving and thinking skills. However, for a significant number of parents the value of school science was strictly limited. Much of their scientific knowledge had been gained from sources outside school, including their own parents, books and, in some cases, their own children. It was widely recognised that the lesson of their own experiences had been that predicting what knowledge might be valuable to learn was extremely difficult. Hence the significance of their aspirations about what they would have liked to have learnt was more of a retrospective rationalisation than an expression of genuine concern.

# thirteen

## The importance of school science for all young people today

Parents from all groups had clear ideas about the reasons why school science was important. The consensus of opinion was that the value of school science for their children lay in its potential to provide a unique insight and an understanding of the world in which they live. Parents highlighted the ubiquitous nature of science, with such comments as, ‘every aspect of life involves science’ (FN1/273) and, ‘society is moving forward because of science’ (MS2/125). It was therefore important for every child to study science at school, to develop an understanding of ‘the basics of what makes things tick, why things occur’ (FN5/389).

***Technology versus Science***

An important precursor to this discussion, for the men’s groups in particular, was some debate about the difference between science and technology. A number of parents drew a distinction between the science they had studied at school, characterised by a physics, chemistry and biology that privileged science over technology, and the science and technology in contemporary society where the two were often inseparable. Men in non-science groups argued that there was no self-evident difference. Similar points were made in some mens’ science groups who failed to reach a consensus on the point, maintaining that, whilst the distinctions between science and technology were ‘blurred’, fundamentally, scientists were the ‘the ideas people’, whilst technologists put the ideas into action. Technologists were people who ‘will take over and do something with it’ (MFS1/269). However, despite some unresolved differences of opinion, it was notable that subsequent discussion made no distinction between the two. In contrast, female groups did not even debate the point. Comments such as ‘I wouldn’t separate science from technology’ (FS3/283) and, ‘I think it’s probably the same’ (FS3/287) indicated that many viewed science and technology as synonymous. Thus, in interpreting the comments that follow, it is important to remember that science and technology were rarely differentiated.

***Why school science matters***

The majority of parents in all groups shared the view that, as well as science, English, mathematics and, particularly information technology, were important subjects for their children to study at school. Not surprisingly, it was parents in science groups who adopted the view that school science was a vital part of their children’s education. As one parent commented, ‘I can’t even think of not offering it to children’ (MFS3/159). Women in non-science groups, whilst emphasising the value of science as one of the most important subjects, stressed the need for the development of rounded individuals who were able to communicate on all levels. The point was made by a number of non-science groups that, with the benefit of hindsight, they had reached the conclusion that school science had always been important for young people, but at the time they had not been encouraged to appreciate its value in their lives in the longer term. As one participant stated, ‘I didn't get a sense that it was going to be so important' (FN1/61) but they now realised, 'when you look back how important it was' (FN1/64).

Women in non-science groups also placed a greater emphasis on the importance of school science for the development of young peoples' understanding of science in everyday life, for instance:

*Anne:* *It's about food and nutrition and bringing up children, gardening, household tasks, everything. I think it is absolutely crucial; I think it's the most important subject.* *(FN1/273)*

Several men and women from non-science groups made the point that their children were growing up in, 'a far more technological society than we were' (MFN1/245) and where, for example:

*Brian:* *We are surrounded with things that require science for us to understand them.* *(MFN1/245)*

Whether it is true or not, that this is a more scientific and technological age than has ever existed before, the important point is that this is the received wisdom of the majority of parents. Its implication is that many parents would support science's demands for a substantial amount of curriculum time.

A further area of importance, identified by parents in a number of science and non-science groups, reiterated their view that the value of science lay in developing what was described as the 'mental tool kit' (MS1/454) of science. Parents in science groups maintained that school science, more than any other subject, had the potential to encourage, 'logical kinds of thought processes' (MFS3/152) and a set of procedures that set it apart from other subjects.

### The value of school science for an understanding of socio-scientific issues in society

Parents from all groups stressed the importance of school science for developing young peoples' understanding of socio-scientific issues. However, it was not considered sufficient for their children to be taught that such issues existed, they needed to understand the root causes, such as, , 'what actually is the greenhouse effect' and 'the gases involved'(MFS3/164). It was insufficient for their children to rely on outside sources of information, such as scientific journalism that were thought to be 'unreliable' as a means of obtaining accurate information.

The reference to the unreliability of media reports of science reveals the crux of this aspect of the discussion among all groups of parents. Reports read by parents in non-science groups had led them to view recent science related issues, such as BSE and genetic engineering to be 'threatening'. A number of parents made comments such as, 'in my day everything seemed so safe' (MFN2/496). In comparison, today's society raised issues such as genetic engineering which were considered to be hazardous, particularly in the area of genetically modified foods. The view was expressed that food 'has all been tampered with...now I think this is dangerous' (MFN2/474). It was of an issue of particular concern to women in non-science groups that school science equipped their children with sufficient understanding of socio-scientific issues to enable them to 'make informed choices' (FN3/496) as to whether they were prepared to accept and consume genetically modified food. With these, and other concerns reported below, parents were articulating the aspects of risk and trust that characterise the public relationship with science where science is no longer seen simply as source of solutions but also a source of risk (Beck, 1992; Giddens, 1990).

Parents in non-science groups argued that it was important that school science provided children with the tools to support an understanding of science and its role in society:

> *Joan:* *They've got to know what's going on in science nowadays. You've got information nowadays, a lot of information, and they've got to understand it.* *(MFN2/476)*

Similarly, parents from science groups emphasised the importance of the role of school science in enabling young people to adopt a 'questioning approach' to scientific advances:

> *Ben:* *We live in a scientific world where youngsters growing up now will, and should, be able to read the press and have a basic understanding of the dilemmas that are coming up. Things like cloning and Dolly the sheep, or whether we should be spending billions of pounds sending rockets to the outer fringes of the solar system. They should be able to make informed choices about those things, so they need that level of interest and that level of understanding.* *(MFS1/359)*

These parents argued that it was important for school science to encourage young people to adopt a 'critical view' of the reporting of science in the media. Women in science groups were concerned that their children should utilise an understanding of science to avoid what they saw as 'public persuasion' through the use of science in advertising:

> *Carol:* *There are so many scientific developments that people have to make a choice about for themselves. I find that more and more, commercially, people try and con people with science. You see it in the adverts, you know, use this shampoo and all this rubbish about absorbing vitamins through the hair.*
>
> *Sheila:* *Yeah, there are a lot of cons, like the great margarine con. Margarine's no better for you than butter.*
>
> *Carol:* *I think if you get the right attitude about science then you're a thinking individual and you'll question these*

*things, and if you don't, if you take things as they are spoon fed to you and just accept them at face value, then you'll be swayed by advertising.* *(FS3/316-320)*

Parents in science groups were also concerned that young people were able to discriminate between the substance of the issues and 'government rhetoric', or sensationalised coverage of issues by branches of the media, described by one participant as 'all this nonsense in the newspapers' (MS2/124). The view was expressed that decisions were being made by politicians that were not 'based on any form of science that I understand' (MS3/333). Socio-scientific issues were said to be reported by people who 'haven't got a clue about science', and who, consequently, were 'leading the general public down the wrong road' (MS2/126). The following example of scientific inaccuracies was proffered as an example of the kind of basic scientific errors committed by journalists, and a rationale for these men's concern:

*Ian:* *There are wonderfully ludicrous mistakes in scientific reporting. The graphics for the latest E coli outbreak on the BBC main news were wonderful to me. It was described as the E coli virus. If E coli has ever been a virus, I don't know...*
*Brian:* *But virus is a much more emotive word you see.*
*Ron:* *Oh yeah, it's more frightening isn't it?*
*Ian:* *I suppose it's because of the AIDs virus.*
*Ron:* *It's a nasty word.* *(MS2/127-143)*

It is very clear from these points that the majority of parents look to school science to provide the wherewithal to be critical consumers of contemporary science that is reported in the media. Critical, that is, not in a hostile sense, but simply in the sense that school science should develop the ability to ask the appropriate questions necessary to assess the significance and import of newly-reported scientific developments. It is then, somewhat ironic, that when there is a reasonable consensus amongst researchers that reading science critically is as much dependent on a knowledge of the social practices of science as it is on a knowledge of science or its methodology *per se*, that school science pays so little attention to the former.

### The importance of school science for personal health

A number of women from science and non-science groups expressed the opinion that school science had an important role to fulfil in informing their children on matters of health. Particular mention was made of the physical dangers of drug and alcohol abuse, and the point was made that school science should teach young people:

*Dawn:* *...what it's actually doing their body and, if they can physically see that, it might make them think twice.*
*Melanie:* *That's it. Unless there's a deterrent, unless there's something that they can physically see, then they're going to possibly have a go.*
*Joan:* *It's quite nice as well, when there's a lot of peer pressure,*

*to have something like that, that they can cling on to.*

Dawn: *That they can fall back on and say, 'no, I'm not doing it because it does this to your brain, it does this to your heart. Have you any idea what you're doing to yourself?'* *(FN3/477-482)*

A criticism levelled at school science by women in both science and non-sciecnce groups was that school science 'didn't go far enough' in providing information for young people to make informed choices and decisions about their lifestyles – a similar point to that made by a number of pupils. The view was expressed that 'too much is left to PSHE', when they would have preferred their children to learn more of the substantive 'facts' about the effects of drugs and alcohol in school science.

### The importance of school science for the future careers of young people

Whilst parents from each science group alluded to the importance of school science for the future careers of young people, non-science groups made few comments. A small number of men in non-science groups expressed the view that employment prospects for young people today were restricted and generally more dependent upon qualifications than twenty years ago. It was perceived that 'the way the world's gone' (MFN1/258) now made it essential for young people to have a qualification in science. Men in other non-science groups made a similar point, though the emphasis was upon the relatively high status of science compared to other subjects:

Ian: *If you get a list of people's qualifications and it's a science, it's, 'oh that's better'. You go down the list and if it's art and history and they don't seem so important.* *(MFN1/263)*

The perception of science as a high status subject in the eyes of prospective employers was shared by a small number of women in science groups, where the point was made that:

Liz: *Your employment prospects are really quite good if you're scientifically literate, that's a good starting point. (FS2/309)*

In two men's science groups, the view was advanced that school science was important in maintaining the supply of future scientists necessary to sustain the economic growth of the country. As the following comment shows, it was considered to be crucial that young people were actively encouraged to consider science related careers:

Anthony: *I think if we don't educate young people in science then the country will go down the drain basically. I don't think it is possible to run an advanced economy or industry without a knowledge of science.* *(MS4/201)*

Two science groups articulated the perceived need for schools to more actively 'market' science. On the one hand, the point was made that young people were frequently unaware of science related career opportunities:

> *Andrew:* *They don't see science or technology as where they are going to get a job* *(MS1/ 220)*

On the other hand, the point was made by men in one science group that school science failed to make the most of science as a way of thinking. 'The ability to model and abstract systems' (MS1/220), a skill developed by science, was seen to be just as valuable in careers such as banking as it was in more overtly science related careers, such as medicine.

Pupils, who often gave pre-eminence to the occupational value of science qualifications, articulated similar instrumental concerns. Taken in conjunction with those of the parents, it suggests that school science needs to make a stronger case for its general value for *all* careers rather than for any specific science-related employment. Increasingly, only a minority of good science graduates now enter science-related careers, choosing instead to follow careers in accountancy, finance and management where the logical and deductive mode of thought developed by science is valued and prized. Pupils, however, as this research and other work have shown, still see science as a propadeutic training for a future career in a science-related profession. It is hard, therefore, to escape the conclusion that this is the message still communicated by school science, either explicitly, or implicitly. If so, some urgent reconsideration is needed so that school science and its teachers emphasise the broad value of a science education for the future careers of all – rather than the chosen few who progress towards entry into the scientific academy.

# fourteen

## Parents' recommendations for changes to the school science curriculum

Parents in all groups initially asserted that they were unaware of the content of the current school science curriculum, other than through fragments of information gleaned from conversations with their children, or 'through what little I see as homework' (MN1/379). Nevertheless, all groups of parents articulated views about the kind of science curriculum thought appropriate for all young people.

The greatest number of recommendations for change was made by parents from science groups who made nearly twice as many comments as parent in non-science groups. There were also significant differences of opinion between parents who were currently engaged in science related careers and those in non-science related fields of work. Parents in non-science groups relied upon the experiences of their own children in forming their views about school science and, therefore, much anecdotal evidence was offered in support of suggestions for change. If their children demonstrated positive attitudes to school science, and were expected to attain satisfactory results in GCSE examinations, then few suggestions for change were made. In contrast, if their children were dissatisfied with aspects of school science, and/or approaches to the teaching of science, these reports prompted recommendations for change. Parents from science groups, on the other hand, adopted a broader perspective which looked to school science to equip young people with the knowledge and skills required to pursue science-related careers such as the ones they themselves had entered.

## Perceived changes in the school science curriculum in the last forty years

***A broader education in science***

Despite their avowed ignorance of the science curriculum, there was a strong current of opinion among parents in all groups that the extension of an education in science to include all pupils from 5 to 16 years, following the implementation of the National Curriculum, implied a 'broader' education in science and higher standards. A number of parents, particularly women in science groups, viewed the expansion of school science as a reflection of changes in society, for instance:

> *Mary:* *As far as I'm concerned, this is a very different society to the one I grew up in twenty years ago as a teenager. I think the science they learn today is much more broad-based and it is a better grounding… I think it's a really good basis for their future lif; they can build on it; it gives them more opportunities.* *(FS1/225)*

Parents across non-science groups felt that the increased breadth in school science had led to the inclusion in the syllabus of more applications of science to everyday life. Aspects of science studied by their children were deemed to be more 'relevant' and 'more to do with their lives' (FN5/389) than the science studied when parents were at school. For example:

> *Elaine:* *I think the content is related more to life outside. Now for example when they're doing something to do with energy, they are asked to give examples and they'll think of running, or putting the kettle on and what energy it's using. I feel more links are made with outside school in science now.* *(FN4/369)*

> *Harry:* *You look at a modern chemistry book and it actually puts it in context. If you are talking about a production line, the reason behind the process is there and you can put it in the context of the society we live in. When we did it had no meaning. You actually had to learn it. All the tests for chemistry, there were hundreds of them, whereas now there's meaning to it. It is so much better today.(MN1/459)*

Such comments stand in stark contrast to those of the pupils who still see too little relevance in the science curriculum. In part, this may suggest, that the quality of 'relevance' is age dependent. Life simply providing a broader set of vicarious experiences that enables the connections between school science and its application to be perceived.

Whilst the majority of parents across all groups welcomed a broader education in science for all young people today, a note of caution was sounded by a small number of parents from science groups, for whom such a development did not necessarily represent positive change:

> *Gerry:* *I think it's a broad-brush approach to an understanding of some basic principles as opposed to having people who are prepared to specialise in the subject. I think the GCSE curriculum is designed to give people a broad understanding, not necessarily a preparation for in-depth further study.* *(MFS1/501)*

### ***Standards of education in science***

A number of parents, particularly those from non-science groups, held the view that an extended school science curriculum had led inevitably to higher standards of education in science in the last 20 years, for instance, 'they learnt things in junior school that we probably did at the age of 15' (MFS1/477) and:

> *Roy:* *It must have changed because I wasn't where my son is now and I don't think we've bred someone who's super intelligent.*
>
> *Greg:* *It is far more advanced. I don't understand it. I was*

*fairly good at science, when I finished school I went straight into mechanical engineering, so I mean, I know, I'm not entirely unscientific. But the things they learn now are far harder than you need for mechanical engineering.* *(MFN1/390-91)*

*Meg:* *Even my little one in year 7 knows more than I did until I was doing my O level course* *(FS1/225)*

However, there was no consensus on this point; men in one non-science group and women in one science group, expressed the view that school science, in common with all subjects of the National Curriculum, had been 'dumbed down' (MN3/426). It was said to lack the depth and rigour of 30 to 40 years ago, for example:

*Tracy:* *I think it's not taught in as much depth – not taught in as much detail. The theory is not taught brilliantly I don't think. It's very much more dilute, they are mixing it together and they are diluting it and not teaching them the proper principles.* *(FS1/313)*

Men in one non-science group concluded that 'generally speaking O levels were more difficult' (MN3/426) than the GCSE examinations of today.

### Changes in approaches to teaching science

It was in this aspect of the discussion that parents' perceptions of school science today differed most notably from the views expressed by their children. Whilst a significant number of pupils had complained about the dearth of opportunities to engage in autonomous practical work in science, parents in all groups had formed the view that school science lessons were less 'regimented' today. Whilst they had been expected to 'do as we were told' and 'follow instructions', young people were now thought to be actively encouraged to work independently, to 'reason for themselves more' (FN1/124) and, as two parents perceived:

*Alison:* *They have to work out experiments, create them themselves in order to solve problems right from the start; set one up to work something out, do it and write it up.* *(FN1/125)*

*Giles:* *They're doing a lot of project work where they have to think about problems. They have to predict what the outcomes are going to be and they have to test their predictions. They check their predictions against the facts and I think that's really good.* *(MN2/146)*

Women in one non-science group had formed the view that pupils were now, 'less inhibited about asking questions' (FN1/127) and one parent expressed the view that, 'teachers think they're failing if they don't ask questions' (FN1/134).

Again, such views stand in stark contrast to those of the pupils, whose major complaints were the dominance of copying, repetition, and the lack of opportunity for autonomous work. They also stand in stark contrast to those of the teachers who saw investigations as little more than ersatz assessment exercises designed to ensure the maximum achievable mark for their pupils.

### Changes parents would instigate in school science

A significant number of parents in all groups were hesitant in making specific recommendations for change in the current curriculum for science, particularly parents from non-science groups, who lacked anything more than anecdotal evidence that changes were necessary. However, many parents in non-science groups had formed the view that their children were receiving a better education in science than they had received themselves commenting, for instance, that 'I actually think they're teaching me a lot' (FN2/486). Parents admitted that they were at a loss to make specific recommendations:

> *Clive:* *I would certainly want to change things, but I wouldn't know what they are. All I know is that I have a 15-year-old daughter who has lost interest totally in science. She comes home in tears about physics.* *(MN1/395)*

> *Dennis:* *I don't know, there isn't a magic formula...but I think a lot of what's taught doesn't seem to interest the children a lot, you know, not spontaneously. So maybe something's got to be done, what I don't know, but that would be my opinion'.* *(MN3/770)*

Although a number of women had stated that gender bias in school science had been eradicated, one science group questioned the extent to which their daughters' lack of interest in science was attributable to ongoing bias:

> *Alice:* *Having three daughters I do think that science is still gender-biased...I never thought I'd say this but that's been my experience. It is gender-biased.* *(FS3/350)*

The small number of pupils who opted to continue their studies in science prompted men in one science group to declare that, 'science education needs a radical change, especially in secondary school' (MS1/458) and that pupils needed to be 'more excited and interested in science' (MS1/460). However, little detail was provided of how this could be achieved other than a suggestion that if better facilities were available, more of secondary science could be taught in the primary school.

A number of parents in non-science groups shared the pupils' views of school science as subject characterised by an academic approach with an emphasis firmly on the learning of facts. For instance:

> *Andrew:* *My son brings home this thick biology textbook and then he has another one for chemistry and it is endless things he has to learn. Sometimes I think I would like to see him perhaps not having to learn quite so much scientific fact,*

*maybe spend a bit more time debating issues, or, you know, discussing values.*

*Phillip:* *There is sometimes a kind of facts grabbing thing, you know. You go home and do a bit of homework and you've learnt that. It's like you say, 'have you discussed it?' Now I don't know whether in science they get the chance to sort of discuss concepts and issues. You know, I'm sure if it was on the syllabus then the teacher would say, 'now we're going to discuss this'.* *(MN1/439- 455)*

One mixed gender science group maintained that a consequence of the academic approach was that science had been 'put on a pedestal', and was seen as having high status and being a difficult subject to learn. School science needed to 'demystify' science by relating it to the world in which children were living, as one parent explained:

*Martin:* *Science is much more integrated into what's happening now, you know genetic engineering, or computer science and without having a basic understanding or exposure to it, it's very easy for people to build up an aversion to it, because they don't understand the basics so they think it's scary and not for them. So I think it's important that they make it understandable and exciting and to know that there are ways of approaching it that won't turn them off.* *(MFS3/161)*

The point was further developed by men in another non-science group who questioned the suitability of an 'academic' school science curriculum for every pupil. These parents recommended a more utilitarian view of the school science curriculum in which the lines of demarcation between science, design and technology and information technology needed to be more diffuse to support those individuals who may have no interest in 'academic science'*:*

*Barry:* *I think we actually need to equate the way we're thinking about GCSE with a much more vocational route, so you're actually preparing people with much simpler sets of real but practical skills in science and D&T, rather than the academic approach that we've got today. That would suit quite a number of kids in this school better than sort of plodding on and ending up in a lower tier, feeling slightly fed up with it all.* *(MN2/145)*

The recommendation that school science should more positively embrace aspects of technology was further developed by men in one science group, who made the point that, 'most of the science that governs our society was there in 1945' (MS1/198), but the technology to develop such things as radar, microwave ovens and computers had not , and it was this component that should form an integral part of school science for all young people today. It was said that the 'social impact' of such technological developments was neglected in school science in favour of 'a very pure sort of science' (MS1/198) such as, 'distillation of things and laws' (MS/199) that were of use to future scientists but not to 'ordinary citizens'.

Although there was some agreement by parents in science groups with the view that there was a greater emphasis needed on technology and science for citizenship, they envisaged this aspect as only one of the two purposes of school science. On the one hand it was stated that school science should enable young people to work in science related fields and to understand scientific issues that impinged upon their daily lives. For such pupils they recommended a broader curriculum encompassing information technology and 'linked with current affairs'. One the other hand it was said that 'society needs excellent scientists' (MS1/302). Women in one science group expressed the view that a lack of specialisation in science earlier in the education of young people would eventually lead to a serious shortage of scientists in the fields of biochemistry and pathology. As one parent pointed out:

> *Anna:* *I think if science carries on being taught the way it is now, being more broadly based, in thirty years we are going to have no people who can do the jobs that we are doing. And where will be then?* *(FS1/250)*

It was stated that problems were already emerging in the recruitment of suitably qualified entrants into science related degree courses at universities. A broadening of the science curriculum with less emphasis on basic concepts was seen to present potential difficulties for those pupils who sought to pursue university degree courses in science-related subjects. These parents argued, therefore, that it was of paramount importance that pupils with academic potential were recognised and encouraged through the provision of a more 'rigorous' education in science than that that was possibly appropriate for 'less able' pupils.

Men in one science group stated that school science today was taught as 'nice little stories' (MS4/370), liberally sprinkled with 'analogies' which effectively undervalued the importance of school science and failed to support pupils' understanding of the 'fundamental laws of science':

> *Adam:* *I don't think it's answering contemporary questions and it's not securing the basic knowledge either.* *(MS4/500)*

Specific recommendations that were made by men in science groups included three possible aspects of change. First, a change in 'emphasis' was required towards a focus on 'the general principles and an understanding of the basics' (MS3/203). It was said, by men in science groups, that young people today were encouraged to express their views about contemporary scientific issues without the benefit of 'enough facts to base opinion on' (MS2/161). Rather an understanding of the basic relevant principles of science was first needed.

> *Joe:* *If they're to have an opinion on things like genetic modification of crops, or BSE, or whether to eat beef, there are certain more fundamental issues they have got to get to grips with first, so they can have an informed*

*opinion of what the technologists are doing at the leading edge.* *(MS1/210)*

Their second recommendation was that school science might be made more interesting and accessible for all pupils if it centred on the 'history of science', which was thought by men in one science group to be 'appealing for most people' (MS1/326). As one parent explained:

*Roland:* *They can see history, they can see the role of science in the long run and it may be a very attractive option which will bring them to an understanding of science. Not necessarily the nuts and bolts, but its long term aims and things like this. But I think the problem is that science has written itself off as it were. It's just for the few and turned off the majority.* *(MS1/326)*

The latter sentiment was strongly supported within the group. Parents commented that a 'rejection of science' was seen by young people to be acceptable in a way that it would not be for other subjects like maths and English:

*Tim:* *There is an anti-scientism that exists and I very much agree that if people understood better what science is doing for them and gave them some idea of the historical significance to society, in building the society which people enjoy, it should help to overcome that.* *(MS1/330)*

The third recommendation was that alternative science courses for pupils should be provided according to their 'interest' in and 'aptitude' for science. Until the age of 14 years it was stressed that all pupils required an education in science that provided a firm understanding of 'the basics'. The point was made that whilst it might be beneficial for teachers to encourage pupils to 'think for themselves', they needed the 'fundamental structure' if they were to make sense of later work in science. As one parent put it:

*Chris:* *The major steps in science were made by the greatest geniuses, not by 15 or 16 year old kids in the classroom trying to make something up.* *(MS3/119)*

When pupils reached the age of 14 years it was proposed that two different courses in science could be provided; a 'general', or 'combined' course for those pupils who 'aren't particularly able or interested in science' (MS3/351), and a 'specialist' course in the three separate sciences for those individuals who showed an interest in and aptitude for science. This was perceived to have the advantage of offering, for those pupils who intended to pursue their studies in science, the benefit of more plentiful resources and equipment.

Currently, parents thought that the current school science curriculum served neither group of pupils well:

*Nigel:* *In order to have a national curriculum you have to have targets which are achievable by everybody I suppose. I feel that a lot of the science is neither contextualised and dealing with real problems, nor is it fundamental and dealing with the laws. It is somewhere in between. I know when I'm talking to my son...he doesn't really understand the contextual side and when I say, 'well what's the law that's operating?'...I was a bit appalled that somehow he hasn't got it.* *(MS4/3666)*

The proposal for greater diversity, espoused by the parents, is similar to that made in the document *Beyond 2000: Science Education for the Future* (Millar & Osborne, 1998) which argued that all pupils should do a basic course in scientific literacy post-14 with additional modules or courses for those who are interested in the further study of academic or vocational science. These parents recognise that young people at age 14 are a diverse group with a range of abilities and aptitudes and that there may be no singular, universal, Procrustean solution to their science education. Finding the 'right balance' in the provision of an education in science for all pupils was something of a 'conundrum'. Nevertheless, it was a problem to which a satisfactory answer was imperative if the potential value of school science was not to be lost through its failure to meet the needs and requirements of young people today.

# fifteen

## Parents' views on the extent to which science is of interest to the general populace

Parents across the groups showed a lively interest in science in their everyday lives. However, opinions differed about the extent to which the general populace were interested in science-related television programmes, or articles on science in newspapers or magazines. On the one hand a significant number of parents across the groups shared the view that the general public had little interest in science, unless, 'it's relevant to you personally' (FN3/605), or alternatively, had a direct bearing on the 'lifestyle' of the individual. The view was expressed by men in one science group that people generally found science 'a turn off' and , 'the majority of people don't want to know' (MS2/289). The reason for this was said to be:

> *Simon:* *Because they've not had sufficient science education to piece together little bits of what they are being told and make something sensible out of it.* *(MS2/289)*
>
> *Ray:* *Joe Public wants to be interested in science, but I don't think he's got the basic knowledge.* *(MS2/283)*

On the other hand many parents, particularly those in non-science groups, maintained that there was a growing interest in science among the general populace. Information was now more readily available, principally through television programmes, and the view was expressed that:

> *Hugh:* *People are becoming aware of how science and everything that goes on around us really does influence things, and interest has gone up an awful lot in the last 40 to 50 years.* *(MN2/183)*

***Science related topics of intrinsic interest to parents***

Whilst parents in all groups expressed an interest in aspects of science and technology, there were differences between science and non-science groups in the television programmes which attracted their interest. The areas of interest for parents in non-science groups included gardening programmes, *Local Heroes, Robot Wars* and *Tomorrow's World.* Parents in science groups, in contrast, most frequently mentioned programmes such as *Horizon* and the *Royal Institution Lectures*.

Parents in non-science groups stated that the appeal of *Tomorrow's World* lay in the 'colourful style' used and the accessibility of the scientific information –'you actually understand what's going on' (FN3/648). However, parents in two science groups questioned the extent to which television programmes such as *Tomorrow's World* and *The Life of Birds* represented 'real science'. The thrust of the argument was that such programmes were designed to present science and technology as 'glamorous', with 'beautiful colours', failing to give an accurate image of 'real science' and that 'most science programmes are just commercial programmes masquerading as science' (FS3/521). This was thought to be particularly true of programmes about space exploration, which were described as 'popular science' and 'pseudo-science' by one science group. In direct contrast, a number of parents in non-science groups expressed their 'fascination' with programmes and articles about space exploration:

> *Alice:* *It's because that is going forward. I know where I come from and I want to know where I'm going. I want to know what's going to be there when I go forward and whether or not I can go with it.* *(FN5/726)*

This disparity of view possibly shows some failure to recognise the achievements of the popularisers of science. Whilst the criticism that popular science is not 'real science' is justifiable in that such books and programmes present science without using the standard symbols, diagrams and mathematics of science, nevertheless, the popularisers have succeeded in achieving that very important first step – engaging the public with science, successfully communicating a sense of wonder at its achievements. In the words of the *Times* commentator, Simon Jenkins (1998), 'the new science is science appreciated, not practised. It is science history, science ethics, science argument and controversy, even scientific method, the science of wonder in micro and macro-dimensions'. Whilst science may offer a vision, described by the 19th century French mathematician Claude Bernard, as a 'superb and dazzling hall', entry 'through a long and ghastly kitchen' is simply alienating for the majority of the public. The popularisers in contrast have found a new point of entry from which school science education may have something to learn.

### *Socio-scientific issues of interest and concern to parents*

Further aspects of science in which all parents expressed an interest were those of personal concern which directly affected their lives and those of their families. There were notable differences in the issues identified by parents in non-science groups and those in science groups. Women in non-science groups were particularly interested in health issues and medical advances which were seen to be important for their own well-being and that of their children. However, although medical science was also of interest to women in science groups, the members of one group voiced their concerns that the public perception emerging from advances in medical science was that science was a source of universal solutions:

> *Jenny:* *If you think about say, premature babies, very, very premature babies. You see these reports that this baby is going home and it only weighed a pound when it was born, and isn't it wonderful. And you see it wrapped in a blanket and everybody says, 'great!' But what they don't mention is perhaps the likelihood is that there is an 80 per cent chance that the baby has got quite a few problems. But there's a growing expectation among the public that science and technology has got the answer for everything.* *(FS3/619)*

However, no evidence was provided to support their view that people with little education in science believed that science had 'all the answers'. In contrast, a comment made by a parent in one non-science group typified the responses of a significant number of parents with similar educational backgrounds in science:

*Brian:* *When you're at school science is, sort of, the predetermined answer. In the big, real world science doesn't have all the answers. There is a new theory about the Big Bang that I heard today. It's sort of, now we've gone back to it again.* *(MFN1/474)*

This view – that science was constantly evolving and that scientists frequently introduced new theories – was a common theme to this component of the discussion across the groups. In the majority of groups parents offered examples of how scientific advances appear to directly contradict earlier findings and discoveries:

*David:* *I mean most peoples, sort of ready contact with science is, this thing is good for you. So this week what is bad for you is potatoes and bread because of all the starch. Next week you're told that starch is good for you and cholesterol is bad for you. This sort of process has been going on for many years now, where somebody has done something, a project or something and they've taken a certain number of a certain sample size, studied their characteristics and then produced a report.* *(MS3/511)*

Views expressed by parents about the reporting of socio-scientific issues in the media highlighted fundamental differences in perceptions of public interest in science between parents in science and non-science groups. Parents from science groups, particularly men, were of the view that the general populace were interested in 'scandal' and 'the hysteria' (MS4/418) associated with socio-scientific issues:

*John:* *It's not because people are interested in the science at all, it's because they want to hear the latest scare. And it's like gossip, 'oh look, there's another scare', or, 'oh look the scientists have got it wrong again. They are not actually interested in the science; they are interested in the latest exposé.* *(MS2/301)*

On the one hand there were those individuals who firmly believed that science held little appeal for the majority of people. On the other hand there were parents who felt that people were interested but had insufficient understanding of science to make sense of the relevant scientific aspects of the topics that were currently in the public arena.

In the science groups, it was suggested that the accuracy of scientific reporting could not be relied on; issues, which were not always new concerns were sometimes 'blown up by the media' to sate the appetite of the general public for the sensational; and that there was currently a climate of 'anti-scientism', perpetuated by the media:

> *Len:* *It's fashionable to be anti-science, you know, when it's reported in the papers about genetically modified foods, it's Frankenstein foods. Why? Who said it was Frankenstein food, what basis does this have? And BSE, what evidence is there that BSE causes this disease called CJD? From what I've read there is very little evidence whatsoever and yet we destroy our beef industry, you know.* *(MS4/478)*

However, if the parents in non-science groups interviewed for this study were at all representative of the general populace, then the last statement is *not* an accurate reflection of their level of interest in socio-scientific issues. There was no suggestion during discussions in the majority of non-science groups that participants were interested only in the 'latest scare'. Whilst several parents acknowledged their 'limited' understanding of the scientific aspects of issues such as BSE and genetically modified organisms, their comments reflected a very real desire to understand the science behind what was described as 'the hysteria' of media reports.

> *Carol:* *Most newspapers have a day in the week where they have science, two pages or something. I would read that. I would always read that.* *(FN4/507)*

A number of parents in non-science groups voiced the opinion that their understanding of scientific issues was hindered by the restricted nature of the information reported in the media:

> *Mary:* *I understand what BSE is, what I don't understand is the actual risk, because everybody seems to have a different opinion and there's no one body that's saying this is definitely what will happen if you eat this particular food.*
> *Lesley:* *This is because it's political isn't it?*
> *Mary:* *Well it's calculated what information you're given, that's what frightens me*
> *Rose:* *That's right, because you're not given the full information.*
> *June:* *Some things are held back by the government and the authorities and you're given a certain amount of information, what they think you can cope with.*
> *(FN3/705-722)*

These comments suggest, that the non-scientific public *is* interested in scientific matters, and they *can engage* with science in a critical questioning manner. Furthermore, it would suggest that simplistic deficit models of the public as ignorant, such as those held by the parents in science groups, particularly the men, are misrepresentations of the public's interaction with science. In short, the gulf between their distinct viewpoints is indicative, perhaps, of many of the failures of the scientific community to engage the wider public.

In two men's science groups the point was made that it was possible that information was withheld from the general public. Parents in one non-science group contested this view, and rather were of the opinion that the lack of information about science-related issues was due to difficulties of interpretation of the science involved:

> *Gavin:* *I think the biggest problem is that scientists are at the cutting edge. They have difficulty in describing or interpreting exactly what they're doing so it's clear cut. Then the reporter has difficulty interpreting what the scientist said to them. Then the editor has difficulty interpreting what the reporter said, but they go ahead and print and publish it. And we have difficulty interpreting what on earth it is because it's got so muddled in between.*
> *(MFN1/466)*

Parents in science groups did not, however, share the view that the inadequacy of media reporting was due to a lack of accurate interpretation.

A comment from a member of one science group encapsulated the perception of a number of parents in science groups about the value of school science in facilitating an understanding of scientific issues:

> *Toby:* *I think there's an inherent trait within people that you're either interested in science or you're not. I think that manifests itself at quite an early age and it obviously dictates what people choose to do at school. But also, going on from that, if you had a bad experience of science at school, you didn't get on with it, you didn't like it and you never understood it. If the teachers never put it across properly, that's going to reinforce your inherent dislike of science to the extent that you just don't want to know.* *(MS2/357)*

The general enthusiasm for this aspect of the discussion reflects a growing perception of the importance of scientific issues that have, at the beginning of the 21$^{st}$ century, become some of the central ethical and moral dilemmas posed for our society. They also reflect a desire to be better informed, and by inference, better educated in such matters. And hence, they explain, at least in part, why so many parents now consider school science education to be a vital component of their children's education.

For school science educators it begs the questions of what kind of knowledge and skills are needed to interpret critically, scientific information presented in the media. If, as Layton et al. (1993) argue, the public 'view scientific knowledge less as an outstanding manifestation of human curiosity about the natural world….than a quarry to be raided', then how might school science education assist them to perform that process? The evidence so far would be that it has only limited success. The research that has been undertaken on students' ability to interpret science in the media shows that even able 18 year old pupils have difficulty recognising justifications or distinguishing evidence from conclusion (Norris & Phillips, 1994). Zimmerman et al. (1999) have shown that much of what students need to know, in the opinion of scientific experts themselves, is knowledge of the social practices and structure of science as much as it is a knowledge of the scientific facts themselves. Thus, the standing of the researcher, whether the research builds on a previous body of work, whether it has been peer reviewed and the level of support the findings accrue from the scientific community are as important as the data and the methods. The omission of these important 'ideas-about-science' from much of what students encounter in their formal science education fails to develop the knowledge necessary to understand science-as-it-is-practised – a component that is essential to interpreting reports of contemporary scientific advances.

## Major Themes

Several important themes emerge from these data from parents. First, there is a recognition that school science has changed principally in two ways. No longer does school science permit the stereotypical gender choices that permitted girls to do biology, and boys to pursue physical sciences. Whilst these parents still expressed doubts about a residual gender bias in the content of the existing curriculum, this change does represent a significant achievement for equity of opportunity for both genders. Moreover, the comments of parents in all groups would indicate that the scientific knowledge developed by school science is something that, retrospectively, is highly prized. Two findings, therefore, which provide arguments to justify the existing provision. Permeating many of the parents' comments is a sense that scientific knowledge is valued not simply for the career opportunities that it affords, but also because it is a strong aspect of contemporary culture which demands both pupils' and parents' engagement – either in their domestic environment or through the issues it raises for society as a whole. Embedded too in their comments is a perception that the school science that their children experience is less based on rote-learning of facts and broader and more engaging, though there was a lack of consensus about whether it is more or less demanding.

Second, the comments of these parents show the features of a school science course that are enduring and leave a positive affective residue. School science is engaging when it is taught by enthusiastic teachers who are also good communicators. The abiding memories of school science are those associated with dramatic events such as dissections or watching chemical reactions. Removing such events, or diminishing the opportunity for such experiences, has a high cost for pupils' affective experience of the subject. School science is remembered positively too when it makes contact with the contemporary events of the age be it the space exploration or the blast furnaces of the 1960s, or the global warming and cloning of today.

Finally, seen too here is the notion that learning science is hard – both because of the nature of the subject matter and the lack of variety in the way in which it is taught with an emphasis on rote learning. Parents recognise that school science serves two masters – the education of the future scientist and the education of the scientifically literate citizen – and that these different needs produce an uncomfortable tension. Their solution was to suggest diversity in the curriculum offered post-14.

# Summary and Conclusions

This report offers an important window on the pupils' perspective of school science education and their reactions to their experience. A decade after the introduction of the National Curriculum and the compulsory imposition of 'science for all', it would be pleasant to conclude that all is well with the teaching of science in schools. The data here would suggest otherwise, and perhaps, that national curriculum science is, for many reasons, unappealing to too many pupils.

Emerging clearly is a number of discontents about current practice, particularly in key stage 4. Dominant amongst these is a sense that, whilst science is considered to be an important subject, that message is not successfully communicated to all pupils by *school* science. Missing, for far too many pupils from far too many of the topics, are those vital ingredients – relevance and greater autonomy. School science engages when it makes connections to the pupils' everyday lives. Hence the success of human biology – knowledge whose application is immediate, transparent and unquestionable. Physics and chemistry, in contrast, have less points of contact with pupils' experiences and, even when technological applications are introduced, they are often done as a postscript whose illustrations appear archaic to some pupils. The privileging of science over technology within the National Curriculum is akin to introducing the grammar of a language before being practising its use. In both situations, the abstractness of the former over the relevance of the latter is simply incomprehensible to pupils. Rather, the findings of this research would suggest that courses that privilege technology over science – introducing the applications first such as *Salters Science* – should be the natural first choice for any school. Any other curriculum course should require careful justification.

> ***Recommendation 1****: School science courses should, wherever possible, be based on an approach that uses technology to introduce new topics and then develop the science content, rather than the obverse.*

Vital to any such course, as well, would be a component that allowed for the exploration of aspects of contemporary science. The findings from the parents' groups show that this *is* an expectation that parents have of the school science curriculum. From the pupils' perspective, such an element is essential to providing a connecting thread between school science and the 'real' world of the adults, endowing the subject with a relevance that no other mechanism can. Whilst pupils will accept a curriculum diet which consists largely of the received wisdom of uncontested and pre-established knowledge, contemporary science offers a glimpse into the world of here and now, and not the world of yesteryear. This is a world of science-in-the-making, of future possibility and uncertainty where their views can begin to matter providing an essential dose of salience and significance. Just as good English teachers have always drawn parallels between the plays of Shakespeare and contemporary life, so effective science teachers make links between the science they teach and today's technology. But the strength of the views expressed in these data suggest that the link between science and contemporary events is too often ignored, or alternatively, crushed by the weight of an overloaded curriculum. Therefore, we would suggest that any future revisions of the curriculum need to institutionalise such links either through the programme of study, schemes of work, or formal assessment.

***Recommendation 2**: The study of some issues raised by contemporary science in any science course post-14 must be an integral part of the curriculum.*

The diet offered by national curriculum science is both insufficiently varied and overwhelming. In a climate of 'high-stakes' assessment where many teachers feel compelled to cover the entire content of the National Curriculum to maximise their pupils' chances of success, the experience is too rushed, forcing teachers to use techniques such as 'copying' which are both mentally stultifying and of little educational value. The other unintended effect is the elimination of anything extraneous of a time consuming nature such as practical work or opportunities for discussion. Yet, it is exactly these components that are highly valued and prized by pupils for the opportunity they offer for a personal contribution, and the interest they generate in the subject. In such circumstances, it is hard to avoid the conclusion, that the imposition of such pedagogic practice by current policy, intentionally or otherwise, is simply shooting the long-term interest of science in the foot. Moreover, it is highly anomalous, that in an age when society increasingly places a premium on the ability to retrieve, sort and sift information, that the science curriculum continues to place an emphasis on the comprehension and recall of basic concepts. The contrast between the political rhetoric, which places a high premium on the value of education for the skills which contemporary society prizes, and the 19$^{th}$ century emphasis on an ability to recall the 'facts' of science is very stark.

All groups, pupils, parents and teachers, independently suggested a post-14 curriculum consisting of a core plus optional modules. The core would provide an essential element of breadth, whilst the options would both permit study in depth of topics that interest pupils, and reduce the content to manageable proportions. The idea that a single, universal Procrustean curriculum would be an appropriate solution to the diverse needs of 14-16 pupils never has had any justification, either psychologically or historically, and for that matter, never will do. Such a solution would also provide an element of choice that many of the pupils seemed to be requesting.

***R*****ecommendation 3**: *The curriculum post-14 should consist of a core course plus further optional modules that would provide an element of choice, both for teachers and their pupils.*

In addition, it would allow some flexibility to provide a curriculum fare that could, for instance, provide more biology and less physics and chemistry. What our data show is that whilst biology still retains its traditional appeal for girls, it is also appealing to boys. The appeal of chemistry and physics is less. Amongst science teachers themselves, the majority have biological science qualifications and find difficulty in teaching outside their specialist domain. In such a context then, there seems little justification for insisting on an equal division between the subjects, especially when large elements of physics and chemistry have been covered at key stage 3.

***R*****ecommendation 4**: *Whilst any post-14 course should contain elements of all physics, chemistry, biology, earth sciences and astronomy, the requirement that it should be balanced is no longer appropriate to the interests of all pupils.*

The issue of repetition is another issue that needs addressing. The latest version of the science National Curriculum (DfEE, 1999) has made some attempts to excise material from key stage 3, covered in key stage 2, and material from key stage 4, covered in key stage 3. However, of itself, such changes are likely to be insufficient. Partly because there is good evidence that secondary science teachers are still failing to recognise the strengths of science in the primary schools (Nott & Wellington, 1999), and partly because the hierarchical nature of the subject means that many topics will be revisited, albeit in a more complex and sophisticated form. A strong finding from this research is that neither the need for repetition, nor the distinction between current and previous approaches is self-evident to pupils. The apparent simple repetition of a topic, which fails to build and develop pupils' knowledge, and to make its new insights distinctive, has the potential to alienate many pupils from the subject. In the short term, teachers need to be more aware that the repetition within the exiting spiral structure of the curriculum is a point of disengagement for many pupils.

In the longer term, it begs the question whether science is best taught in this manner? An alternative would be to cover fewer topics in each key stage in more depth, eliminating much of the potential for repetition. If variety is truly the 'spice of life', then a curriculum which, unintentionally or not, fails to provide a varied diet and enhances the opportunities for repetition is doomed to generate some of the negative affective outcomes that we have reported here.

***R**ecommendation **5**: The curriculum at Key Stage 2, Key Stage 3 and Key Stage 4 should be clearly differentiated from each other both in their aims and content.*

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Emerging spontaneously and unsolicited, from interviews with both pupils and parents, was a plethora of comments about the importance of 'good', enthusiastic teachers of science for sustaining their own interest in the subject. Maintaining school science as a vibrant, stimulating and lively subject within schools is, in our opinion, absolutely dependent on the ability of the education system to recruit and retain competent and confident teachers of science who are justly remunerated for their skills. The current recruitment crisis, particularly in physics and chemistry does not bode well for the future of school science. In the long term, the failure of school science to engage its pupils will inevitably lead to a greater exacerbation of this problem as fewer and fewer pupils choose to return to a subject that lacked appeal. In the short term, we feel that this is a problem that requires urgent attention and reconsideration to make the profession of science teaching both valued and financially rewarded if school science is not to enter a spiral of decline.

***R**ecommendation **6**: The recruitment of effective science teachers is vital to sustaining the subject and requires urgent and immediate attention by the science education community.*

Whilst the science education community saw national curriculum science as a means of ensuring all sciences were taught to all children until age 16 – a deliberate, uncontested and positive outcome – they failed to recognise that policy changes are often accompanied by unintended, or unrecognised outcomes, in this case often negative. If so, and our data would suggest that there are significant concerns about the affective outcomes of current practice, then these should not be ignored.

For its consequences – alienation or disengagement with science have two obvious effects. First, there has been no improvement in the uptake of the sciences post-16 (Department for Education, 1994; Osborne et al., 1996). Whilst there is some debate over whether the economy needs to increase the present supply of scientifically educated individuals (Coles, 1998; DfEE, 1997), there is no doubt that there is a concern with the quality of the existing recruitment and the declining point-score averages of students entering undergraduate courses in science. Second, whilst there is no evidence that the experience of school science is a causal factor in the public's relationship to science, evidence from social psychology does suggest that attitudes to an object (in this case school science), once formed, are enduring and difficult to change (Ajzen, 1984; Petty & Cacioppo, 1986). Thus negative affective experiences, of the type described in these data, may remain long after any cognitive achievements. The consequence may be disenchantment with science which is seen as a subject of little interest; a domain which is hermetic, exclusive and 'not for me' – essentially one which is beyond the comprehension of the average individual. In an era where scientific issues such as genetic modification of foods, global warming and others continually surface as *the* political and moral dilemmas confronting society, the disengagement or disenchantment of our youth with science may increase the separation that currently exists between science and society. Such a consequence is one that an advanced industrial society can ill afford to pay, both at the individual level where it might lead to the rejection of sound scientific advice, or at the societal level where limitations may be imposed on scientific research that could have potentially beneficial outcomes for humanity. Perhaps, more tragic, will be the simple rejection of a body of knowledge that must, on any account, represent one of the greatest cultural achievements of Western societies. As a society, we ask, is this a price we can afford?

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# Appendix 1A:

## Questions used in Focus Group Interviews with *Pupils*

*The value of school science*

**Q1** What was your favourite subject at school and why?

**Q2** Comparing science to your favourite, or other subjects you studied at school, in what ways would you say that science was different from your favourite, or other subjects?

**S2** In today's society science is one of the most important subjects to study at school.

*The application of science to everyday life*

**S1** The science I learnt at school has been of little use or value to me in my life to date.

*Visions of school science in the future*

**S3** If I had a free hand to decide what young people learnt in school science, I would not change anything.

*The appeal of science in everyday life*

**S4** The science that I read in the newspaper and see on TV is of no interest to most people.

# Appendix 1B:

## Questions used in Focus Group Interviews with *Parents*

**Q1** What was your favourite subject at school and why?

**Q2** Comparing science to your favourite, or other subjects you studied at school, in what ways would you say that science was different from your favourite , or other subjects?

**Q3** In what ways was science similar to your favourite, or other subjects?

**S1** The science I learnt at school has been of little use or value to me in my life to date.

**Q4a** Can you think of occasions when you have found the science you learnt at school of any use or value to you in your daily life?

**Q4b** Can you think of aspects of science you learned at school that have been of no use or value to you in your daily life?

**S2** In today's society science is one of the most important subjects to study at school.

- Explain why/why not

**Q5** Do you think learning science at school should be optional for young people? Why? Why not?

**S3** If I had a free hand to decide what young people learnt in school science, I would not change anything.

**Q6** With the benefit of hindsight, what would you have liked to have learned about in school science that you didn't? Why?

**S4** The science that I read in the newspaper and see on TV is of no interest to most people.

**Q7** What science related things have you seen in the newspapers and on TV?

**Q8** To what extent has school science helped you to understand any of these issues?

**Q9** Do you talk with your children about science related things, issues or events in your home? What issues have you discussed recently?

**Q10** Do you think school science helps them to understand the issues you discuss?

# Appendix 1C:

## Questions used in Focus Group Interviews with *Teachers*

**Q1**. What one aspect of science do you enjoy teaching more than any other and why?

**S1** The negative views of school science offered by many pupils in the report are not justified.

**Q2** Pupils attributed their loss of interest in science to the steady decline in opportunities for engagement with science in KS3/4. How might this be resolved?

**Q3** How do you respond to pupils' comments that, on the one hand, there is too much to learn in science in KS4, but, on the other hand, there is too much repetition in certain aspects of science?

**Q4** How do you respond to pupils' comments that there is excessive 'copying' in science?

**Q5** In the light of these findings, how would you make more school science attractive to more school pupils?

- What would you change and why?
- Should science be optional? Why? Why not?

**S2** School science does not equip pupils with adequate knowledge and skills necessary to understand and participate in discussion of scientific issues in society.

**Q6** How do you respond to pupils' perceptions of the value of science in career terms rather than in cultural terms?

**S3** Science is certain knowledge and there is no role for creativity in learning science, i.e. argument, discussion, using your own initiative, collaborative work, undertaking your own investigations