# Pupils' attitudes towards science: a long term perspective

In this study the attitudes of four pupils, two boys and two girls, towards science are followed over the course of six years. Data were obtained in two ways. First, and principally, by annual interviews undertaken in the pupils' homes throughout their science education from the ages of 11 to 16 years, and at the age of 17, one year after the ending of their compulsory schooling; secondly, by means of observations made during their science lessons in an English state (non-fee-paying) school from 1994 to 1999. Each pupil's attitudes towards science and their experiences of their school science education are described by means of quotations and episodic biographical vignettes. These allow us to track the ways in which the pupils' attitudes about science developed over the course of the study. The findings help to shed light on the reasons why many pupils lose interest in science during the course of their secondary science education.

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## Long term research in science education

As is widely recognised, there are not that many pieces of long term research in science education. A review of the field was produced in 1988 by Hanna Arzi who pointed out that one value of longitudinal research (the term she used) is it can look at the 'permanence' of measured outcomes. Arzi concluded that 'extrapolation of short-term outcome measures over the long-term can be misleading and hence is unjustified' (Arzi, 1988, p. 19). Another value of longitudinal research is that it can look at the development over a significant period of time of traits, attitudes, knowledge, understandings and views.

This is not to maintain that all valid educational research must be longitudinal. However, educational research with *no* temporal dimension would be severely limited in scope. Presumably it would provide only a snapshot of a classroom, a textbook or a document such as a country's curriculum for science education. Yet practically nothing could be learnt from such atemporal information. Even to interpret a photograph to any significant extent one needs to be able to compare it with something produced either elsewhere or at another time.

There is a parallel here with how each of us attaches meanings to things, including memories and experiences: we do so very largely as a result of our personal histories. As Proust (2002, pp. 51-5) famously and memorably made us realise in his account of the taste of the spoonful of tea into which a morsel of a petite madeleine had been soaked, our present experiences, including our attitudes, are largely constituted by our memories, our present memories by our past experiences.

One of the advantages of longitudinal research is that it allows us to follow developments in entities (i.e. individuals, organisations, policies, etc.) over time as these entities change (or don't). Arzi provided a useful working definition of 'longitudinal': ' … the label 'longitudinal' is reserved henceforth for *studies in which information on the same subjects was collected at least twice, over a time span of at least one calendar year extending beyond the boundaries of a single school year*' (Arzi, 1988, p. 23). Since Arzi's review, a number of longitudinal studies in science education research have been published including those by Bonnie Shapiro (1994), Gustav Helldén (2001) and myself (Reiss, 2000).

One of the things I have found attractive, and intellectually fruitful, when reading the work of Shapiro and Helldén is the way they write about individual pupils. Papers or books on science education very rarely have much that is memorable about individual children. It is not, of course, that the sort of research, such as ethnographic research, that focuses on

individuals is rare in schools; far from it. Rather, it is that it has rarely been used in the study of science lessons or learning in science over long periods of time. As a result, we hear little of individual children and how they experience and learn science, and even less of how their experiences and what they learn develop over time.

The focus of the first six years of my study has been on how pupils experience school science lessons and why some pupils enjoy science and do well at it while other don't. It is widely recognised in the UK and in a number of other countries that pupils enter their secondary schooling (around the age of 11 years) with high expectations of science and a positive attitude towards it. Over the succeeding years, though, interest in science generally wanes, especially in chemistry and physics (Osborne *et al.*, 1998, Parkinson *et al.*, 1998, Ramsden, 1998, Lindahl, 1999), though at least to some extent this is a feature across subjects in general rather than specific to science (Sutcliffe, 1998).

**Methodology**

Data collection began in September 1994 at a state (i.e. non-fee-paying) non-selective school for 11-16 year olds in a semi-rural setting in the South of England. One group of 21 mixed ability pupils was followed from their first Yr. 7 science lesson in the school onwards. (In England schooling normally

begins at the age of 5 years in primary schools with Yr. 1; most secondary schools in England, including the one I studied, begin at the age of 11 years with Yr. 7.) Classroom observations were recorded as I sat quietly at the back of science lessons making field notes.

In all, I sat in on 563 fifty minute lessons. Depending on the options they chose in Yrs 10 and 11, each pupil could have gone during the five years to a maximum of either 818 lessons or 1008 lessons. In fact, only two of the pupils I was observing ended up on the more extensive science course – Triple Award GCSE (General Certificate of Secondary Education) Science – in which each pupil gets three science qualifications at the age of 16. The other pupils did Double Award GCSE Science and ended up with two science qualifications (i.e. two GCSEs) at the age of 16. During the five years of fieldwork at the school, pupil absenteeism rate averaged 6.4%, indicating that a median pupil went to about 765 fifty minute science lessons during their time at the school.

Half way through Yr. 7 I wrote to the parents of all the 21 pupils in the class. The letter told them a bit about myself and the focus of my research and asked them if they would kindly let me come and interview their daughter/son at home. Nineteen of the 21 sets of parents agreed to this and the other two agreed from Yr. 8. The initial interviews half way through Yr. 7 were only with the pupils. At the end of Yr. 7 and each subsequent year I interviewed each pupil, one or both parents, and each teacher, learning

support assistant and student teacher who had taught classes during the year with any of the 21 pupils I was following. With the exception of two sets of parents and their children in Yr. 7 and one set of parents and their daughter in Yr. 10, all parents, pupils and staff at the school agreed to be interviewed by me on each occasion I asked. In all, 225 interviews were undertaken, each typically lasting between 15 and 30 minutes.

Attitude studies raise substantial epistemological issues. As Judith Bennett (previously Ramsden) pointed out in her review, the word 'attitude' is used, often uncritically, by researchers in a variety of ways (Ramsden, 1998). Frequently it is used interchangeably with such terms as 'interest' and 'motivation' or alongside such terms as 'views' and 'images'. Bennett concluded 'Where definitions, interpretations or explanations of terms are offered there appears to be a significant degree of overlap' (Bennett, 1998, p. 127). A related issue is that 'attitude' is not unidimensional: there are cognitive, emotional and action-tendency components (Oppenheim, 1992).

Assuming that a suitable understanding (or understandings) of 'attitudes' can be found, the question then arises as to how one attempts to determine or measure them. The most frequent method is to use Lickert-type scales. These have their uses – for example, they enable quantitative comparisons to be made between different groups (e.g. girls versus boys; pupils of different ages) and permit factor analysis (e.g. Parkinson *et al*., 1998) – but can suffer from problems to do with validity and reliability. In particular, Judith

Bennett notes 'there are very few examples of studies where repeat measurement of attitude over time have been incorporated in the design phase of a research instrument … such an approach is based on the erroneous perception that attitudes are stable and unrelated to cognitive states' (Ramsden, 1998, p. 131).

Nevertheless, despite these various difficulties in both understanding and measuring attitudes, Weinburgh's (1995) meta-analysis of the literature on gender differences in student attitude and on correlations between quantified attitude towards science and achievement in science found mean correlations between attitude and achievement of 0.55 for girls (so $r^2 = 30\%$) and 0.50 ($r^2 = 25\%$) for boys, suggesting, indirectly, that the studies she reviewed were indeed succeeding in measuring something reasonably close to what they intended.

In this study a different approach to the use of Lickert-type scales was employed. Pupils' attitudes towards science and their experiences of their school science education are described qualitatively, principally by means of their responses to those interview questions which asked them about their attitudes or feelings towards science or their science lessons. These allow us to track the ways in which their attitudes about science developed (or remained constant) over the course of the study. This approach allows for richer data and interpretation than is possible with larger-scale approaches such as those using questionnaires, however well designed.

Of course, this way of analysing and presenting data is less objective than most other approaches to the gathering of data on attitudes, particularly self-completed questionnaires. In this sense my analytical framework can be described as 'interpretative', as is, and has been for decades, the analytical framework of most ethnographic fieldwork. While I obviously hope that my interpretation has a certain validity, it is principally that – my interpretation. I maintain that objectivity is not to be equated with validity. I am in favour of validity but that which cannot be measured objectively can be of especial value to educational researchers. Notwithstanding this, in an attempt to allow readers to judge for themselves the worth of my conclusions, I include below verbatim quotations and a certain amount of objective detail to aid in interpretation.

**Results**

Here, for reasons of space, I concentrate on just four of the pupils, two females and two males. Any of the pupils could have been chosen, so the four described here are the first two females and two males in alphabetical order of pseudonym who were at the school for all five years: Burt, Catherine, Edward and Mary. In describing, and attempting to understand changes in, their attitudes to science, I have tried to set the information I

gathered on their attitudes to science into a context, informed by my impressions of their personalities and home circumstances.

*Burt*

Burt, his three older sisters and his parents lived in a large detached house in a village some four miles from the school. In the Yr. 7 lessons I noticed that he had a good knowledge of science and behaved as most teachers like children to behave: Burt was quiet and diligent. After my first home visit I found myself feeling that he had a very distinctive personality though it was hard to say just how. In answer to my question 'How are you finding [Pasmoor School – also a pseudonym] compared to your previous school?, he described the school as 'frantic', a word he used several times in the interview. He then asked me, laughingly, whether I was concerned that the room might be bugged. I said cheerfully that that wouldn't worry me as nothing I was going to say to him had to be kept secret. We then talked, at his instigation, about bugging devices.

Burt was happy at this interview to show me his room. He had a small bedroom and then a sort of converted area next to it under the roof. He showed me his coin collection and some Citadel models of soldiers, though he told me he collected these less now because they had got so expensive. He

had some fine model planes hanging up and approximately 60-70 books including a number of children's classics.

At the end of that interview I asked (as I do in all interviews) if there was anything Burt would like to add to what he had said. Unlike any other pupil I interviewed at any time in the study, Burt asked me to read out the questions again. This I did and we went through two of them again.

The second Yr. 7 interview I did with Burt had a somewhat similar feel to it. When asked to describe himself he said 'Sarcastic … Tight with money' and then gave a long rambling answer without my being able to follow fully either what he was saying or why he was saying it. Later in the same interview I asked 'How have you found the science lessons so far?'. He replied, notably and with a considerable degree of reflectiveness for a Yr. 7 pupil, 'Gradually slipping down considering I used to like it a lot and now it's OK'.

In his Yr. 8 interview Burt talked about enjoying in science 'Things that are slightly different from the routine. Thing's that aren't copying down or the usual solutions … Air pollution project was quite good … Things that are different and make you remember it and you think "Cor, that was a really nice day" … if we just get told on the board, we might forget about it'. However, when asked 'How have you found the science lessons?' he said 'Umm. Nothing that new. Colour was quite, I quite liked doing colour. I

think we did shooting water bottles which was quite fun, hands on … but most of the time it's discussion'.

By the time of his Yr. 9 interview Burt wasn't sure what he wanted to do when he left Pasmoor School: 'Not too certain but something to do with design – graphic design maybe'. Supplementing what he had said the year before, he said that in science he liked 'Finding things out and … why things are why they are … why they work'. He talked with particular enthusiasm about a time when they dismantled an engine – but it transpired that this was in Scouts not in his school science lessons.

In his Yr. 10 interview Burt's entire reply to the question 'How have you found the science lessons?' was 'Slightly dull' and he went on to tell me about a time he fell asleep in chemistry. He was clear that he didn't like 'copying from the book in your own words' but liked the sort of science teaching that involved 'explaining things, practicals, to the point writing down what it is, rather than having to write down lots of things'.

I conducted Burt's Yr. 11 interview after the GCSE examinations but the day before the results were out. I asked him 'What's the most useful thing you reckon you learnt in science at [Pasmoor School]?'. He replied 'Depends what I'm going to do … I suppose practically round the home, electricity … physics and chemistry … I suppose it just explains how things happen so it's

nice to know but not useful … and if you want to do anything scientific later on, it's always there'.

Burt got two As in his science GCSEs and another A, four Bs, two Cs and a D in his other GCSEs. (To continue in full-time education in England and Wales, pupils normally need to get five or more GCSEs at grades A* (the best), A, B or C in the examinations they take at the end of compulsory schooling at the age of 16 years. Most schools and colleges that provide full-time education for 16-19 year-olds expect pupils to gain at least a grade B at GCSE in any subject they will be studying post-16, i.e. after the age of 16 years. In England and Wales, pupils typically study three subjects, called advanced levels, post-16 though there are other more vocational qualifications available.) Burt went on to study advanced levels in physics, mathematics and computing at one of the nearby town's VIth Form Colleges (that is, a state educational establishment that specialises in education for 16-19 year-olds). When I asked him a year after he had left Pasmoor School what he thought the science lessons in an 11-16 school (i.e. a school for 11-16 year-olds) should consist of he talked about how he 'Quite liked the practicals but I'm not sure I learnt much from them … Oh and not things like what colour did it burn … when you heat a metal … that aren't incredibly useful'. When asked 'Looking back on it, how do you feel about the Science you did at [Pasmoor School]' he replied laconically 'It was alright [pause]. It was, er, did well'.

*Catherine*

Catherine, her two older sisters and their parents lived in an extremely tidy detached house in a village a couple of miles from the school. On my first Yr. 7 interview with her Catherine told me she liked reading horror books and Roald Dahl's children's books. The family also had a rabbit which I spent five minutes admiring with Catherine and her mother at the end of the interview. In the interview itself Catherine told me that she quite liked science, the best bits being 'Finding out things; experiments'. She didn't like writing up the experiments but liked the cutting out and colouring in of digestion cut-outs.

On the second Yr. 7 visit, Catherine talked about how she liked 'The lessons where we do experiments and things and most them are quite fun' but she didn't like it 'If it's just writing all the way through'. Her mother was pleased that Catherine was settling in well and told me that her report was excellent, with an A in science. When I asked Catherine how she had found the science lessons so far, Catherine said 'Umm. I like the lessons where we do experiments and things and most of them are quite fun but it it's just writing all the way through then it's'. She didn't finish the sentence and after a short pause went on 'Some of them I've found quite hard; some of the lessons'.

During Yr. 7 it was clear to me from lesson observations that Catherine sometimes volunteered responses and asked questions in class but that, as with many of the pupils, this became less evident in succeeding years.

In her Yr. 8 interview Catherine told me 'I didn't like the teacher so much this year … the lessons were a bit boring. All he ever does was stand at the front … 'cos like if he's been standing up at the front talking, then I won't really remember it'. She most enjoyed 'The practicals … I just think I like practicals and doing them. It's something different to do, other than just taking notes and things'.

In her Yr. 9 interview Catherine reiterated that she most enjoyed 'The experiments I think. All like practical pieces of work we do'. She least enjoyed 'The copying up of experiments'. When I asked her 'Why is that?' she replied 'Dunno. It's just more exciting to do the experiments really'. However, although both the teachers who taught her Yr. 9 science did do large numbers of experiments, when I asked Catherine in her Yr. 9 interview to 'Give me an example of something you have learned in science' she replied 'I can't think of anything'. I asked her a second time, explaining what I meant, and got the identical reply. Somewhat taken aback, I left out my follow up question 'What's the most important thing you reckon you have learnt in your three years at [Pasmoor School]?' and went on to ask what she wanted to do when she left Pasmoor School. Catherine said she wasn't sure

but thought she would like to go to VIth Form College. She said that she was thinking of becoming a social worker.

When I asked Catherine in her Yr. 10 interview 'How have you found the science lessons?' she answered in terms of who was teaching her and went on to say 'They've been alright … lots of work to do … but I think I've done alright'. It was clear that what Catherine liked in science were the bits that she understood or, in her words, didn't find 'hard'. When asked 'Which do you most like out of biology, chemistry, physics. Why?' she replied 'I don't know. It's between physics and chemistry, I think. I would have said biology before this year but that's like got harder'. I asked Catherine to say a bit more about why she now liked biology less, and she replied 'For example, like in tests you can't just answer a question, you have to have an explanation, like with most of them'. I then asked her if she had any preference between physics and chemistry and she replied 'No, 'cos I find some bits of chemistry hard and some bits of physics hard'.

In her Yr. 11 interview, Catherine told me that the whole year had been 'Quite hard work, making all the coursework deadlines … apart from that it's been OK'. When I asked her 'What's the most useful thing you reckon you learnt in science at [Pasmoor School]?' she replied 'Oh God!' and laughed. After a long pause she continued 'Umm. I think it's got to be sort of biology as a whole 'cos that teachers you about life … what is happening outside the creatures [I understood this as ecology], the drugs, alcohol, so you're looking

at all aspects of life'. I asked how useful that was for her and Catherine said 'Like smoking, drugs and alcohol it teaches you the effects and show you and explains how everything works like in our bodies and the animals grow and things'. I asked if she smoked herself. 'Occasionally, yes' to which I responded 'I really don't know if school lessons make a difference?' to which Catherine responded 'They definitely make a difference like watching the videos and that smoking machine thing turning yellow'.

Catherine got two grade Cs in her science GCSEs and two Bs and six Cs in her other subjects. She went on to one of the local VIth Form Colleges and began her advanced levels in psychology, sociology and business studies. A year after she had left Pasmoor School she told me that she thought an 11-16 science curriculum should have 'A lot of practical work, I think, umm. Well, basically practical work and then like the writing up and stuff for homework 'cos if it is practical work it gives you a picture like … and it just keeps you interested'.

*Edward*

At the start of the study Edward, his parents and younger brother lived in a detached village house about five miles from the school. His room was decorated with daggers and other weapons, calendars and a number of model aeroplanes. He told me about how to paint these and how they were

arranged to show a dog fight. There were about 40 books, almost half of them comic annuals such as *The Beano* and *The Dandy*.

On the first Yr. 7 visit Edward said of the science lessons 'Most of them are interesting, but some of them are a bit boring, but sometimes when I'm not well I feel a bit out of it'. He said that in science lessons he would 'like to do rocket experiments and, umm, to find out more about the explosive chemicals. I'm interested in how you can lift objects a certain height by explosions … I've been to Cape Canaveral … brilliant'. There then followed a quite detailed account of a visit to Cape Canaveral.

On the second Yr. 7 visit Edward said that so far he had found the science lessons to be 'Enjoyable. I enjoy science and maths lessons. There's only one part of science I don't like and that's the writing part. I enjoy the experiments'. Edward described himself as being 'The sort of person who enjoys having, doing a lot more things, having fun, trying out things … I like to hear of new things and meet new people'.

Even in Yr. 7 Edward stood out as a most individual character with a lateral way of thinking. His mother was a teacher and at my first visit she and I chatted about the fact that Chris Woodhead [the Chief Inspector of Schools in England and Wales at the time] had come to see her school recently. Edward wanted to know who Chris Woodhead was and, after he had been told, said it was fortunate he wasn't called Chris Deehead. 'Why?' I asked. 'Because

then he'd be CD Head' replied Edward. A couple of weeks earlier at school Edward had spent several minutes trying to get me to sign what was in effect a Pupils' Bill of Rights as we waited for the science teacher to arrive and start the lesson. I went through each statement carefully and signed about a quarter of them. Some of them seemed eminently sensible. For instance, he wanted 'brake' [break] patrolled. I asked why. ''Cos there's lots of drugs and smoking and things'. Others were humorous. For example, he wanted long assemblies – not something for which most pupils gather petitions. When I asked him why he replied, admittedly with a certain logic, 'So the lessons would be shorter'.

In his second Yr. 7 interview I asked Edward how he had found the science lessons so far. 'Enjoyable. I enjoy science and maths lessons. There's only one part of science I don't like and that's the writing part. I enjoy the experiments' he replied.

At the Yr. 8 interview Edward told me that he found science lessons 'Good fun a large amount of time'. He most enjoyed 'The experiments. I like the experiments. I also like the discussions. Only yesterday we had an interesting discussion with [the teacher teaching him science]'. Edward told me that he didn't join in the discussion but at the end of the lessons went to [the teacher] and told him his idea which was that anything would turn into a gas if you heated it enough, even wood provided you heated it with no oxygen. He also told his teacher about what would happen if you had a gas and froze it very,

very fast; for example, Edward thought that if you did that with a gas from steel you could get an invisible steel shield. His science teacher said that he thought a problem with that might be freezing the gas quickly enough and Edward and I then chatted a bit about this, with me telling him about freezing strawberries and raspberries very fast to avoid getting large crystals of ice.

At his Yr. 9 interview Edward told me that he most enjoyed in science 'The practical work. It might sound pyro but I like the ones with the Bunsen burners'. On the other had what he didn't enjoy was 'The writing. I don't mind writing if it's in your time, if it's like creative, but off the board is boring … Some teachers think that if you don't write you don't learn … I don't learn by writing. I read it [i.e. something in a book] a couple of times and I feel that gets me by'. During the same interview I asked him what he would like to do when he left school. 'Take it as it comes. As I see it, you can have your heart and mind set on something but not actually get it so take what you can get and when you can get what you want, get it'.

At his Yr. 10 interview when I asked Edward how he had found the science lessons he said 'Been getting a lot harder but I've been attaining the same grades, Cs and Bs … coursework is the problem'. He told me that he thought it would be much more sensible if the school invested in everyone having a personal laptop rather than spending more on a central computer resource centre. I asked him about the sort of science teaching he liked and then the

sort of science teaching he didn't like. The second question drew the longer response: 'The kind of teacher which doesn't take a personal interest … who teaches to the whole class not you personally; who reads from the book … but you don't want Mr [xxxx] who just sits there and writes on the board and you haven't an idea what the hell is going on'.

Edward found his Yr. 11 'A lot more fun than other years' but also 'Very stressful' because of the amount of work. When I asked him 'What's the most useful thing you reckon you learnt in science at [Pasmoor School]?' he thought carefully and then replied 'Actually, umm, I don't think I can put it into a generalisation. What you put into use is an amalgam … if you think of each section [i.e. of the syllabus] you'd be hard pushed [i.e. to think of a use] … liquid … a body that takes the shape of its container … So?!'.

Edward didn't do as well in his GCSEs as he had hoped. He had got two Cs in his science GCSEs, an A* in photography, one other C, three Ds and two Es. Fortunately, although the VIth Form College to which he wanted to go had originally stipulated five grade Cs or better, the A* in photography with three Cs proved sufficient to let him go there to take photography and media studies at advanced level, electronics at GCSE and to re-take English language at GCSE.

A year after he had left Pasmoor School Edward told me that he thought an 11-16 science curriculum should have 'Things that are useful in everyday life.

What chemicals are available in everyday society that shouldn't be mixed. Actually learning about fire rather than that is needs oxygen and warmth … also teaching you respect for electricity. On the biology side it would be nice to know less about flowers and more about the human body'.

*Mary*

Mary lived with her mother, step-father and younger brother and sister in an extended cottage in a village some three miles from the school. In her Yr. 7 science lessons I had noticed that she sometimes managed to read non-science books for quite long periods. When I asked her at the first interview about her reading she mentioned *Dracula*, R. L. Stine and another horror author. She also liked the *Sweet Valley High* series of school books and told me about the breaking of the Stone Table in *The Lion, The Witch and The Wardrobe*. In addition to reading, Mary volunteered that she liked 'Guides, swimming, dancing, art, playing the violin'.

I asked what she did at weekends and she said that she spent most of Sundays doing homework – her mother explained that this was because Mary's life was so full during the week. I said that that sounded very efficient and Mary's mother described her daughter as being organised. Mary also mentioned at weekends staying with friends or going into town, for example to buy clothes. She then launched into needing new jeans and

another top and some shoes this Saturday which her step-father gently and partially deflected.

Mary's step-father talked about the fact that they had thought quite carefully a full year in advance about which secondary school Mary should go to. They had investigated two other state schools – 'they sell drugs outside the school gate there' Mary commented dismissively of one of them – and the private sector. Mary told me she wasn't keen on the idea of private schools and describe one local private educational establishment of national renown as a 'stuck up school'.

Because I hadn't heard her say a great deal in the first few months of the Yr. 7 lessons I hadn't appreciated how quick witted Mary was until I interviewed her. On my first Yr. 7 visit she talked amusingly about the way the school bus was driven and on my second, in response to my asking her how she had found the science lessons so far, she produced a succinct and pretty devastating critique of the teacher's teaching style. She told me that the lessons were 'Boring. They don't make sense. He tells us to reread our books before a test and all we've got is our half-finished experiments'. When I had asked Mary on my first visit 'How have you found the science lessons?' she hesitated and, after her mother had encouraged her to say what she really felt, she said 'Really boring'. Earlier in that interview she had told me about the chemistry experiment they had done in their fist Yr. 7 science lesson. I asked her how that felt and she said 'It was OK. It was quite exciting'.

On my Yr. 8 visit Mary told me that in science she most enjoyed 'Practical and mucking around with Bunsen burners'. What she didn't like was 'Having those big discussions round the front'. I asked why she didn't enjoy those. 'Everything sort of drags on. We have to answer questions from the book. I don't like comprehensions or revising for the test for three-quarters of an hour or an hour [i.e., I think, immediately preceding the test]'. Mary went on to say how she didn't like 'Wiping the board and your trousers or skirts get all covered with chalk'. I asked if she had wiped the board but she hadn't. She went on to add that she didn't like 'Stools … [with] cracks and snags your tights'.

In the Yr. 9 interview, Mary told me that she most enjoyed in science 'Practical. Doing experiments and stuff because you don't have to concentrate all the time. You can do your stuff and then drop out a bit'. What she least enjoyed was one of her teacher's 'Talks … boring and go on and on and he doesn't explain himself really. You shouldn't talk about something you can only half explain'. When I asked her what she would like to do after leaving the school she replied 'Probably something to do with medicine … depends what grades I get'.

When I asked Mary in her Yr. 10 interview how she had found the science lessons she said 'Quite good. Mr [xxx]'s been rubbish as usual'. When asked which she most liked out of biology, chemistry and physics and why, and

which she most disliked out of those three and why Mary replied mainly with respect to characteristics of those teaching her. 'Physics has been the best because it's been the most structured. She's very good at explaining things … I just generally enjoy her lessons more … I got my first B in biology [which I took to mean that Mary felt that that was a poor mark which indicated that Mary felt that that year's biology teacher wasn't a good teacher] … chemistry … is quite a difficult subject' and being taught by that year's chemistry teacher 'is twice as worse … he never fully explains anything; then he says it's in the book … he can't explain … he doesn't have any control over the class'.

At her Yr. 11 interview Mary told me that she had been 'Quite stretched with all the exams' that year. She gave a number of examples of the most useful things she reckoned she had learnt in science – 'Probably all the plant and animal and cells and body and [bimetallic strip]'. I asked why these were useful and she said that they were 'The everyday things'. After leaving the school she was hoping to do advanced levels at one of the nearby VIth Form Colleges in chemistry, biology and maths with an AS [half an advanced level] in art. She explained to me that she liked maths and art. She was happy to do biology because she was thinking of doing medicine or something in research and although she didn't really want to do chemistry she needed it for medicine.

Mary's mother is a teacher of deaf children. Mary's biological father had been a scientist but had died six weeks before Mary was born. Her step-father is a solicitor. When I asked her parents, in Mary's presence, how they felt about what she was hoping to do, her step-father, light-heartedly, said 'Disaster doing sciences! She's obviously very keen to do what she wants to do … hope the results are OK … she's on her own; we know nothing about maths'. Her mother then said to her 'It's your choice … we don't want you to do too much …'.

Mary got two As for her science GCSEs, one A*, five other As and two Bs. A year after she left Pasmoor School I asked her what she thought science lessons in an 11-16 school should consist of. She answered not with regard to the content but the form of the lessons: 'Well structured. At the beginning lots of discussion … notes … experiment … some notes, conclusion … lots of teacher involvement, then homework'.

**Discussion**

My attitudes to something, e.g. science, art history or baseball, could principally be studied by someone carefully observing me and what I do, by them interviewing me, or by them getting me to write about how I feel about these subjects. For example, observations of my behaviour would show that I spend quite a bit of time reading science and art history books and watching

science and art history programmes on the television (though probably less than 4% of my time in total on all these things) whereas I never read about baseball and almost never watch it on television – unless alone in Japanese hotel bedrooms.

Every research instrument to determine attitudes raises issues about validity. It is difficult when observing lessons to conclude much about a pupil's attitudes. There is little social cachet in appearing keen in school lessons, so by the time the pupils in this study were about 13 years old (the beginning of Yr. 9) classroom observations were of limited use in telling me much about what they thought of school science. I maintain that information obtained in the interviews had a high degree of validity. As the limited selection of quotes above indicates, pupils clearly did not feel constrained to claim that they liked their science lessons when they did not. The closest I was aware of a pupil feeling thus constrained is cited above (Mary at her first Yr. 7 interview). As the pupils got to know me over the course of the study, most of them, I felt, became increasingly relaxed at my presence and were able to articulate much of what they felt about science.

In my interviews I sometimes failed to distinguish between attitudes to science and attitudes to school science, and when I did distinguish these the pupils did not always do so in their replies. To a certain extent, this is hardly surprising. Pupils develop attitudes to science in part as a result of their developing attitudes to school science lessons. Attitudes to school science

were affected by its content matter, the way the subject was taught and how it was examined.

*Attitudes over time*

By most accounts, Pasmoor School was a 'good school'. It had two Ofsted (Office for Standards in Education) inspections during the five years I was visiting and both were extremely complimentary, the second one especially so with regard to the science department. While many of the parents voiced specific criticisms of the school (e.g. with regard to setting, communications with the school and revision), only one parent of the 15 pupils still at the school at the end of Yr. 11 said they wished their child had not gone there. Most of the parents were pleased with what the school including the science department had done for their children.

Despite this, in common with findings from other research, the evidence from the four pupils followed here shows that much of an initial Yr. 7 enthusiasm for science dissipated over the five years of the study. This trend is the same when all the pupils in the sample are considered (Reiss, 2000) though the richness of the data makes firm generalisations difficult. In particular, individual teachers played a significant role in maintaining or losing the enjoyment and interest that certain pupils had in science lessons, as is suggested by Mary's comments about 'boring' science lessons, a word also

used above by Burt and Catherine. 'Boring' is a common pupil term of deprecation but Mary was able to substantiate her overall assessment by indicating how lessons that 'don't make sense', exercise books with write-ups of 'half-finished experiments' and teacher talk that went 'on and on' and lacked clarity all contributed to boring science lessons. Of the four pupils considered here, the decline in enthusiasm for school science is particularly evident for Burt. As early as the end of Yr. 7 Burt talked about how 'I used to like it a lot and now it's OK'. By Yr. 10 he was finding the science lessons 'Slightly dull' and telling me of an occasion when he fell asleep in chemistry.

In recent years many science educators have questioned the purpose of practical work in school science (e.g. contributions in Wellington, 1998). However, one of most popular aspects of science lessons is the practical work. Other research (Delamont *et al.*, 1988, Jarman, 1993, Campbell, 1999) shows that primary pupils look forward to secondary school science because they feel that the laboratories will let them do 'real science'. The quotations from the four pupils considered here indicate the popularity of practical work. At the same time, there is more than a hint that part of this popularity was because practical work was considered preferable to the alternatives, notably writing and listening to the teacher talking. As Catherine put it in her Yr. 8 interview: 'It's something different to do, other than just taking notes and things'. In her Yr. 9 interview Mary said that she most enjoyed in science 'Doing experiments and stuff because you don't have to concentrate all the time. You can do your stuff and then drop out a bit'. A year after he had left

Pasmoor School Burt concluded that he had 'Quite liked the practicals but I'm not sure I learnt much from them'. It is also noteworthy that when Burt in his Yr. 9 interview answered my question 'What do you most enjoy doing in science?' the enthusiastic answer he gave, about a time when he and others had dismantled an engine, turned out to have been done not in a school science lesson but in Scouts.

The aim of this paper is not to provide a review of the way(s) in which attitude connects with learning (for analysis and reviews see Strike and Posner, 1992 and Alsop, 1999). Nevertheless, despite some loss in enthusiasm for science, it is noteworthy that all four of the pupils followed here – and 60% of the sample in all – were going on to make direct use of their science in their employment or further education (Burt – physics; Catherine – psychology; Edward – electronics; Mary – biology and chemistry). Interestingly, though, when these four pupils were asked a year after they had left their 11-16 school what they thought science lessons in an 11-16 school should consist of, they said little about them providing a basis for advanced level study or for employment. Rather, they wanted compulsory school science to be relevant and useful in life. As Burt said 'Oh and not things like what colour did it burn … when you heat a metal … that aren't incredibly useful' and as Edward said 'Things that are useful in everyday life'. A similar finding was reached by Osborne and Collins (2000) in a study involving focus groups with 16-year-old pupils in London, Leeds and Birmingham between September 1998 and September 1999.

*Implications for science education*

One of the most important factors influencing pupil attitudes towards science at Pasmoor School seemed to be the curriculum. I reached this conclusion not so much from the contents of the interviews but from my observations of the science lessons, especially in Yrs 9, 10 and 11. The English and Welsh National Curriculum has been extensively critiqued since its introduction for its content and assessment arrangements and for the consequences these have had for classroom practice (e.g. Donnelly *et al.*, 1996; Donnelly & Jenkins, 2001). Both the Yr. 9 SATs (national examinations in English, mathematics and science) and the Yrs 10-11 GCSEs had a very substantial influence on the science teaching at Pasmoor School.

As the GCSEs approached, the number of hours of homework and revision that some pupils did became very considerable. At the same time (April 1999), national newspapers reported that revision guides and practice exam papers were outselling popular fiction. Many of the pupils put in two or more hours of schoolwork a night and said that they 'Hated it', that they 'Cancelled quite a lot of after school activities' and that their 'Social life went down the drain'. Mary me that she was doing '20, 25 hours a week' of homework and revision throughout Yr. 11 and talked with considerable insight about international comparisons of the amount of time pupils spent

on homework, something she had read about in *The Times*. It was clear to me, to the pupils, to the teachers and to the pupils' parents that learning and teaching were being dominated by assessment. One can only hope that the excessive and inappropriate assessment of school science lessens, otherwise even more pupils will lose their enthusiasm for science.

Finally, one of the conclusions I reached during the study was that for the great majority of the pupils, science education played only a small part in their lives. Attempts by me on all six interviews I did with each pupil to get them to talk in any detail about what they had learnt in their science lessons were not especially successful. For example, the same pupils who were both happy and able to talk to me on their Yr. 11 interviews cogently and in some detail about their sex education classes, the extent of drug use at the school, the prevalence of bullying, differences between the ways that boys and girls behave and their favourite science teachers were often unable to give me what I would consider to be a reasonable answer to the question 'What's the most useful thing you reckon you learnt in science at [Pasmoor School]?'. Perhaps the most notable answer to this question was delivered in all seriousness by one of the six pupils who got AA or better in their science GCSEs. The pupil stated 'That's a hard one! Reflection and refraction really. 'Cos that really helps when you're playing snooker – you know how things rebound'.

Now, while this is just an anecdote, it illustrates the point that existing science curricula seem never to require pupils to reflect on *why* they are learning in science what they are learning. To be bluntly honest, there were times when I wondered why on Earth pupils were studying the science they were. In particular, there seemed to be a time in Yr. 11 when lesson after lesson in chemistry consisted of relative molecular masses. For most pupils this is not a science topic of great significance and worth. School science education is only likely to succeed when pupils believe that the science they are being taught is of personal worth to themselves. Unless science teaching genuinely engages with the concerns of real pupils, they will be more than capable of losing interest in it and learning little from it.

**Acknowledgement**

I am especially grateful to the pupils, their parents and the staff who allowed me to conduct this study.

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