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Abstract

This paper describes a four-year project involving the development of a new instrument, the *Attitudes to School Science and Science* instrument, and its use to collect baseline attitudinal data from 280 students aged 11, 14 and 16. A key feature of the instrument is that it collects data on both descriptive and explanatory data. Significant differences emerged in responses by both age and gender, with positive attitudes declining with age (though with evidence of some upturn in the later years of secondary schooling), and female students displaying less positive attitudes and less clear-cut views on a variety of aspects of science. The early years of secondary school emerged as critical, with attitudes to school science in particular declining most sharply between the ages of 11 and 14 - an 'age 14 dip'. A sense of science being important in general terms, though not having much appeal for individual students, also emerged clearly from the data. The paper suggests that attitudinal instruments have a role to play in research, but that these need to be complemented by studies of detailed features of schools that may influence attitudes, some of which may not be apparent form data collected from students.

Why look at attitudes to science?

What views might a class of sixteen-year-olds have about science? Here is a selection of comments from students involved in the study reported here:

"We use science for everything. We ARE science."

"Science is important because modern society is built entirely around the scientific advances of recent centuries."

"Science causes problems in the first place, so how can it get rid of them?"

"Would YOU want to talk to a scientist at a party?"

Most people involved in science education would probably be very pleased if any sixteen-year-old they knew made one of the first two comments. Sadly, it is the case that far too many young people are likely to have more empathy with the last two comments. Such

1

comments also serve only to reinforce the considerable disquiet felt in the science education community and beyond over the numbers of students taking science subjects, particularly chemistry and physics, in post-compulsory education in a number of countries. It would seem that there is widespread disenchantment amongst young people, who are 'voting with their feet' and turning away from science when they have a choice. In England and Wales, for example, data from public examination entries show that the percentage of young people choosing to study physical science subjects at Advanced level (the first point of choice at age 16+) fell by 2.1% in the period 2001-2005 for chemistry, and by 14 % for physics, continuing a steady downward trend (Hyam, 2006). It is therefore not surprising that concerns about participation in science feature prominently in current debates over policy and practice in science teaching, such as in the recent research report for the Department for Education and Skills (DfES, 2006) on *The Supply and Demand for Science, Technology, Engineering and Mathematics Skills in the UK Economy*. The Government has also set ambitious target for increased participation and performance in science subjects over the decade from 2004-2014 (H.M. Treasury, 2004). Factors affecting participation in science (and mathematics) are also the focus of a major research initiative launched in the UK by the Economic and Social Research Council in 2007.

Concern over levels of participation poses a number of questions. What is it about science that seems to make it so unappealing to so many young people? How do students' feelings about school science compare with their feelings about science more generally? What action, if any, could or should be taken to alter the situation? In looking for answers, students' *attitudes to science* are seen as crucial.

The literature on attitudes to science

The literature on attitudes to science is extensive and includes a number of detailed review articles (e.g. Gardiner, 1975; Ormerod and Duckworth, 1975; Schibeci, 1984; Munby, 1990; Ramsden, 1998; Osborne et al., 2003). The 'broad brushstroke' findings are well known: science is perceived as difficult and not relevant to the lives of most people, interest in science declines over the years of secondary schooling, science is more attractive to male students than female students, with problems being most acute in the physical sciences. Whilst work on attitudes has remained a consistent feature of research in science education for more than 40 years, there has been a noticeable increase in studies more recently. In England and

2

Wales, this is linked to the increasing body of evidence that the compulsory study of science up to age 16, introduced for all 11-year-olds in the National Curriculum for Science in 1988, has had little impact on numbers choosing to continue study beyond the compulsory period. A notable feature of recent work, and an indicator of the widespread concern, is the range of groups involved in sponsoring the work, including employers, Government bodies, learned societies and Examination Boards.

Whilst to a large extent newer studies confirm earlier findings, some new slants have emerged. The most noticeable of these is neatly encapsulated in the title given by Jenkins and Nelson (Jenkins and Nelson, 2005): "Important but not for me." Jenkins and Nelson were reporting the UK data from a large and ongoing comparative international survey of students aged 16, the Relevance of Science Education (ROSE) project, which began in 2001 and involves over 30 countries (Schreiner and Sjøberg, 2004; Sjøberg and Schreiner, 2005). The ROSE data indicate that a general appreciation of the value of science outside school is not reflected in responses about enjoyment of science in school, or a desire to have jobs involving science. This message is echoed in other studies. For example, Osborne and Collins, (2001) showed sixteen-year-old students to believe science was an important subject in the school curriculum, but more for career purposes for those interested in science than because of intrinsic interest. In the *Science in my future* report (Haste, 2004), young people emerge with a moderately positive image of science and technology, but are far less interested in jobs in science or in science in the media.

There is also a growing body of evidence to indicate that attitudes to science decline most sharply in the early years of secondary education. Galton et al. (2003) conducted a large-scale survey of attitudes of over 1000 students in the UK, and established that attitudes to science (compared with Maths and English) decline more appreciably across the first year of secondary schooling (age 11), a trend that continues through the early years of secondary education. Set against this is the importance students place on the quality of their science teaching. Osborne and Collins (2001) found that students see science teachers as being influential in determining their response to science, particularly in the early years of secondary education, findings that also emerged very strongly the Planet Science survey (Cerini, Murray and Reiss, 2004). The decline in positive attitudes to science across the early years of secondary education is all the more serious as interests and views on future career

3

directions, including science careers, begin to shape in the early years of secondary schooling (Munro and Elsom, 2000).

The case for developing a new instrument

A number of concerns have been raised and criticisms levelled at work on attitudes in science education, principally relating to the plethora of existing instruments, failure to draw on ideas from psychological theory, and poor instrument design and analysis. These have been extensively documented (e.g. Gardiner, 1975; Ormerod and Duckworth, 1975; Schibeci, 1984; Munby, 1990; Ramsden, 1998; Osborne et al. 1998; Simon, 2000; Osborne et al., 2003). One message emerging from these reviews is that of caution over the need to develop yet another instrument, given the number that already exists. A further issue to emerge concerns the nature of the instruments used. A consistent feature of attitude research is the use of fixed-response inventories and scaling techniques to gather data. Of these, Likert-type scales predominate (for example, Haste, 2004; Kelly, 1986; Misiti, *et al*., 1991; Qualter, 1993; Simpson and Oliver, 1990; Sjøberg and Schreiner, 2005), though others, such as Thurstone-type rating scales (for example, Johnson, 1987; Smail and Kelly, 1984) and semantic differential scales (for example, Crawley and Koballa, 1994) have also been used. Much more limited use has been made of interviews (for example, Piburn and Baker, 1993) and, more recently, focus groups (Osborne and Collins, 2001). One outcome of a heavy reliance on fixed-response inventories is that much attitude data is characterised by an emphasis on descriptions of 'the problem'.

Despite the notes of caution sounded in the literature, the study reported here does involve the development of a new instrument which, though taking the form of a 'pencil-and-paper' inventory, does allow attitudinal factors to be probed in a more open format. Whilst the nature of the data generated by such an instrument does not lend itself to the rigours of statistical methods for design and analysis often followed in the development of attitudinal instruments, it offers the potential to go beyond largely descriptive data to probe for explanations and insights that, in turn, might point to possible areas to target for action.

The aims of the study

The aims of the study were as follows:

4

- to design an instrument to enable both descriptive (Level 1) and explanatory (Level 2) data to be gathered on students' affective responses, or attitudes, to science;
- to use the instrument to gather baseline data from school students aged 11, 14 and 16;
- to explore the data for trends in responses, particularly in relation to age, gender and ability, with particular emphasis on explanatory (Level 2) responses.

The development of the research instrument

The design of the instrument adapted the approach developed in the *Views on Science-Technology-Society* (VOSTS) study, undertaken in Canada in the late 1980s to document the views of upper high school students (aged 16-17) on science-technology-society topics (Aikenhead and Ryan, 1989; 2002). In essence, the VOSTS approach involved the empirical development of a fixed response item pool based on views expressed by the students. This was achieved through presenting students with a series of statements on aspects of science, technology and society, and inviting free responses. Common themes within these responses then formed the basis of categories for the fixed-response version of the instrument. The VOSTS approach had two particular attractions. Firstly, the options in the fixed-response instrument drew directly on the words of the students, and, secondly, through the use of a pencil-and-paper instrument, it offered the potential to probe for explanatory data from a large dataset.

The development of the research instrument is reported in detail in the full project report Author 1 and Author 2, 2005). The process involved six steps, summarised in Table 1.

Table 1: Stages in the development and validation of the research instrument

Stage	Procedure	Data sources
1	Identification of areas to be explored	Literature search plus interviews with 36 students aged 11, 14 and 16 (12 of each age)
2	Composition and peer validation of disposition statements	Initial development by team of three researchers plus two teachers; validation by approximately 25 science educators and teachers

5

3	Gathering of free responses to disposition statements	Approximately 40 responses per item, 10-15 per age range in two all-ability comprehensive schools
4	Development and validation of trial fixed-response items	Categorisation and validation of responses
5	Production, use and validation of fixed-response version of instrument	Trial with 91 students in four classes, two aged 11 and two aged 16

Stage 1 yielded responses in a number of areas including: response to science lessons (teacher effects, views of particular activities); views of social implications of science (from school science and experiences outside school); views of teacher characteristics; views of learning situations; views of the influence of peers and family; views of science as presented in the media; views of scientists and their work. To avoid producing a lengthy instrument, it was decided to gather data in two main areas: responses to school science and responses to science outside school.

Stage 2 involved the development of a series of statements relating to school science and science outside the classroom. These took the form of *disposition statements*, i.e. the responses were indicative of attitude to science or school science. An initial pool of around 40 items was reduced to 25 through a series of peer validation meetings involving approximately twenty-five science educators and teachers. These statements are shown in Table 2.

In Stage 3, each of the statements was in a form which invited students to respond on a Likert-type scale (strongly agree/agree/neutral/ disagree/strongly disagree) to indicate their view, followed by a request to explain, as a free response, their reasons for holding this view.

The first step in Stage 4 involved the free responses being independently categorised into groups by two members of the research team. There was over 90% agreement on categorisation. Each category of response was summarised in a sentence, drawing as closely as possible on the words used students' written responses. These then formed the basis of the fixed responses to the disposition statements. Typically, an item would have between eight and ten fixed response options. A sample fixed-response item is shown in Table 3. Once students had selected their Level 1 response (agree/neither agree nor disagree/disagree), they

6

were invited to select as many of the Level 2 responses as they felt applied to them. The instrument thus enables responses to be gathered at two levels: Level 1 responses indicate agreement or otherwise with the disposition statement, and Level 2 responses probe for explanations.

Validation of the trial fixed-response items took place approximately three months after the collection of the free responses. The process involved asking the same classes of students who had originally given free responses to complete eight fixed-response items, with items being distributed to students in such a way that at least ten responses per item were collected. The responses selected by the students on the fixed-response item were then compared with the original free response. The very good agreement (85%) between free responses and the fixed-response options is a measure of the reliability of the items. Short interviews with students where differences had emerged established that these students had not originally held any particularly strong view.

To maximise the validity of the range of Level 2 responses, each item offered the options of not selecting any of the fixed responses offered, but giving "another reason – please say what". The intention was to look for any further patterns emerging in from these options and add them to the options offered. In practice, though between three and five students per item selected "another reason", the reasons were very varied and no consistent patterns emerged. It was decided to leave the "another reason ..." option in the final version of the instrument to allow student to express different views if they so wished.

Stage 5 involved the trial of the instrument. Four classes in two schools participated in the trial, such that data were gathered from 91 students in two classes aged 11 and two aged 16. This enabled the instrument to be tested with students at the upper and lower ends of the target age range.

Content validity was assessed by the following procedure. At the point where their students completed the instrument, the class teacher was asked to indicate their view of each student's attitude to science on a five point scale, where a score of five represented a very positive attitude, and a score of one represented a very negative attitude. A numerical total was then calculated for each student based on their responses to the instrument. Any 'agree' options selected were given a score of three, 'neither agree nor disagree' options were given a score of

7

two, and 'disagree' options a score of one. Whilst there are drawbacks to assigning numerical scores to Likert-type responses, it was felt that these were outweighed by the advantages of having some indicator of the validity of the instrument in gauging attitudes to school science and to science. Visual inspection of the scattergrams of the teacher scores for students' attitude and the students' score on the instrument showed a good line of fit, and there were no instances where the instrument had indicated a negative attitude and the teacher had indicated a positive attitude. In a limited number of instances (10%), the instrument indicated a positive attitude whilst the teacher had indicated a negative attitude. Conversations with the teachers showed that these cases tended to be students who were seen as not very hard-working by the teachers, and that this influenced their view of the students' attitude.

The full instrument may be accessed at www.york.ac.uk/depts/educ/ResearchPaperSeries/, under Paper 8.

Table 2: The disposition statements

Dispositions towards school science

A01   Science lessons are among my favourite lessons.
A02   I try extra hard in science lessons.
A03   My science teachers make me more interested in science.
A04   The things we do in science lessons make me more interested in science.
A05   If I had a choice I would study biology.
A06   If I had a choice I would study chemistry.
A07   If I had a choice I would study physics.
A08   I enjoy reading science textbooks.
A09   What we do in science lessons is useful whatever you do after you leave school.
A10   Everybody should study all three science subjects (biology, chemistry and physics) up to age 16.
A11   When they have a choice, young people should be given particular encouragement to study science subjects.

Dispositions towards science outside school

B01   I like watching science programmes on the TV.
B02   I like reading about science in newspapers and magazines.
B03   News items about science interest me.
B04   I like reading science books other than school science textbooks.
B05   I would trust something a scientist said.
B06   I would like a job involving science.
B07   It would be good to have a job as a scientist.
B08   Science is blamed for things that are not its fault.
B09   Science has a positive influence on society.
          Science can help solve problems (e.g. environmental and social problems).
B11   Science makes an important contribution to the wealth of the nation.

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B12	The Government should spend more money on scientific research.
B13	It is important for this country to have well-qualified scientists.
B14	It is important to promote this country as a scientific nation.

9

Table 3: Example of final format for multi-choice items

B06   I would like a job involving science.

I agree because…		I neither agree nor disagree because…		I disagree because…	
a	…I enjoy science at school	k	…it depends on what science you would be doing	p	…I find science boring
b	…they are generally well paid			q	…science causes too many problems for the world
c	…science makes the world a better place to live in			r	…they don't get well paid
d	…there are good jobs you can do with science				
x	… another reason – please say what	y	… another reason – please say what	z	… another reason – please say what

The main study: the sample and methods of analysis

The instrument was used to gather baseline data in a survey of 280 school students in four 11-18 all-ability (mixed comprehensive) schools in late April 2004. Data were collected from whole-class sets. All the students completing the attitudes inventory were following conventional science courses, i.e. none were following courses linked to any new intervention. The instrument was administered to three cohorts of students aged 11, 14 and 16. These are the first, third and fifth (final) years of compulsory secondary schooling in England and Wales, and the study of science is compulsory throughout this age range.

Data on students' ability levels were obtained based on actual or estimated results from external tests and examinations, these being the only external measures of ability common across all schools. Internal measures would be unreliable as they would be developed within schools. These were Standard Assessment Tasks (SATs) at Key Stage 2 taken by students taken at age 11 or at Key Stage 3, taken by students at age 14, or General Certificate of Secondary Education (GCSE) examinations, taken by students at age 16. These measures were used to designate students as high, middle or low ability.

Details of the sample are given in Table 4.

Table 4: Details of sample

Age	N	%	%	Low ability		Middle ability		High ability	
		Male	Female	Male	Female	Male	Female	Male	Female
11	104	49	51	2	0	27	25	22	28
14	78	47	53	5	3	13	16	19	22
16	98	49	51	0	3	17	33	31	14
Total	280	136	144	7	6	57	74	72	64

Although data were collected from whole class sets, the sample turned out to be balanced in terms of gender, with just slightly more female students (n=144) than male (n=136). External measures of ability resulted in the majority of the students in the sample being designated as middle or high ability. The likely explanation for this is that

11

the external measures used for ability are not very discriminating in that the majority of student will be placed in one of three broad bands at age 11 and 14. Overall, however, the sample was felt to be representative of the group from which it was drawn, as data were collected from classes across the whole ability range.

Analysis of the non-parametric data was carried out using the SPSS 11 package, and applying the Chi-squared test to look for significant differences in responses.

The data were interrogated by age, gender and ability. As there were few lower ability students in the classes (5% of the total sample), the responses for the lower and middle ability groups were combined. This decision was felt to be justified as visual inspection of the responses for the small numbers of lower ability students did not indicate any appreciable differences in individual responses or patterns of response. A number of significant differences emerged for age and gender effects. However, no statistically significant differences emerged in relation to ability. The detailed statistical analysis of the data may be found in the full report of the study (see details at the end of the paper).

Results

The results are presented in five sections. The first two present an overview of responses to school science and responses to science outside school, drawing on both Level 1 and Level 2 responses. The nature of the instrument means that the database developed for the Level 2 data is extensive, and it is beyond the scope of this paper to present and discuss all the Level 2 findings in detail. Therefore the remaining three sections focus on particularly notable features to emerge from the data: the 'age 14 dip', patterns in relation to individual scientific disciplines, and a shift in opinion with maturity.

Responses to school science

Figure 1 shows the percentage of students in each age group who selected 'agree' responses to items. Figure 2 show the percentages of male and female students who selected 'agree' responses to the items about school science. (See Table 2 for details of items.) There was a noticeable trend for positive attitudes to items relating to both

12

school science to decrease overall from age 11 to age 16, and, within this for female students to be generally less positive than male students.

Figure 1: Percentage of 'agree' responses to items A01-A11 (by age)
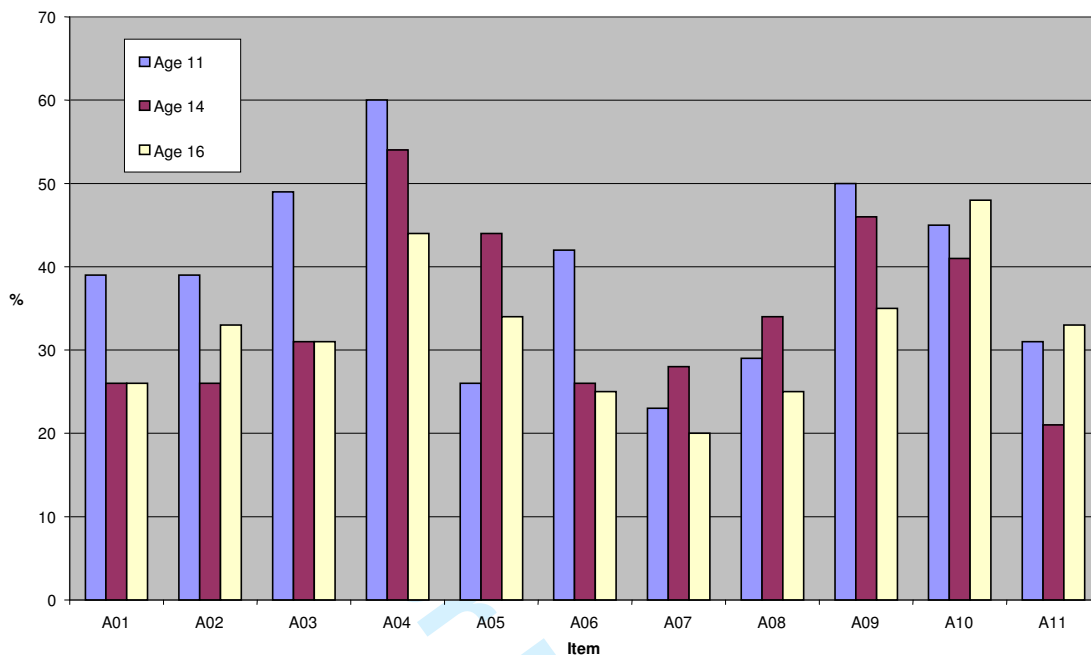
Figure 2: Percentage of 'agree' responses to items A01-A11 (by gender)
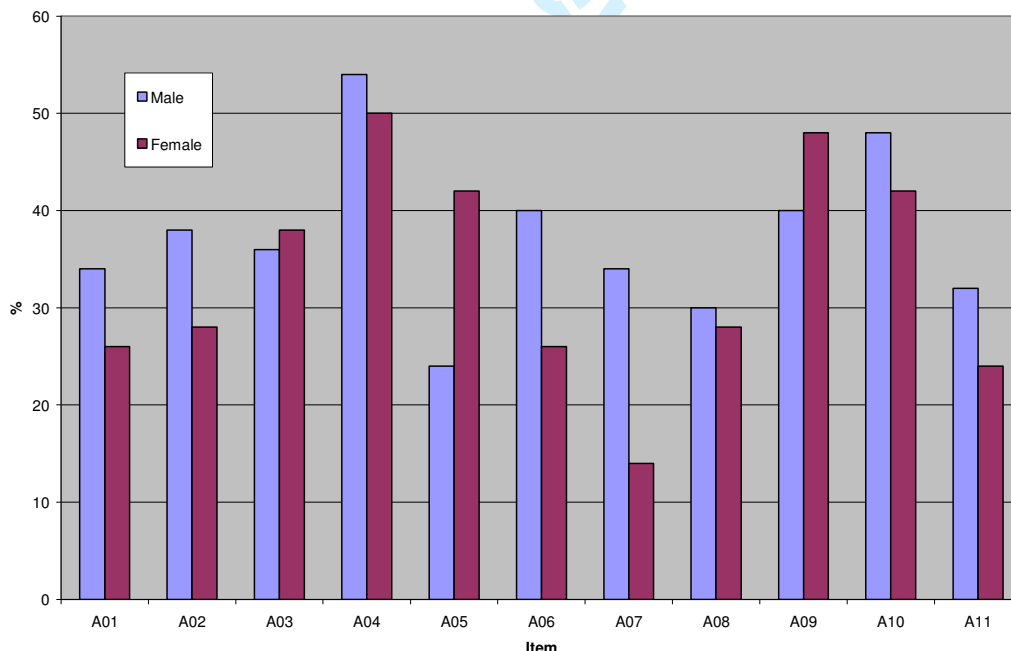
Five items were statistically significant in terms of decreasingly positive responses by age. These items were A01, A03, A05, A06, A07. These items are about liking for science (A01), teacher effects (A03) and responses to the individual disciplines within science (A05-A07). Significant gender differences were established in responses to

13

biology (A05), chemistry (A06) and, in particular, physics (A07), with students in the sample conforming to the well-established pattern of female students preferring biology, and male students preferring the physics and, to a lesser extent, chemistry. These patterns in response are discussed more fully in the section on 'scientific disciplines'.

Of particular note is the fall in number of students reporting that science is one of their favourite subjects (A01), with the proportion of students who responded positively to this statement dropping sharply between age 11 (39%) and age 14 (26%) ($\chi2$=10.131, p<0.02). This change was associated with a doubling in the percentage of those who disagreed from 10% to 21% ($\chi2$=8.370, p<0.05). There was a small further increase to 25% in negative responses from students age 16. Within the groups saying that science lessons are amongst their favourite lessons, a striking finding is the particularly positive response to chemistry (85% at age 11, 75% at age 14 and 65% at age 16). Biology becomes increasingly important in reporting liking of science (45% at age 11, 75% at age 14 and 77% at age 16), ($\chi2$=8.761, p<0.02) whilst physics held similar levels of interest across the years with 48% at age 11, 45% age 14 and 46% at age 16. At age 11, the students who disagreed with the statement all did so because they did not like any of the three science areas. By age 14, the number of students disagreeing with the statement had increased, with the physical sciences, and physics in particular, being cited as 'hard' as well as being disliked, a pattern repeated at age 16. The responses to individual subjects within science (A05-A07) are discussed in more detail later in the paper.

Two items offer interesting insights into students' responses to their experiences in science lessons: *A03: My science teachers make me more interested in science*, and *A04: The things we do in science lessons make me more interested in science.* Responses to A04 were positive at age 11, with 60% of students agreeing with the statement. This figure remained comparatively high through to age 16, where, at 44%, it was the second most highly rated item in relation to school science. In both age groups, the Level 2 explanation most frequently selected was practical work which also showed a small significant rise from 87% at age 11 to 100% at 16 ($\chi2$=6.973, p<0.05). In contrast interest in investigations tailed off significantly from 55% at age 11, to 32% at age 14 and 26% at age 16 ($\chi2$=10.608, p<0.01). It was notable that positive responses to group work on presentations and posters decreased significantly across the age range (65% at age 11, 41% at age 14 and 30% at age 16; $\chi2$=12.917, p<0.01). The Level 2

14

explanations offered by students disagreeing with A04 were fairly equally divided amongst the following: too much time spent on writing, dislike of maths and theory, not seeing the point of what they were doing, and too little variety in lessons, with very little change in the picture between age 11 and age 16.   In contrast, A03 elicited a very positive response at age 11, with 49% of students agreeing with the statement, but responses dropped significantly by age 14 to 31% and remained at this level at age 16. Level 2 responses demonstrated a range of ways in which teachers created interest in science. For the two younger age groups, variety of activities was highly important (78% at age 11 and 71% at age 14). The next most important aspect at age 11 was being made to think (57%). (Level 2 data responses total more 100% because more than one option could be selected if desired.) Explaining things clearly was important for over half of all ages (58%) and was the most common response at age 14 (71%). Significantly more female students (74%) than male students (41%) in each age group cited this as important ($\chi2=11.660$, p<0.001). Similarly female students (48%) were more likely than male students (37%) to report their interest in science being influenced by their teachers' enthusiasm ($\chi2=3.869$, p<0.05). Although there was a drop across the years on the importance placed on relating science to the outside world, from 45% of 11 year olds to 25% of 14 year olds and 23% of 16 year olds, this was not statistically significant. These responses point to teachers being particularly influential at age 11, i.e. in the early stages of secondary science courses, and thus having the potential to make a crucial difference at this point.

A08: I enjoy reading science textbooks elicited negative responses from the majority of students in all age ranges, with Level 2 explanations revealing that they were seen as boring by two thirds or more of the students in each age range and a waste of time over one third of students. Between 27% and 42% of students said they learned more by listening to their teacher.

Exceptions to the trend of decreasing overall positive attitudes to school science were items *A10: Everybody should study all three science subjects up to age 16,* and *A11: When they have a choice, young people should be given particular encouragement to study science subjects.* Level 2 data showed that over one-third of students in all age groups agreeing with A10 felt science was an important part of a good general education. However significantly more of the students agreeing with this item at age 16 (45%) also said that they thought there was too much science on the timetable,

15

compared with just 13% at age 11 (χ2=11.319, p<0.01). Level 2 data for A11 showed high proportions of students who agreed with the statement supporting that view by saying science affects so much in everyday life. However there was a significant drop in the proportion at 16 (94% at 11, 100% at 14 and 63% at 16; χ2=15.065, p<0.001). All ages felt science leads to good jobs (88% - 100%) and there was little difference in this view between males (100%) and females (91%). Between a third and a half of students cited the importance of training the scientists of the future. Around 20% in each age group disagreed with the statement, saying people should be allowed to study the subjects they are best at and not pushed into some subjects more than others. The responses to A10 and A11 do suggest that, whatever, their views, students approaching the end of their compulsory period of studying science at school place some value on the experiences they have had, a finding supported to some extent by responses to item *A09: What we do in science lessons is useful whatever you do after you leave school.* At all ages, this item was one of the top three responses for items about school science, with Level 2 data showing that two thirds or more of students felt it helped people understand the worth they live in. There was a small significant difference (χ2=7.455, p<0.05) with age that demonstrated a dip in this view at age 14 (84% at age 11, 67% at age 14 and 91% at age 16). A high proportion (80%-86%) of this sub-set of students also thought science affects much in everyday life. Around 15% in each age group disagreed, with between three quarters of them (aged 11 and 14) and 100% (age 16) saying you did not need science as you could get by with common sense. These disagreeing students also showed a small significant difference (χ2=5.995, p<0.05) with age in acknowledging that knowing something (e.g. the link between lung cancer and smoking) may not change how people behave: 32% at age 11, 67% at age 14 and 69% at 16.

Responses to science outside school

Figures 4 and 5 show responses to the items on science outside school by age and by gender. (See Table 2 for details of items.)

Figure 4: Percentage of 'agree' responses to items B01-B14 (by age)
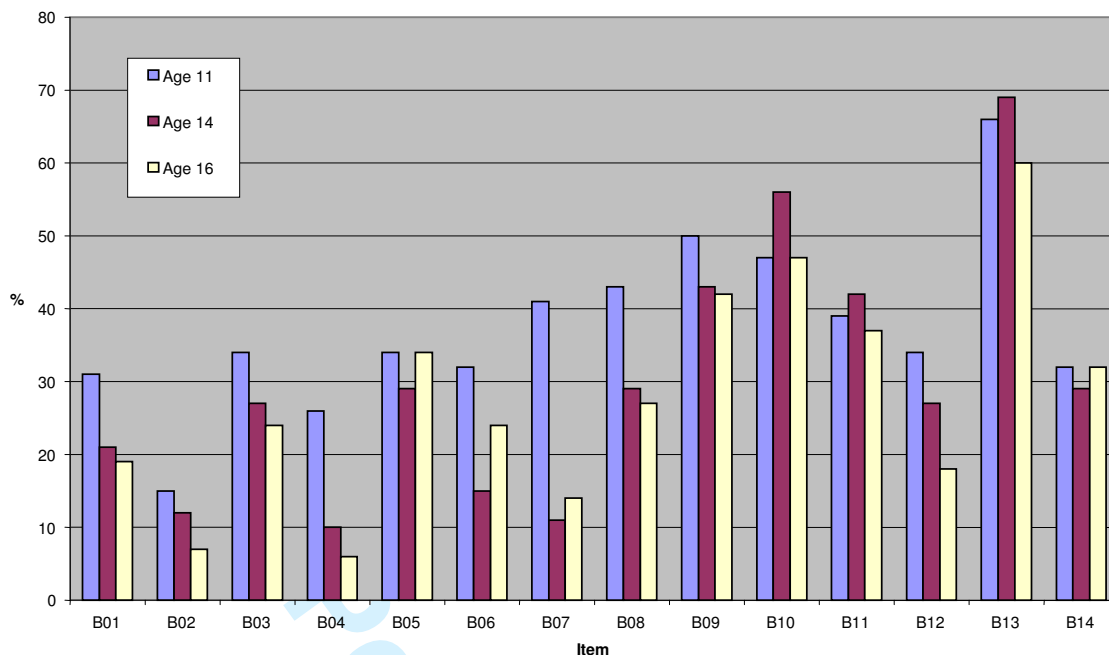
The overall pattern shows that attitudes to science outside school are less positive at age 16 than age 11, with four items showed statistically significant decreases in positive responses: *B04: I like reading science books other than school textbooks, B06: I would like a job involving science, B07: It would be good to have a job as a scientist*, and *B08: Science is blamed for things that are not its fault.* With the exception of *B02: I like reading about science in newspapers and magazines*, male students were more positive than female students in their responses to science outside school, with four items showing significant differences: *B08: science is blamed for things that are not its fault, B10: science can help solve problems, B11: science makes an important contribution to the wealth of the nation* and *B14: It is important to promote this country as a scientific nation*.

Figure 5: Percentage of 'agree' responses to items B01-B14 (by gender)
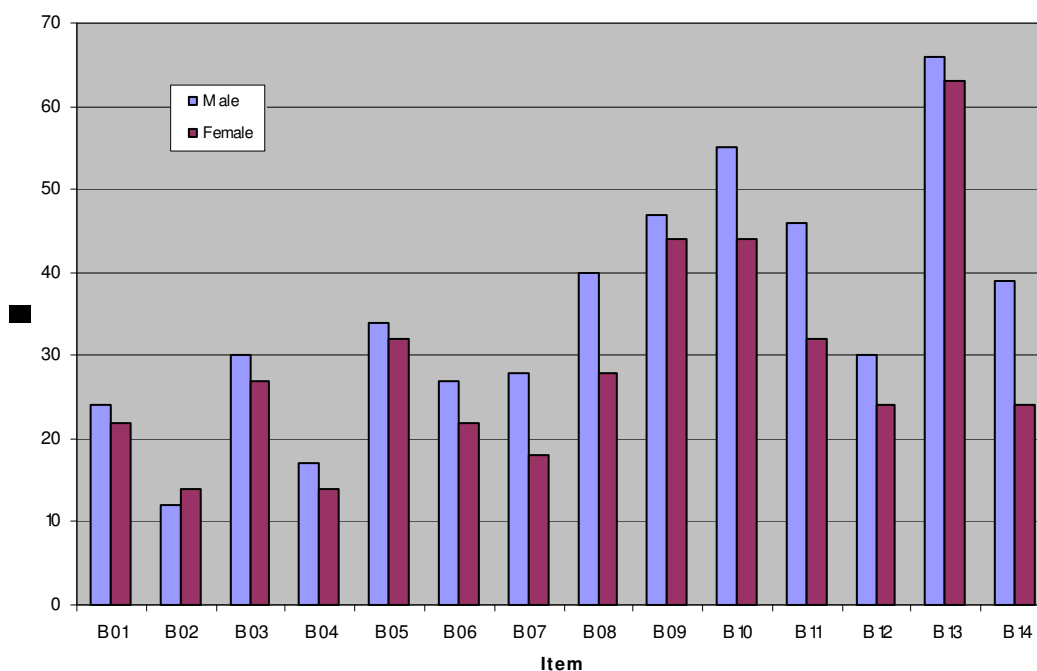
Overall responses to science in the media (B01, B02, B03) were not very positive, i.e. less than one third for all ages. Level 2 explanations for those students who were positive about watching science programmes on TV show no significant difference with age. Between 56% and 74% reported that the programmes made them more interested in science; and similar proportions found that they helped school science understanding (53% - 75%) and that they liked seeing how science is used in the real world (63% to 81%).

More than half of the students disagreeing with the statement declared they would never watch a TV programme about science (55% at age 11, 75% at age 14 and 69% at age 16). This lack of interest was also reflected in responses to *B02: I like reading about science in newspapers and magazines,* where the overwhelming majority of students - over 68% in each age group - said that they never read anything to do with science in newspapers and magazines. Whilst *B03: News items about science interest me* showed that over three quarters (78% - 81%) of the agreeing students thought it was important to learn about things that could affect them, around two thirds (65% -74%) of those who disagreed in each age group reported never bothering with news items about science. Within this overall pattern of response, female students were slightly more negatively disposed than male students to science in the media.

18

Item B02 (see above), together with *B04: I like reading science books other than science textbooks*, focuses on reading. Both statements did not elicit particularly positive responses at age 11, and became even less positive with age, B04 significantly so ($\chi2=17.906$, p<0.001). Around 15% of students aged 11 responded positively to B02, and this figure halved by age 16. The responses to B04 demonstrate that few students are interested in reading science books. What interest there was dropped off sharply between age 11 (26%) and age 14 (9%), declining further by age 16 (6%), where just short of half the students (49%) explicitly disagreeing with the statement. Wildlife books were the most interesting for three-quarters (74%) of students at age 11 and just under half (48%) liked science fiction. Close to half of the students at age 11 also related their extra-curricular science reading to their science lessons, both in terms of helping them understand the science they were studying (48%) and seeing the relevance of what they did in science lessons (52%). By age 16, these responses had virtually disappeared, with almost half the students report that they would never choose to read science books because they are so boring.

Responses to *item B05: I would trust something a scientist said*, were fairly equally divided between across age range and gender (around 30%). Level 2 responses showed that around 78% of students across all age groups agreeing with the statement felt that scientists were intelligent, and had expert knowledge (70%). 57% of students aged 11 felt scientists were respected members of the community, and it was part of their job to care about things (77%). Although students' respect for scientists dropped to around 38% at age 14 and 16, this was not significant. In contrast the perception of scientists as 'caring about things' did drop significantly to 44% at aged 16 ($\chi2=8.001$, p<0.02). The most frequently-selected responses for students disagreeing with the statement were that scientists confused people with long words and scientists might get things wrong.

Items B06 and B07 focused on careers in science, with B06 asking about liking a job involving science, and item B07 asking about being a scientist. Both showed significant differences in results. For item B06, students aged 11 were equally divided amongst agree/neutral/disagree. By age 14, there was a very low (15%) positive response and a very high negative response (60%) ($\chi2=11.863$, p<0.02).   However this was reversed to some extend by age 16, where close to one quarter (24%) of students were positive about the idea and just less than half (47%) opposed. The most frequent reason given in

19

the Level 2 data, irrespective of age, was that there are good jobs available in science (70% at age 11, 83% at age 14 and 78% at age 16). The next most frequent response related to enjoyment of science at school at age 11 (61%) and age 14 (58%), but this was of less relevance at age 16 (39%) than the perception of jobs as well-paid (61%). Finding science boring appears to be the most common reason at all ages for lack of interest is taking up a science-based job (76% at age 11, 70% at age 14, 76% at age 16). Antipathy to science as a source of problems for the world was a consideration for around one-third of the respondents in each age group.

For item *B07: It would be good to have a job as a scientist*, there was a highly significant (χ2=33.180, p<0.001) change of views between age 11 and age 14 with a drop from 41% to 10% agreeing with the statement. This change of view was sustained at age 16 (14%). At age 11, students gave a wide range of reasons: the nature of the work, remuneration and the view that scientists can have a positive influence on the world, suggesting that they have a generally positive overview of science as a job or career. Relatively few students at age 14 or 16 agreed with the statements, though, of those that did, by far the most common explanation (over two-thirds at each age) was that they felt that scientists were people who could change the world for the better. The Level 2 data for students disagreeing with B07 showed they had a wide range of negative opinions of scientists, with the two most prominent views being that scientists do boring jobs (61% at age 11, 85% at age 14, 63% at age 16) and are a bit weird (63% at age 11, 53% at age 14 and 53% at age 16). Scientists were also seen as uncaring by around two-fifths of students in each age group, with a similar proportion also seeing scientists as causing problems in the world, and as risk takers.

There was a highly significant drop (χ2=14.345, p<0.01) between age 11 (43%) and age 14 (26%) in the proportion of students agreeing with *B08: Science is blamed for things that are not its fault*, with little further change at age 16 (27%). The percentage disagreeing also fell, but less markedly, between age 14 (27%) and age 16 (17%). Level 2 data indicated these changes were associated with a steady increase over the year groups from one third (33%) at age 11 to well over one half (57%) by age 16 who neither agreed nor disagreed. A high proportion of students of all years (93% at age 11, 91% at age 14, 73% at age 16) were of the opinion that information was often misrepresented in the media and by implication that this tendency is a reason that 'science is blamed for things that are not its fault'. The drop in this view at age 16 was

20

significant ($\chi2$=6.389, p<0.05). Half of the respondents in each age group perceived that it is scientists who are often blamed for (negative) aspects of science that are actually a consequence of the actions of others. There was a tendency that increased with age for students to believe that science is bound to get blamed for some things as it is so common in everyday life (42% at age 11, 55% at age 14, 65% at age 16), and the opinion that only bad things about science get reported rose steadily with age (24% at age 11, 36% at age 14, 46% at age 16). In contrast, close to three-fifths of all ages (56% at age 11, 55% at age 14, 63% at age 16) who chose to disagree with the main statements felt that this was because science helps to create problems, but only the good things about science are reported. Three-quarters or more of students in each age group were not interested in the way science is reported.

It is apparent from Figures 4 and 5 that more students respond more positively to items towards the right hand side of the chart than the left. What characterises these latter items is that there is a shift from the more personal (e.g. *B06: I would like a job involving science*) to the less personal (e.g. *B14: It is important to promote this country as a scientific nation*). However, five of the fourteen items relating to science outside schools showed significant differences in favour of positive responses by male students: *B08: science is blamed for things that are not its fault*, *B10: Science can help solve problems*, *B11: Science makes an important contribution to the wealth of the nation* and *B14: It is important to promote this country as a scientific nation*. Whilst the general pattern of responses being more positive to less personalised items is repeated, it is clear that, within this, female students are less positively disposed towards science outside school than their male counterparts. In part this is because they are more cautious in their judgements.

For item *B10: Science can help solve problems*, male students had a significantly more optimistic view of the beneficial role of science (M=55%, F=44%; $\chi2$=10.052, p<0.01). Level 2 data showed a very high proportion (over 90%) of students agreeing with the statement felt that scientists can help to solve problems by inventing things, with close to three quarters supporting the view that science can give us the knowledge to sort out problems. Regardless of gender, all students who disagreed with the statement supported the view that science causes the problems in the first place and so is unlikely to solve them.

A significantly higher proportion of female students (54%) responded in a neutral or cautious fashion to *B11: Science makes an important contribution to the wealth of the nation* compared to male students (37%) who were much more likely to agree (M=46%, F=32%) ($\chi2$=7.675, p<0.05). Percentages disagreeing with the statement were similar (M=17%, F=22%). Level 2 data revealed that 80% of students believed that science helps to create jobs, with close to 40% of both sexes supporting the view that science lead to inventions which people then buy. The importance of science to industry and the economy was recognised by similar proportions of male and female students (M=66% , F=70%). Of the students who disagreed with the statement a high proportion of both sexes (F=90%, M=73%) felt that science costs money rather than generating wealth. Appreciably more male students (73%) than female students (55%) thought that science was not about money but about finding things out.

While two-thirds of students agreed with item *B13: It is important for this country to have well-qualified scientists*, there was a significant difference in those who were neutral or disagreed. The female students (31%) were more uncertain than the male students (20%) balance by a higher proportion of male students who disagreed (13%) than female students (6%). Level 2 data showed that a very high proportion of students (95%) who agreed with the main statement did so because they thought science important for certain areas such as medicine. Additionally 60% of students supported the suggestion that scientists in this country can help other countries. Rather more male students (60%) than of female students (46%) felt that scientists make the country a better place in which to live.

Significantly more male students than female students (39% and 24% respectively, $\chi2$=6.672, p<0.05) agreed with *B14: It is important to promote this country as a scientific nation*. This was balanced by a higher proportion of female students (31%) than male students (25%) who disagreed or who neither agreed nor disagreed. Level 2 data showed that high proportions of both sexes (M=85%, F=82%) thought that promoting the country as a scientific nation would be good for the economy and for employment. Very similar proportions thought that the UK should not be left behind other nations given that people in this country have good ideas. The sizable majority of students disagreeing with the statement thought there were more important things to promote about the UK (M=83%, F=100%).

22

The 'age 14 dip'

Within the overall pattern of declining positive attitudes, responses to several questions showed the decrease is particularly sharp between age 11 and age 14 with, in some cases, a slight improvement by age 16. This might be termed an 'age 14 dip' in attitudes.

Of the nine items that showed a significant difference in responses with age (A01, A03, A05, A06, A07, B04, B06, B07 and B08), six of these showed the biggest change in attitude between ages 11 and 14, where attitudes appeared to dip sharply, sometimes followed by a rise at ages 16. These items, with percentage responses, are summarised in Table 5.

Table 5: Items showing the most significant decline between the ages of 11 and 14

		Agree at age 11 (%)	Agree at age 14 (%)	Agree at age 16 (%)
A01	Science lessons are among my favourite lessons	39	26	27
A03	My science teachers make me more interested in science	49	31	31
B04	I like reading science books other than school science textbooks	26	10	6
B06	I would like a job involving science	32	15	24
B07	It would be good to have a job as a scientist	41	10	14
B08	Science is blamed for things that are not its fault	43	26	27

This 'age 14 dip' is illustrated in Figure 6.

Figure 6: The distribution of 'Agree' percentages for those items related to attitude to science as a whole that showed significant variations in 'Agree', 'Neither agree nor disagree' and 'Disagree'
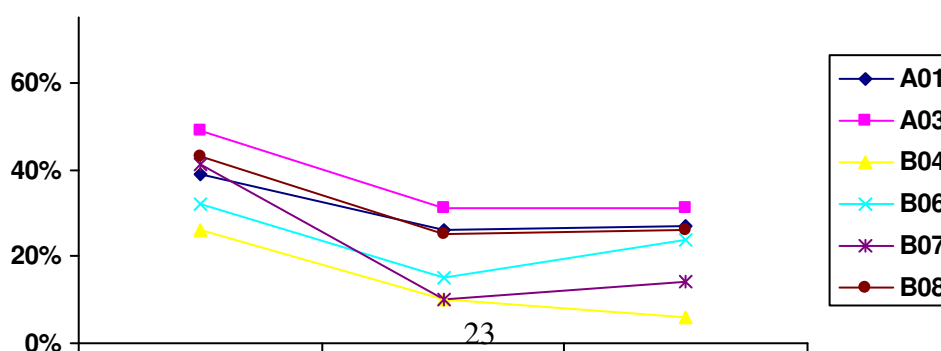
This sharp decline in attitudes from age 11 to age 14 is in keeping with the findings of the study be Galton *et al.* (2003).

The explanatory (Level 2) responses to some of the items offer interesting insights into the 'age 14 dip'. For example, over 40% of students at age 11 were attracted to careers in science, giving a wide variety of reasons: the nature of the work, remuneration and the view that scientists can have a positive influence on the world. This would suggest that they have a generally positive overview of science as a job or career. By age 14, the figure has fallen very significantly to 11% ($\chi2=20.541$, $p<0.001$), with jobs involving science being seen as unattractive because they are perceived as boring, because science is perceived as causing too many problems in the world and scientist having to make too many compromises. However, almost all the students aged 16 who did want a job involving science gave as their reason the fact that scientists could change the world for the better. There was a sense in the data that, as students matured, some at least, came to feel that science offered a way of making a positive difference to people's lives.

Scientific disciplines

One particular aspect which generated polarised responses concerned attitudes to the individual science subjects. These were probed in items A05 (biology), A06 (chemistry) and A07 (physics). There are clear differences in responses as shown in Table 6.

Table 6: Differences in responses to the statements for individual science subjects (by age)

Age	A05: If I had a choice, I would study biology			A06: If I had a choice, I would study chemistry			A07: If I had a choice, I would study physics		
	Agree (%)	Neither (%)	Disagree (%)	Agree (%)	Neither (%)	Disagree (%)	Agree (%)	Neither (%)	Disagree (%)
11	26	38	36	42	31	27	23	35	43
14	43	20	37	26	16	58	28	18	54
16	34	12	54	25	16	59	20	12	68

24

Interest in biology increases from age 11 to age 14 before decreasing slightly at age 16. In contrast, interest in chemistry and physics declines from age 11 to age 14, a pattern which continues through to age 16. Each of these subjects appears to have a slightly different problem. Significantly more students are interested in chemistry (42%) than in physics (23%) at age 11 ($\chi 2$=8.739, p<0.01). Indeed, chemistry attracts the highest level of interest of all three sciences at this age. For physics, the problem is that interest is low to begin with, and declines with age, whereas for chemistry interest is comparatively high initially but characterised by a steep and significant decline between age 11 and age 14 ($\chi 2$=7.713, p<0.01).

Level 2 data showed the most prominent reason for wishing to study biology at all ages was that students found the subject interesting (74% at age 11, 70% at age 14 and 61% at age 16). The most common reasons given for not wanting to study biology was it not being necessary for the jobs students had in mind (68% at age 11; 71% at age 14 and 62% at age 16). In addition to interest in the subject, practical work emerged as significant in students reporting whether or not they wanted to study chemistry (66% at age 11, 80% at age 14 and 67% at age 16). The two most important reasons for not wanting to study chemistry were it perceived lack of relevance of chemistry for the job the student had in mind (79% at age 11, 62% at age 14 and 59% at age 16) and the strategic aspect of obtaining better grades in other subjects (43% at age 11, 29% at age 14 and 48% at age 16). There was a marked reluctance to study physics, and this increased steadily with age. While the proportion who wanted to study the subject did not change greatly (23% at age 11, 28% at age 14 and 20% at age 16), the proportion who disagreed increased significantly from 42% at age 11, 54% at age 14 to 67% at age 16 ($\chi 2$=7.370, p<0.05). Level 2 responses showed physics is increasingly seen as hard, with significantly more older students feeling they could get better grades in another subject (34% at age 11, 29% at age 14 and 53% at age 16) ($\chi 2$=7.146, p<0.05).

Within these overall patterns, clear gender differences emerged, as shown in Figure 7.

Figure 7: Percentages of male and female students agreeing with the items 'If I had a choice I would study …'

25
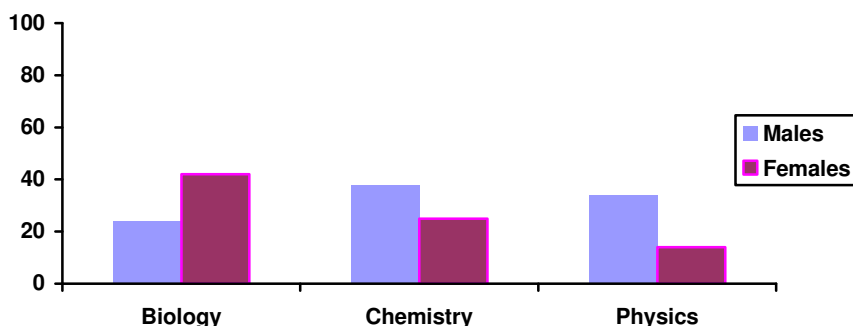
The gender responses were significantly different for all three subjects. Nearly twice as many females (42%) than males (24%) wanted to study biology if they had a choice ($\chi2=10.120$, $p<0.01$). For chemistry, 39% of males wanted to study chemistry, compared with only 25% of females ($\chi2=5.897$, $p<0.02$). For physics, more than twice as many males (34%) as female students (14%) wanted to study physics ($\chi2=15.026$, $p<0.001$).

Significant differences emerging in the Level 2 responses included all three science subjects being perceived as harder by female students than male students. Biology was seen as hard by 40% of female students and 20% of male students ($\chi2=5.244$, $p<0.02$). The parallel figures for chemistry were 46% for female students and 28% for male students ($\chi2=7.069$, $p<0.01$) and, for physics, 51% for female students and 34% for male students (34%) ($\chi2=4.138$, $p<0.05$). There were marked gender differences in the number of students selecting chemistry because they needed it for a job (M=15%, F=33%) ($\chi2=3.902$, $p<0.05$), and in the extent to which the sexes did not see the point of the things they do in chemistry (M=8%, F=22%) ($\chi2=4.759$, $p<0.05$), suggesting that chemistry appears to have more relevance to male students than to female students.

The most gender-polarised responses were for physics. Although the most frequent Level 2 reason given by both sexes was that they chose the subject because they found it interesting (M=84%, F=55%), this was the case for significantly more male students than female students ($\chi2=6.469$, $p<0.02$). Very similar responses were given in relation to the maths component of physics. The two most frequent reasons identified for not choosing to study physics was that it was not required for the job of choice (M=56%, F=54%) and that better grades could be obtained with other subjects (M=45%, F=38%).

Shift in opinion with maturity

26

One feature of particular interest in the data is the shift from 'agree' or 'disagree' to 'neither…' responses as students get older. There are examples of items where there was no significant difference with age in the number of agree responses, but a very apparent difference in shift from 'disagree' to 'neither …' responses. For example, in item B07, *It would be good to have a job as a scientist,* numbers disagreeing with this statement stayed roughly constant at around the 40% level. However, the very significant fall in numbers agreeing with the statement (from 41% at age 11 to 10% at age 14 ($\chi2$=20.541, p<0.001) was mirrored by a corresponding rise in number selecting the 'neither…' option (22% to 45%; ($\chi2$=10.384 p<0.01). A similar pattern in responses may be seen for item B08, *Science is blamed for things that are not its fault*.

Within this overall shift in opinion with maturity, it is also apparent that a significantly higher proportion of female students chose the 'neither …' option in all cases where there was a significant gender difference in responses. One possible explanation for this is that female students may be more cautious than male students in opting for a definite 'agree' or 'disagree' response which, in turn suggests that male students may have firmer opinions or a more 'black and white' view of the world. A number of aspects of the data would appear to support this hypothesis. For example, in item B13, significantly more male students (13%) than female students (6%) disagreed with the notion that it is important for the country to have well qualified scientists ($\chi2$=3.857, p<0.05). Furthermore, when looking at the reasons why the 'neither …' option is selected, there is a consistent trend for more female students than male students being prepared to admit they did not know enough to make an informed response.

Conclusions

Research into attitudes to science often results in feelings of comfort (though very often cold comfort) from reaffirmation of the findings of other work, demonstrating that concerns are common and widespread, coupled with frustration at the seemingly intractable nature of the problem.

A number of the findings of this study, particularly the Level 1 responses, reaffirm the well-documented findings of other studies: that attitudes to science become less positive

27

over the period of secondary schooling, that interest in science as a school subject and in jobs involving science is much lower at the end of compulsory secondary education, that the physical sciences elicit more negative responses than biology, and that female students are less positively disposed than male students towards science. The Level 1 responses also add to the growing evidence that attitudes to science outside school are more positive than attitudes to school science.

The principal justification for developing the new instrument was to go beyond descriptive data to probe for explanations and insights that, in turn, might point to possible areas to target for action. What, therefore, has emerged from the explanatory (Level 2) data, and what messages emerge for future research, and for policy and practice?

The 'age 14 dip' suggests areas where more detailed research could prove fruitful. Clearly the early years of secondary education are crucial, with students seeing their teachers as very influential, particularly at age 11, citing 'being made to think' in lessons, variety in activity and seeing how science relates to life as the reasons for this. These responses point to teachers having the potential to make a crucial difference at this point. Most curriculum materials now do contextualise science, but rather less is known about the range of activities teachers use in science lessons and their effects. The notion of what students see as activities that make them 'think' in science lessons would certainly benefit from further exploration. Within this, it would be helpful to explore these dimensions in relation to the different scientific disciplines, as each appears to have a different problem. Interest in physics remains consistently low, while interest in biology increases. The science reported as most interesting at age 11 - chemistry - shows the sharpest decline.

Other insights to emerge from the explanatory data point to possible changes in the school science curriculum. Young people, particularly female students, appear less clear-cut in their views as they mature, and feel they need more information before they can reach views in relation to, for example, wanting a job involving science. Thus one area for action would appear to be to look carefully at how information about jobs involving science might feature in curriculum materials, both in relation to the jobs themselves and in the context of the view of scientists as 'uncaring'.

28

Some tensions do emerge from the data: young people see science leading to good jobs, and a need to training the scientists of the future, yet most do not aspire to jobs involving science. This reflects the "important but not for me" message from the study by Jenkins and Nelson (2006). The largely negative image of scientists appears to be a factor that comes strongly into play here, particularly as the Level 2 data showed that the majority of those students at age 16 who said they wanted a job as a scientist felt that scientists could change the world for the better.

One challenging area for policy to emerge from the data is the perception that science subjects are hard, and there are greater rewards in terms of examination grades for effort put into other subjects. There appear to be messages here for the subject content of science curricula, and, possibly, ways in which national tests and examinations are graded.

Looking more widely at the nature of research on attitudes to science, we believe the instrument developed for this study has a number of strengths: considerable care has been taken in its design and validation, its language draws on 'the student voice', and it probes for explanatory insights as well as establishing general patterns.

We also believe that the study points to the future direction of attitude research. Well-designed instruments certainly have a role to play in surveying attitudes, but their principal strength lies in providing the 'board brush stokes' of the picture, rather than providing much of the detail that might point to action. There is evidence that some schools that are much more effective than others at encouraging uptake of particular subjects. For example, Fitzgibbon (1999) established significant inter-school variations in numbers of students electing to study mathematics beyond the compulsory period, and her finding suggested that there might be similarities with the sciences in factors underlying student choice. A recent report of three small-scale case studies by Ponchaud (2006) suggests that school-based factors, such as enthusiastic teaching by specialist teachers, and provision of good information about the value and flexibility of science qualifications, can exert significant effects on uptake of science. Moreover, some of the factors that may promote more positive attitudes to science may not be apparent to students and therefore not easily accessible through attitudinal instruments. Thus, we contend, the priority for research on attitudes to science is to explore in more

detail features of schools that are more - and less - successful at encouraging uptake of

science beyond the compulsory period.

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Storage of the original data

All the original data are stored at [to be added].

The full report

The full report may be accessed at: [to be added].

Acknowledgements

[To be added.]

32

Would YOU want to talk to a scientist at a party? High school students' attitudes to school science and to science

Abstract

This paper describes a four-year project involving the development of a new instrument, the *Attitudes to School Science and Science* instrument, and its use to collect baseline attitudinal data from 280 students aged 11, 14 and 16. A key feature of the instrument is that it collects both descriptive and explanatory data in a pencil-and-paper format. The data gathered is probed in detail for explanatory insights into features that have emerged from more recent research on attitudes to science, in particular the suggestions that students view science outside school more positively than their experiences in science lessons, and that the early years of secondary education (ages approximately 11 to 14) are the most crucial in shaping attitudes. The study shows that positive attitudes to school science decline significantly between the ages of 11 and 14, with little appreciable downward change beyond this and, in some cases, a slight upturn. Female students display less positive attitudes and less clear-cut views on a variety of aspects of science. A sense of science being important in general terms, though not having much appeal for individual students, also emerged clearly from the data. The paper suggests that attitudinal instruments have a role to play in research, but that these need to be complemented by studies of detailed features of schools that may influence attitudes, some of which may not be apparent from data collected from students.

Introduction

What views might a class of sixteen-year-olds have about science? Here is a selection of comments from students involved in the study reported here:

1

"We use science for everything. We ARE science."

"Science is important because modern society is built entirely around the scientific

advances of recent centuries."

"Science causes problems in the first place, so how can it get rid of them?"

"Would YOU want to talk to a scientist at a party?"

Most people involved in science education would probably be very pleased if any sixteen-

year-old they knew made one of the first two comments. Sadly, it is the case that far too

many young people are likely to have more empathy with the last two comments. Such

comments also serve only to reinforce the considerable disquiet felt in the science education

community and beyond over the numbers of students taking science subjects, particularly

chemistry and physics, in post-compulsory education in a number of countries. It would seem

that there is widespread disenchantment amongst young people, who are 'voting with their

feet' and turning away from science when they have a choice. In England and Wales, for

example, where the study reported here was undertaken, data from public examination entries

show that the percentage of young people choosing to study physical science subjects at

Advanced level (the first point of choice at age 16+) fell by 2.1% in the period 2001-2005 for

chemistry, and by 14% for physics (Hyam, 2006), continuing a steady downward trend that

has yet to be reversed. Such patterns are not unique to the UK, and it is therefore unsurprising

that concerns about participation in science feature prominently in current debates over policy

and practice in science teaching in a number of countries, as reflected in publications such as

Europe needs more scientists (European Commission, 2004), *Evolution of student interest in*

science and technology (Organisation for Economic Co-operation and Development [OECD],

2006), and *The supply and demand for science, technology, engineering and mathematics*

skills in the UK economy (Department for Education and Skills, 2006). The recent focus on

2

numbers choosing science in the post-compulsory period of study reflects a longstanding

concern about levels of participation. Underpinning this is the notion that *attitudes to science*

are crucial, as they are a major determinant of subject choice.

Research on attitudes to science

The research on attitudes to science is extensive, and the 'broad brushstroke' findings are

well-known: science is perceived as difficult and not relevant to the lives of most people,

interest in science declines over the years of secondary schooling, science is more attractive to

male students than female students, and problems being most acute in the physical sciences.

These findings have emerged as relatively constant features in a number of countries over the

past four decades, and are well-documented in a literature that including several detailed

review articles (e.g. Gardiner, 1975; Ormerod and Duckworth, 1975; Schibeci, 1984; Munby,

1990; Ramsden, 1998; Osborne et al., 2003).

Whilst to a large extent more recent studies confirm earlier findings, some new slants have

emerged that appear worthy of further probing. The most noticeable of these is neatly

encapsulated in the title given by Jenkins and Nelson (Jenkins and Nelson, 2005): "Important

but not for me." Jenkins and Nelson were reporting the UK data from a large and ongoing

comparative international survey of students aged 16, the Relevance of Science Education

(ROSE) project, which began in 2001 and involves over 30 countries (Schreiner and Sjøberg,

2004; Sjøberg and Schreiner, 2005). The ROSE data indicate that a general appreciation of

the value of science outside school is not reflected in responses about enjoyment of science in

school, or a desire to have jobs involving science. This message is echoed in other studies.

Osborne and Collins (2001) showed sixteen-year-old students to believe science was an

important subject in the school curriculum, but more for career purposes for those interested

in science than because of intrinsic interest. In a similar vein, Haste (2004) found young

people emerged from compulsory schools with a moderately positive image of science and

technology outside school, but with far less interest in jobs in science.

Newer studies are also contributing to a growing body of evidence that points to attitudes to

science declining most sharply in the early years of secondary education (Galton et al., 2003),

a decline that is more appreciable in for science other school subjects. This period has also

emerged as crucial in relation to the impact of science teachers on students' views of science

and careers involving science (Osborne and Collins, 2001; Cerini, Murray and Reiss, 2004;

Munro and Elsom, 2000).

The literature on attitudes to science has also signalled a number of methodological concerns

about work in the area. Principally, these relate to poor instrument design and analysis,

including failure to address matters of reliability and validity, the plethora of existing

instruments, many of which are limited in use to a single study, and failure to draw on ideas

from psychological theory (e.g. Gardiner, 1975; Ormerod and Duckworth, 1975; Schibeci,

1984; Munby, 1990; Ramsden, 1998; Osborne et al. 1998; Simon, 2000; Osborne et al., 2003;

Blalock *et al.*, 2008).   One message emerging from these reviews is that of caution over the

need to develop yet another instrument, given the number that already exists. A further issue

to emerge concerns the nature of the way in which data are gathered. A consistent feature of

attitude research is the use of fixed-response inventories and scaling techniques to gather data.

Of these, Likert-type scales predominate (for example, Haste, 2004; Kelly, 1986; Misiti, *et

al.*, 1991; Qualter, 1993; Simpson and Oliver, 1990; Sjøberg and Schreiner, 2005), though

others, such as Thurstone-type rating scales (for example, Johnson, 1987; Smail and Kelly,

1984) and semantic differential scales (for example, Crawley and Koballa, 1994) have also

been used. Much more limited use has been made of interviews (for example, Piburn and

4

Baker, 1993) and, more recently, focus groups (Osborne and Collins, 2001). One outcome of a heavy reliance on fixed-response inventories is that much attitude data is characterised by an emphasis on descriptions of 'the problem', with rather less attention paid to possible explanations.

The purpose of this study

The study reported here involves the development and use of a new instrument to gather data on attitudes to science, characterised by two particular features in relation to the instrument design. Firstly, it sought to develop a 'pencil-and-paper' instrument that moved beyond the largely descriptive data generated by most other survey instruments to probe for explanations of particular responses. Secondly, steps were incorporated into the development of the instrument to address a number of common problems the literature has identified in attitudinal instruments. The nature of the data generated by the instrument does not lend itself to the rigours of statistical methods often followed in the design and development of attitudinal instruments. However, probing for explanations offers the potential to yield deeper insights into areas to target for possible action.

The aims of the study were as follows:
- to design an instrument to enable both descriptive (Level 1) and explanatory (Level 2) data to be gathered on students' affective responses, or attitudes, to science;
- to use the instrument to gather baseline data from school students aged 11, 14 and 16.

Within the context of these overall aims, the study also sought to explore in more depth some of the new slants emerging from more recent work on attitudes by looking, firstly, at possible differences between responses to science in school and science outside school, and, secondly,

at changes in attitudes in the early years of secondary schooling. The study did not set out to look specifically at differences between the responses of male and female students, but the number of significant gender differences that emerged in the analysis suggested it would be important to include these in a report of the findings. Equally, though the study did not set out to look specifically at differences in responses in groups of differing ability, data on ability were collected. This was because a particular concern about levels of participation is the number of able and well-qualified students electing not to study science in the post-compulsory period, and it seemed useful to look for any particular patterns in attitude and ability. However, as none emerged, these data are not reported here, other than in characterising the sample.

The development of the research instrument

The design of the instrument adapted the approach developed in the *Views on Science-Technology-Society* (VOSTS) study, undertaken in Canada in the late 1980s to document the views of upper high school students (aged 16-17) on science-technology-society topics (Aikenhead and Ryan, 1989; 2002). Underpinning the VOSTS approach was the belief that attitudinal survey instruments most usually reflect the perceptions of the developers, rather than the respondents, on the likely influences. Thus an instrument that draws n students' views in its development is likely to generate more valid data.   In essence, the VOSTS approach involved the empirical development of a fixed response item pool based on views expressed by the students. This was achieved through presenting students with a series of statements on aspects of science, technology and society, and inviting free responses. Common themes within these responses then formed the basis of categories for the fixed-response version of the instrument. The VOSTS approach had two particular attractions. Firstly, the options in the fixed-response instrument drew directly on the words of the

6

students, and, secondly, through the use of a pencil-and-paper instrument, it offered the

potential to probe for explanatory data from a large dataset.

The development of the research instrument involved six steps, summarised in Table 1.

Table 1: Stages in the development and validation of the research instrument

Stage	Procedure	Data sources
1	Identification of areas to be explored	Literature search plus interviews with 36 students aged 11, 14 and 16 (12 of each age)
2	Composition and peer validation of disposition statements	Initial development by team of three researchers plus two teachers; validation by approximately 25 science educators and teachers
3	Gathering of free responses to disposition statements	Approximately 40 responses per item, 10-15 per age range in two all-ability comprehensive schools
4	Development and validation of trial fixed-response items	Categorisation and validation of responses
5	Production, use and validation of fixed-response version of instrument	Trial with 91 students in four classes, two aged 11 and two aged 16

Stage 1 yielded responses in a number of areas including: response to science lessons (teacher

effects, views of particular activities, views of different branches of science); views of social

implications of science (from school science and experiences outside school); views of

teacher characteristics; views of learning situations; views of science as presented in the

media; views of scientists and their work. These areas were divided into the two broad

categories of responses to school science and responses to science outside school.

Stage 2 involved the development of a series of statements relating to school science and

science outside the classroom. These took the form of *disposition statements*, i.e. responses

were indicative of attitude to science or school science. An initial pool of around 40 items

was reduced to 25 through a series of peer validation meetings involving approximately

twenty-five science educators and teachers. These statements are shown in Table 2.

7

Table 2: The disposition statements

Dispositions towards school science

A01   Science lessons are among my favourite lessons.
A02   I try extra hard in science lessons.
A03   My science teachers make me more interested in science.
A04   The things we do in science lessons make me more interested in science.
A05   If I had a choice I would study biology.
A06   If I had a choice I would study chemistry.
A07   If I had a choice I would study physics.
A08   I enjoy reading science textbooks.
A09   What we do in science lessons is useful whatever you do after you leave school.
A10   Everybody should study all three science subjects (biology, chemistry and physics) up to age 16.
A11   When they have a choice, young people should be given particular encouragement to study science subjects.

Dispositions towards science outside school

B01   I like watching science programmes on the TV.
B02   I like reading about science in newspapers and magazines.
B03   News items about science interest me.
B04   I like reading science books other than school science textbooks.
B05   I would trust something a scientist said.
B06   I would like a job involving science.
B07   It would be good to have a job as a scientist.
B08   Science is blamed for things that are not its fault.
B09   Science has a positive influence on society.
B10   Science can help solve problems (e.g. environmental and social problems).
B11   Science makes an important contribution to the wealth of the nation.
B12   The Government should spend more money on scientific research.
B13   It is important for this country to have well-qualified scientists.
B14   It is important to promote this country as a scientific nation.

In Stage 3, each of the statements was in a form which invited students to respond on a Likert-type scale (strongly agree/agree/neutral/ disagree/strongly disagree) to indicate their view, followed by a request to explain, as a free response, their reasons for holding this view.

The first step in Stage 4 involved the free responses being independently categorised into groups by two members of the research team. There was over 90% agreement on categorisation. Each category of response was summarised in a sentence, drawing as closely as possible on the words used students' written responses. These then formed the basis of the fixed responses to the disposition statements. Typically, an item would have between eight

8

and ten fixed response options. A sample fixed-response item is shown in Table 3. Once students had selected their Level 1 response (agree/neither agree nor disagree/disagree), they were invited to select as many of the Level 2 responses as they felt applied to them. The instrument thus enables responses to be gathered at two levels: Level 1 responses indicate agreement or otherwise with the disposition statement, and Level 2 responses probe for explanations.

Validation of the trial fixed-response items took place approximately three months after the collection of the free responses. The process involved asking the same classes of students who had originally given free responses to complete eight fixed-response items, with items being distributed to students in such a way that at least ten responses per item were collected. The responses selected by the students on the fixed-response item were then compared with the original free response. The very good agreement (85%) between free responses and the fixed-response options is a measure of the reliability of the items. Short interviews with students where differences had emerged established that these students had not originally held any particularly strong view.

To maximise the validity of the range of Level 2 responses, each item offered the options of not selecting any of the fixed responses offered, but giving "another reason – please say what". The intention was to look for any further patterns emerging in from these options and add them to the options offered. In practice, though between three and five students per item selected "another reason", the reasons were very varied and no consistent patterns emerged. It was decided to leave the "another reason ..." option in the final version of the instrument to allow student to express different views if they so wished.

9

Table 3: Example of final format for multi-choice items

B06   I would like a job involving science.

I agree because…		I neither agree nor disagree because…		I disagree because…	
a	…I enjoy science at school	k	…it depends on what science you would be doing	p	…I find science boring
b	…they are generally well paid			q	…science causes too many problems for the world
c	…science makes the world a better place to live in			r	…they don't get well paid
d	…there are good jobs you can do with science				
x	… another reason – please say what	y	… another reason – please say what	z	… another reason – please say what

(**Bold text** in table = Level 1 responses; plain text = Level 2 responses)

10

Stage 5 involved the trial of the instrument. Four classes in two schools participated in the

trial, such that data were gathered from 91 students in two classes aged 11 and two aged 16.

This enabled the instrument to be tested with students at the upper and lower ends of the target

age range.

Content validity was assessed by the following procedure. At the point where their students

completed the instrument, the class teacher was asked to indicate their view of each student's

attitude to science on a five point scale, where a score of five represented a very positive

attitude, and a score of one represented a very negative attitude. A numerical total was then

calculated for each student based on their responses to the instrument. Any 'agree' options

selected were given a score of three, 'neither agree nor disagree' options were given a score of

two, and 'disagree' options a score of one. Whilst there are drawbacks to assigning numerical

scores to Likert-type responses, it was felt that these were outweighed by the advantages of

having some indicator of the validity of the instrument in gauging attitudes to school science

and to science. Visual inspection of the scattergrams of the teacher scores for students'

attitude and the students' score on the instrument showed a good line of fit, and there were no

instances where the instrument had indicated a negative attitude and the teacher had indicated

a positive attitude. In a limited number of instances (10%), the instrument indicated a positive

attitude whilst the teacher had indicated a negative attitude. Conversations with the teachers

showed that these cases tended to be students who were seen as not very hard-working by the

teachers, and that this influenced their view of the students' attitude.

Details of the full instrument may be accessed from the web-link at the end of this paper.

11

The main study: the sample and methods of analysis

The instrument was used to gather baseline data in a survey of 280 school students in four all-ability (mixed comprehensive) secondary schools in late April 2004. Two of the schools were in a comparatively small city, one in a town and one in a semi-rural area. For ease of administration, data were collected from whole-class sets. All the students were following conventional science courses of similar content prescribed in external, national specifications. None was following courses linked to any new intervention. The instrument was administered to three cohorts of students aged 11, 14 and 16. These are the first, third and fifth (final) years of compulsory secondary schooling in England and Wales, and the study of science is compulsory throughout this age range.

Data on students' ability levels were obtained based on actual or estimated results from external tests and examinations, these being the only external measures of ability common across all schools. Internal measures lack reliability as they are based on tests developed within schools. These were Standard Assessment Tasks (SATs) at Key Stage 2 taken by students taken at age 11 or at Key Stage 3, taken by students at age 14, or General Certificate of Secondary Education (GCSE) examinations, taken by students at age 16. These measures were used to designate students as high, middle or low ability. Details of the sample are given in Table 4.

Table 4: Details of sample

Age	N	% Male	% Female	Low ability Male	Low ability Female	Middle ability Male	Middle ability Female	High ability Male	High ability Female
11	104	49	51	2	0	27	25	22	28
14	78	47	53	5	3	13	16	19	22
16	98	49	51	0	3	17	33	31	14
Total	280	136	144	7	6	57	74	72	64

12

Although data were collected from whole class sets, the sample turned out to be balanced in terms of gender, with just slightly more female students (n=144) than male (n=136). External measures of ability resulted in the majority of the students in the sample being designated as middle or high ability. The likely explanation for this is that the external measures used for ability are not very discriminating in that the majority of student will be placed in one of three broad bands at age 11 and 14. Overall, however, the sample was felt to be representative of the group from which it was drawn, as data were collected from classes across the whole ability range.

Analysis of the non-parametric data was carried out using the SPSS 11 package, and applying the Chi-squared test to look for significant differences in responses.

Results

The nature of the instrument means that the database developed is extensive, particularly in relation to the Level 2 responses, and it is beyond the scope of this paper to present and discuss all the findings in detail. This paper therefore presents the most notable features of the data in six main sections. The first presents an overview of responses, with the second and third highlighting key features of the data in relation to school science and science outside school. The next two sections focus on particular aspects of the data that offer insights into two of the particular foci of the study: differences in responses to science in school and science outside school, and changes in attitudes in the early years of secondary schooling. The last section reports a noticeable, though unanticipated, outcome of the study, a shift in opinion with maturity.

13

Overview of responses

Figure 1 provides a visual overview of the positive responses to each of the items by showing the percentage of students in each age group who selected 'agree' as their Level 1 response for each item. Figure 2 show the percentages of male and female students who selected 'agree' as their Level 1 response for each item. The figures show a noticeable trend for positive attitudes to items relating to both school science and to science outside school to decrease overall from age 11 to age 16 and, within this, for female students to hold less positive attitudes than male students.

The items where differences in responses were statistically significant for all Level 1 responses (i.e. 'agree', 'neither agree nor disagree' and 'disagree'), are summarised in Table 5.

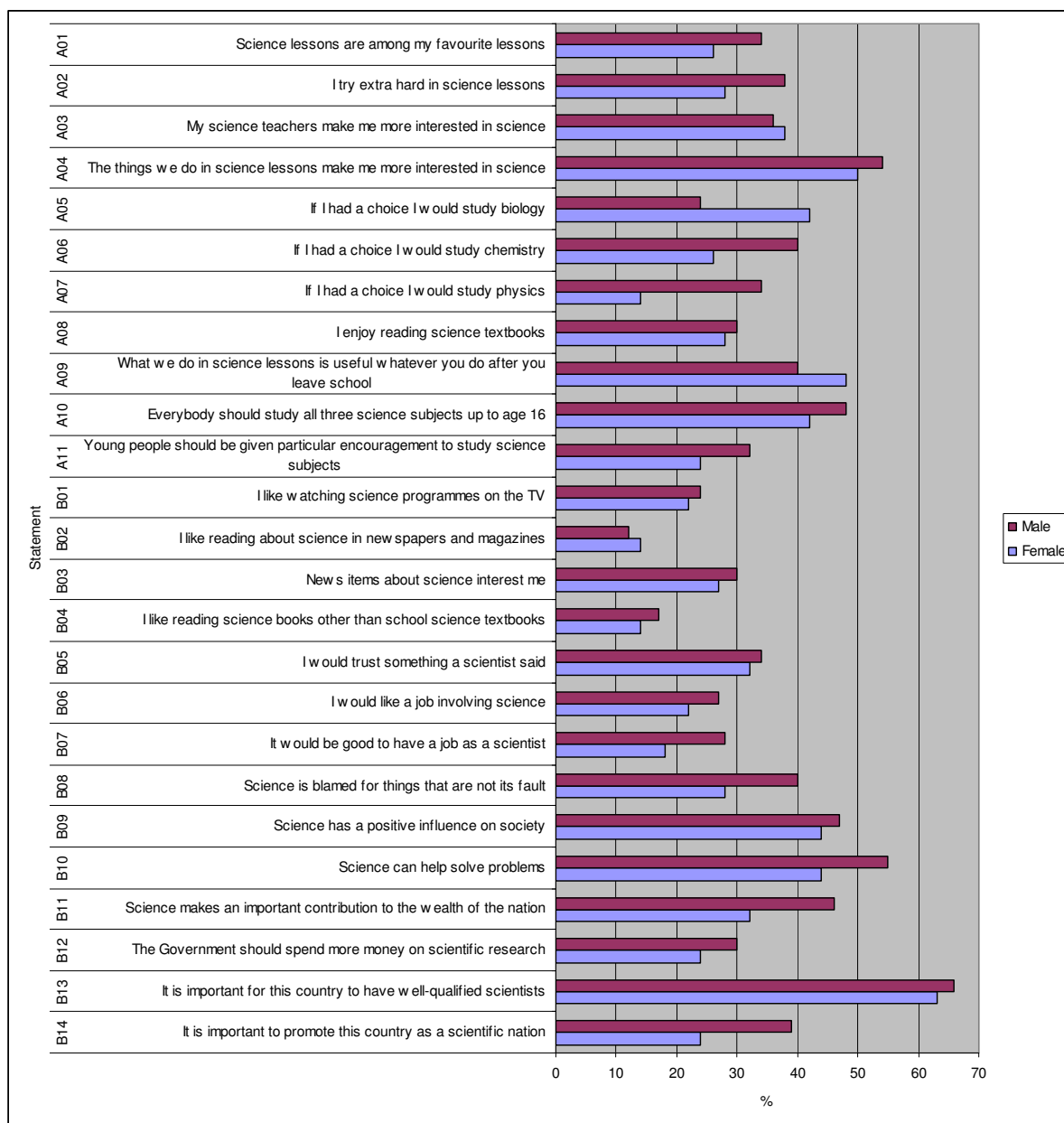14

Figure 1: Percentage of 'agree' responses to items (by age)

Figure 1: Percentage of 'agree' responses to items (by age)

Figure 2: Percentage of 'agree' responses to items (by gender)

16
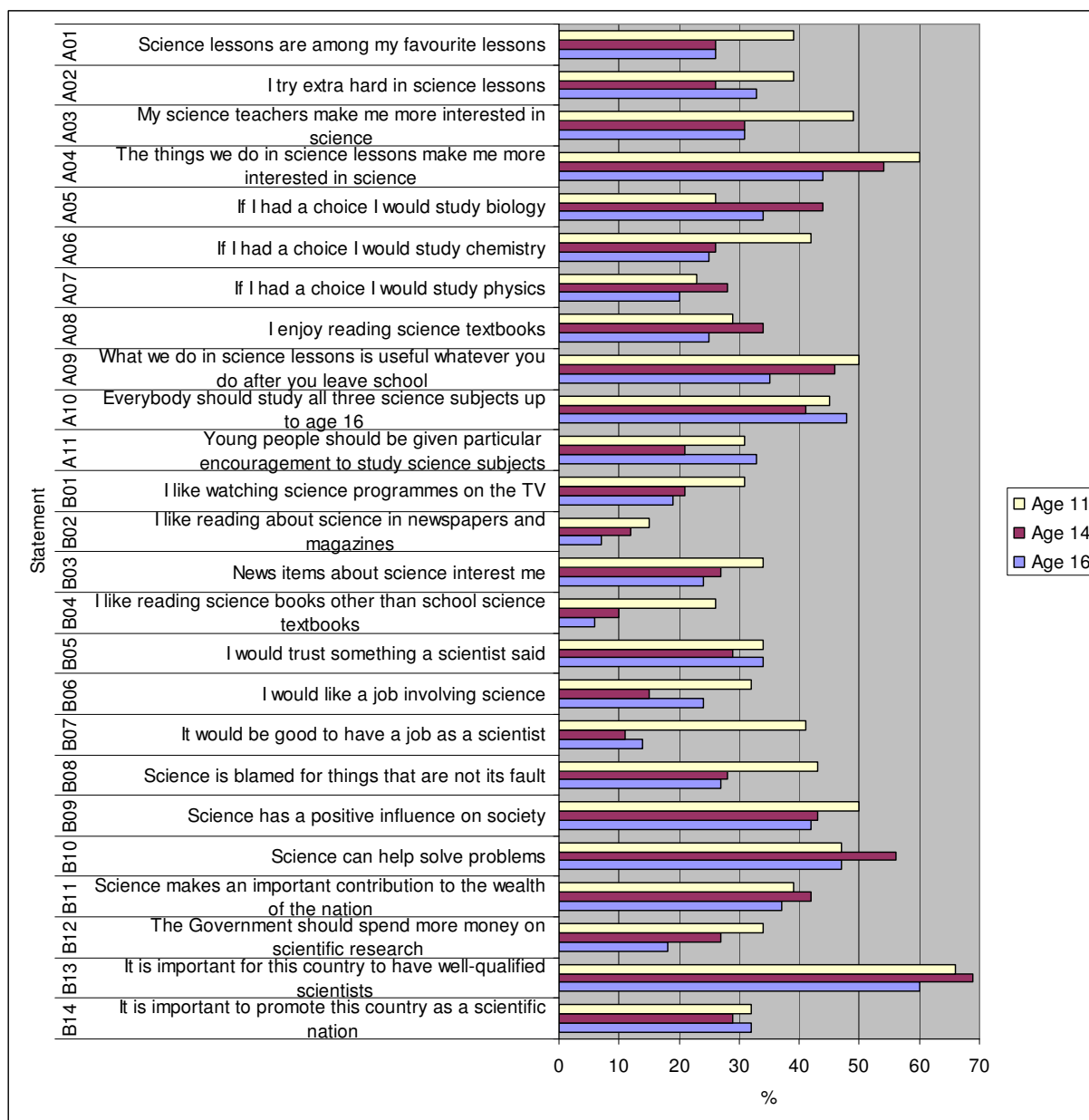
Table 5: Statistically significant differences in Level 1 responses

	Statement	Significant differences (age)	Significant differences (gender)
A01	Science lessons are among my favourite lessons.	Agree = 39% age 11, 26% age 14 ($\chi2$=10.131, p<0.01) Disagree = 10% age 11, 21% age 14 ($\chi2$=8.370, p<0.05)	None
A03	My science teachers make me more interested in science.	Agree = 49% age 11, 31% age 14 ($\chi2$=9.810, p<0.01)	None
A05	If I had a choice, I would study biology.	Disagree = 37% age 14, 54% age 16 ($\chi2$=22.637, p<0.001)	Agree = 24% male, 42% female ($\chi2$=10.120, p<0.01)
A06	If I had a choice, I would study chemistry.	Agree = 42% age 11, 26% age 14 ($\chi2$=26.924, p<0.001)	Agree = 40% male, 26% female ($\chi2$=7.397, p<0.05)
A07	If I had a choice, I would study physics.	Disagree = 43% age 11, 68% age 16 ($\chi2$=18.817, p<0.001)	Agree = 34% male, 14% female ($\chi2$=15.135, p<0.001)
B04	I like reading science books other than school science textbooks.	Agree = 26% age 11, 10% age 14 ($\chi2$=17.906, p<0.001)	None
B06	I would like a job involving science.	Agree = 32% age 11, 15% age 14 ($\chi2$=11.863, p<0.01)	None
B07	It would be good to have a job as a scientist.	Agree = 41% age 11, 11% age 14 ($\chi2$=33.180, p<0.001)	None
B08	Science is blamed for things that are not its fault.	Agree = 43% age 11, 28% age 14 ($\chi2$=14.345, p<0.01)	Agree = 40% male, 28% female ($\chi2$=7.013, p<0.05) Neither agree nor disagree = 34% male, 51% female ($\chi2$=6.203, p<0.05)
B10	Science can help solve problems (e.g. environmental and social problems).	None	Neither agree nor disagree = 27% male, 44% female ($\chi2$=10.042, p<0.01)
B11	Science makes an important contribution to the wealth of the nation.	None	Agree = 46% male, 32% female ($\chi2$=7.592, p<0.05) Neither agree nor disagree = 37% male, 54% female ($\chi2$=7.675, p<0.05)
B13	The Government should spend more money on scientific research.	None	Neither agree nor disagree = 20% male, 31% female ($\chi2$=6.483, p<0.05)
B14	It is important to promote this country as a scientific nation.	None	Agree = 39% male, 24% female ($\chi2$=6.672, p<0.05)

17

Science in school: key features of the data

Responses to science lessons

The number of students reporting that science is amongst their favourite lessons decreases
significantly between the ages of 11 and 14. Within the group saying that science lessons are
amongst their favourite lessons, the Level 2 responses revealed a particularly positive
response to chemistry (85% at age 11, 75% at age 14 and 65% at age 16), linked to a liking of
practical work. Biology became increasingly important in reporting liking of science (45% at
age 11, 75% at age 14 and 77% at age 16), with the difference between ages 11 and 14 being
significant ($\chi2=8.761$, p<0.01). Level 2 responses showed that the significant increase
between ages 11 and 14 in students not reporting science as being amongst their favourite
subjects was associated most strongly with increasing dislike of the physical sciences, and
physics, in particular, being cited as 'hard'.

Responses to individual subjects within science

One particular aspect which generated polarised responses concerned attitudes to the
individual science subjects, probed in items A05 (biology), A06 (chemistry) and A07
(physics).

Each of the subjects appears to have a slightly different problem associated with it.
Interest in biology increases from age 11 to age 14 before decreasing at age 16, though
remaining higher than interest in the physical sciences. In contrast, interest in chemistry and
physics declines between age 11 and 14, and this continues through to age 16. Significantly
more students are interested in chemistry (42%) than in physics (23%) at age 11 ($\chi2=8.739$,

18

p<0.01). Indeed, chemistry attracts the highest level of interest of all three sciences at this age. For physics, the problem is that interest is low to begin with, and declines with age, whereas for chemistry interest is comparatively high initially but characterised by a steep and statistically significant decline between age 11 and age 14 ($\chi2$=7.713, p<0.01).

Level 2 data showed the most prominent reason for wishing to study biology by two-thirds or more of students in all age groups at all ages was that students found the subject interesting. The most common reasons for not wanting to study biology was it not being necessary for the jobs students had in mind. In common with biology, around two thirds of students in each age group cited a perceived lack of relevance of chemistry for the jobs they had in mind. However, around two-fifths of students also cited the strategic aspect of obtaining better external examination grades in other subjects. There was a marked reluctance to study physics, and this increased steadily with age. While the proportion who wanted to study the subject did not change greatly, the proportion who disagreed increased significantly. Level 2 responses showed physics being increasingly seen as hard, with significantly more older students feeling they could get better grades in another subject (34% at age 11 and 53% at age 16; $\chi2$=7.146, p<0.05). Studies of grades achieved in external examinations at age 16 (e.g. Coe *et al*., 2008) have indicated that it is more difficult for student to achieve higher grades in the physical sciences than in other subjects, so it would seem that students' perceptions of levels of difficulty are accurate, and exert a considerable influence on their subject choices.

Gender patterns in responses to science subjects were significant, conforming to the widely reported differences of girls being more favourably inclined towards biology and boys towards the physical sciences. Level 2 responses indicated that all three science subjects were perceived as significantly harder by female students than male students. Though significantly more female students than male students felt they did not see the point of the things they did

19

in chemistry, significantly more of the female students who viewed the subject positively did so for carer reasons, suggesting that subject 'hardness' is more likely to be tolerated if it has potential utility for future jobs.

Teacher effects

Two items offered interesting insights into students' responses to their experiences in science lessons: *A03: My science teachers make me more interested in science*, and *A04: The things we do in science lessons make me more interested in science.*

A03 elicited a very positive response at age 11, with 49% of students agreeing with the statement, but responses dropped significantly by age 14 to 31% and remained at this level at age 16. Level 2 responses demonstrated a range of ways in which teachers created interest in science. For the two younger age groups, almost three-quarters of students cited a variety of activities as being very important, with "being made to think" being cited by 60% of student aged 11. Explaining things clearly was important for over half of all ages, and was the most common response at age 14, with significantly more female students than male students in each age group citing this as important (F=74%, M=41%; $\chi2$=11.660, p<0.001). Similarly female students were more likely than male students to report their interest in science being influenced by their teachers' enthusiasm (F=48%, M=37%; $\chi2$=3.869, p<0.05).

Item A04 elicited the most positive responses of all the items about school science, with 60% of students aged 11 agreeing that the things they did in their lessons made them more interested in science. This figure remained comparatively high for all age groups. The Level 2 explanation most frequently selected by all age groups was enjoyment of practical work. In contrast interest in investigations tailed off significantly. One striking feature of the responses

20

was the significant decrease in enjoyment of group work linked to presentations (age 11=65%, age 16=30%; χ2=12.917, p<0.01). This may suggest that the introduction of such tasks into science courses and lessons needs sensitive handling if students are to feel the activities are of benefit to them.

Taken together, the responses to these items point to teachers, and the activities they choose to use in lessons, playing a particularly influential role at age 11, and thus having the potential to make a crucial difference in the early years of secondary schooling.

The importance of science in the curriculum

Exceptions to the trend of decreasing overall positive attitudes to school science were the two items relating to the importance of science in the curriculum, *A10: Everybody should study all three science subjects up to age 16,* and *A11: When they have a choice, young people should be given particular encouragement to study science subjects.* Level 2 data showed that over one-third of students in all age groups agreeing with A10 felt science was an important part of a good general education. However significantly more of the students agreeing with this item at age 16 also said that they thought there was too much science on the timetable (age 11=13%, age 16=45%; χ2=11.319, p<0.01). Level 2 data for A11 showed high proportions of students who agreed with the statement supporting the view that science affects so much in everyday life. However there was a significant drop in the proportion of students selecting this option at age 16 (age 11=94% at 11, age 16=63%; χ2=15.065, p<0.001). Almost all students felt science leads to good jobs, and around half cited the importance of training the scientists of the future.

21

One feature these two statements share in common is that they are less personal than the other statements about science in school. The responses suggest that students approaching the end of their compulsory period of studying science at school place some general value on the study of science, whilst not necessarily finding it sufficiently interesting and engaging themselves to want to pursue their studies of science subjects. This finding is supported by responses to item *A09: What we do in science lessons is useful whatever you do after you leave school*. At all ages, this item was one of the top three items about school science to get a Level 1 response of 'agree'. Level 2 data showed that many students felt science helped people understand the world they live in, though there was a significant difference in responses that demonstrated a dip in this view from age 11 to age 14 (age 11=84%, age 14=67%; $\chi2$=7.455, p<0.05).

Science outside school: key features of the data

The overall pattern shows that attitudes to science outside school are less positive at age 16 than age 11, with four items (B04, B06, B07 and B08) showing significant decreases in positive responses. With the exception of *B02: I like reading about science in newspapers and magazines*, male students were more positive than female students in their responses to science outside school, with three items (B08, B11 and B14) showing significant differences. Four items (B08, B10, B11 and B13) also showed significant differences in neutral responses, with more female students than male students selecting the 'neither agree nor disagree' options.

Science as presented in the media

22

Responses to items about science as presented in the media (B01, B02, B03) were not very

positive, with less than one-third of students in all age groups selecting 'agree' as their Level

1 response. Level 2 explanations for those students who were positive about watching

science programmes on TV (B01) indicated between half and three-quarters of students

reported that the programmes made them more interested in science, and similar proportions

found that they helped understanding of school science understanding, and seeing how

science is used in the real world. Half to three-quarters of the students disagreeing with the

statement declared they would never watch a TV programme about science. This lack of

interest was also reflected in responses to *B02: I like reading about science in newspapers*

and magazines, where the overwhelming majority of students - over 70% in each age group -

said that they never read anything to do with science in newspapers and magazines. Of those

students who selected 'agree' as their Level 1 response to *B03: News items about science*

interest me, the majority thought that it was important to learn about things that could affect

them. However, two-thirds of the much larger numbers who disagreed in each age group

reported never bothering with news items about science. It is clear from these responses that

items in the media about science do little to engage most students.

Reading about science

Item B02 (see above), together with *B04: I like reading science books other than science*

textbooks, focuses on reading. Both statements did not elicit particularly positive responses at

age 11, and became even less positive with age, B04 significantly so. Around 15% of

students aged 11 responded positively to B02, and this figure halved by age 16. The

responses to B04 demonstrate that few students are interested in reading science books. What

interest there was dropped off sharply between age 11 (26%) and age 14 (9%), declining

further by age 16 (6%), where just short of half the students explicitly disagreeing with the

23

statement. Wildlife books were the most interesting for three-quarters of students at age 11 and just under half liked science fiction. Close to half of the students at age 11 also related their extra-curricular science reading to their science lessons, both in terms of helping them understand the science they were studying and seeing the relevance of what they did in science lessons. By age 16, these responses had virtually disappeared, with almost half the students report that they would never choose to read science books because they are so boring. These findings indicate the majority of young people's leisure reading rarely involves books on science.

Careers in science

Items B06 and B07 focused on careers in science, with B06 asking about liking a job involving science, and item B07 asking about being a scientist. Both showed significant differences in results. For item B06, students aged 11 were equally divided amongst agree/neutral/disagree. By age 14, there was a very low positive response (15%) and a very high negative response (60%) ($\chi2=11.863$, p<0.01). However this was reversed to some extend by age 16, where close to one quarter of students were positive about the idea and just less than half opposed. The most frequent reason given by three-quarters of students in the Level 2 data, irrespective of age, was that there are good jobs available in science. Around 60% of students at age 11 and 14 explained their Level 1 agree responses by citing enjoyment of science at school, but this was of less relevance at age 16 (39%) than the perception of jobs as well-paid (61%). Finding science 'boring' appears, fairly predictably, to be the most common reason for lack of interest is taking up a science-based job, cited by three-quarters of students in all age groups.

For item *B07: It would be good to have a job as a scientist*, there was a highly significant change of views over the early years of secondary schooling (age 11=41%, age 14=10%;

24

$\chi2=33.180$, p<0.001), a change of view sustained at age 16 (14%). Level 2 data pointed to a range of factors being of influence, particularly at age 11, where students cited the nature of the work, remuneration and the view that scientists can have a positive influence on the world. These responses suggest that younger students have a generally positive overview of science as a job or career. Relatively few students at age 14 or 16 agreed with the statements, though, of those that did, by far the most common explanation (over two-thirds at each age) was that they felt that scientists were people who could change the world for the better. The most common Level 2 explanation for students at age 16 was that scientists had well-paid jobs. The Level 2 data for students disagreeing with B07 showed they had a wide range of negative opinions of scientists, with the two most prominent views in all age groups being that scientists do boring jobs (two-third or more of students) and are a bit weird (just over half of students). Scientists were also seen as uncaring by around two-fifths of students in each age group, with a similar proportion also seeing scientists as causing problems in the world, and as risk takers. The findings suggest that, for the majority of students, there is little overlap between their perceptions of themselves and of scientists.

The positive responses to the items about jobs in science point to two rather different factors being particularly influential for those attracted to jobs in science. For some, the attraction is linked to altruistic notions of being able to make a difference for the better to the world, whilst, for others, there is the more pragmatic attraction of seeing jobs involving science as being well-paid. The perception is of interest in the context of the findings of a survey of graduate earning potential in a range of disciplines undertaken in the UK for the Royal Society of Chemistry and the Institute of Physics (PricewaterhouseCooper, 2005). This showed that graduates with degrees in physics and chemistry, though not necessarily working in science-related careers, had the fourth and fifth highest earning potential after medicine, law and engineering. If students' choice of subjects to study is influenced by their beliefs

25

about potential earnings, as the work reported here suggests, then there would appear to be a case for ensuring that they are aware of the possible financial benefits of studying science subjects.

Is science misrepresented?

There was a highly significant drop between age 11 (43%) and age 14 (26%) in the proportion of students agreeing with *B08: Science is blamed for things that are not its fault*, with little further change at age 16. There were also significant gender differences in response, with male students being much more likely to agree with the statement than female students. The percentage disagreeing declined with age, with Level 2 data indicated these changes were associated with a steady increase over the year groups from one-third at age 11 to well over half by age 16 who neither agreed nor disagreed. Over 90% of students aged 11 and 14 were of the opinion that information was often misrepresented in the media and, by implication, this means science is blamed for things that are not its fault. The drop in this view by age 16 was significant ($\chi2=6.389$, $p<0.05$). Half of the respondents in each age group perceived that it is scientists who are often blamed for (negative) aspects of science that are actually a consequence of the actions of others. There was a tendency that increased with age for students to believe that science is bound to get blamed for some things as it is so common in everyday life (42% at age 11, 65% at age 16), and the opinion that only bad things about science get reported also rose with age (24% at age 11, 46% at age 16). In contrast, close to three-fifths of all students in all age groups who chose 'disagree' as their Level 1 response felt that this was because science helps to create problems, but only the good things about science are reported. Three-quarters or more of students in each age group were not interested in the way science is reported, reflecting the lack of interest in science in the media reported earlier. The somewhat complex data here appear to suggest that, as they mature, students develop a

26

more sophisticated view of the range of effects of science and how these are portrayed, whilst,

at the same time, becoming more critical of the effects of science.

The personal and impersonal response to science

The views on the importance of science in the school curriculum discussed earlier are

forerunners of the very appreciable trend in responses to science outside school for students to

become increasingly positive about science as the items to which they are responding become

less personalised. Items B09 to B14 sought views of the more general importance of science,

and it is clear from Figures 1 and 2 that these elicited a greater proportion of Level 1 'agree'

responses than almost all the other items. Within this, male students were generally

significantly more positive than female students who, in turn, were significantly more likely

than male student to be more cautious in their judgements by selecting 'neither agree no

disagree' as their Level 1 response.

For item *B10: Science can help solve problems*, male students had a significantly more

optimistic view of the beneficial role of science. Level 2 data showed a very high proportion

(over 90%) of students who agreed with the statement felt that scientists could help to solve

problems by inventing things, with close to three-quarters supporting the view that science

can give us the knowledge to sort out problems. Regardless of gender, all students who

disagreed with the statement supported the view that science causes the problems in the first

place and so is unlikely to solve them.

A significantly higher proportion of female students responded in a neutral or cautious

fashion to *B11: Science makes an important contribution to the wealth of the nation* compared

to male students who were much more likely to agree. Level 2 data revealed that 80% of

27

students believed that science helps to create jobs, with close to 40% of both sexes supporting

the view that science lead to inventions which people then buy. The importance of science to

industry and the economy was recognised by around two-thirds of male and female students.

Most of the students who disagreed with the statement felt that science costs money rather

than generating wealth.

Item *B13: It is important for this country to have well-qualified scientists*, received the most

positive responses of all the items about science outside school from all age groups. Even

though students aged 16 were the least positive, 60% selected 'agree' as their Level 1

response, providing a stark contrast to the 14% who responded positively to *B07: It would be

good to have a job as a scientist*. Level 2 data showed that a very high proportion of students

(95%) who agreed with the main statement did so because they thought science important for

certain areas such as medicine. Additionally around two-thirds of students supported the

suggestion that scientists in this country can help other countries, and similar numbers feeling

that scientists make the country a better place in which to live.

Significantly more male students than female students agreed with *B14: It is important to

promote this country as a scientific nation*. This was balanced by a higher proportion of

female students who neither agreed nor disagreed. Level 2 data showed over 80% of both

sexes thought that promoting the country as a scientific nation would be good for the

economy and for employment. Very similar proportions thought that the UK should not be

left behind other nations given that people in this country have good ideas. The sizable

majority of students disagreeing with the statement thought there were more important things

to promote about the UK. These responses add to the evidence from other studies (Osborne

and Collins, 2001; Jenkins and Nelson, 2005) that young people's attitudes to science outside

school are more positive than their attitudes to their personal experience of science in school.

28

The 'age 14 dip'

The study provides ample evidence of the particularly sharp fall in positive attitudes between age 11 and age 14, in keeping with the findings of the study by Galton *et al*. (2003). Within the overall pattern of declining positive attitudes, seven items showed a statistically significant decrease in 'agree' responses between age 11 and age 14 with, in some cases, a slight improvement by age 16. No items showed similar significant differences between ages 11 and 14. These items are summarised in Table 6.

Table 6: Items showing statistically significant decline in 'agree' responses between the ages of 11 and 14

	Statement	Agree at age 11 (%)	Agree at age 14 (%)	Agree at age 16 (%)
A01	Science lessons are among my favourite lessons	39	26	27
A03	My science teachers make me more interested in science	49	31	31
A06	If I had a choice, I would study chemistry	42	26	25
B04	I like reading science books other than school science textbooks	26	10	6
B06	I would like a job involving science	32	15	24
B07	It would be good to have a job as a scientist	41	11	14
B08	Science is blamed for things that are not its fault	43	28	27

The explanatory (Level 2) responses to the items offer interesting insights into the 'age 14 dip', some of which have been discussed earlier. The most pertinent of these relate to students views of their science lessons, their responses to what their teachers do, and their perceived value of jobs and careers involving science. In science lessons, an increasing feeling that the subject matter is difficult – science is 'hard' – exerts a very significant influence between ages 11 and 14. Enthusiastic teachers who challenged students to think and provided variety in activity were seen as very influential at age 11. At this age, students were also attracted to careers in science, giving a wide variety of reasons: the nature of the

29

work, remuneration and the view that scientists can have a positive influence on the world.

This view has altered dramatically by age 14, with jobs involving science being seen as

unattractive because they are perceived as boring, science being perceived as causing too

many problems in the world and scientists having to make too many compromises. However,

students aged 16 who did want a job involving science gave as their reasons the fact that

scientists could change the world for the better, or that jobs involving science were well-paid.

It appears that some students at least, as they mature, come to feel that science offers a way of

making a positive difference to people's lives.

Shift in opinion with maturity

One unanticipated feature of particular interest in the data is the shift in Level 1 responses

from 'agree' or 'disagree' to 'neither agree nor disagree' as students get older. There are

examples of items where there was no significant difference with age in the number of agree

responses, but a very apparent difference in shift from 'disagree' to 'neither …' responses.

For example, in item B07, *It would be good to have a job as a scientist,* numbers disagreeing

with this statement stayed roughly constant at around the 40% level. However, the very

significant fall in numbers agreeing with the statement (age 11=41%, age 14=11%;

$\chi 2$=33.180, p<0.001) was mirrored by a corresponding rise in number selecting the

'neither…' option (age 11=22%, age 14=45%; $\chi 2$=10.384 p<0.01). A similar pattern in

responses may be seen for item B08, *Science is blamed for things that are not its fault*. The

majority of neutral Level 1 responses were linked to Level 2 responses in which students said

they did not feel they knew enough to have a view. These findings suggest that, as students

mature, they feel they need more information to make an informed judgement.

30

Within this overall shift in opinion with maturity, it is also apparent that a significantly higher

proportion of female students chose the 'neither …' option in all cases where there was a

significant gender difference in responses. Furthermore, when looking at the reasons why the

'neither …' option was selected, there was a consistent trend for more female students than

male students being prepared to admit they did not know enough to make an informed

response. One possible explanation for this is that female students may be more cautious than

male students in opting for a definite 'agree' or 'disagree' response which, in turn suggests

that male students may have firmer opinions or a more 'black and white' view of the world.

Conclusions

Research into attitudes to science often results in feelings of comfort (though very often cold

comfort) from reaffirmation of the findings of other work, coupled with frustration at the

seemingly intractable nature of the problem. Certainly some of the responses in the study

reported here support well-documented findings on the decline of positive attitudes to science

and jobs involving science over the period of secondary schooling, with physical sciences

eliciting particularly negative responses and female students less positively disposed than

male students towards science.

The study adds to the growing evidence that attitudes to science outside school are more

positive than attitudes to school science, and that experiences of school science between ages

11-14 are crucial in shaping students' attitudes and subsequent behaviours in relation to

subject choice. Whilst the decline in positive attitudes between 11 and 14 is of considerable

concern, a more positive feature of the findings is the identification of school science as

exerting the greater influence, as what students experience in their science lessons is easier to

control than what they experience of science outside school.

31

The principal justification for developing the new instrument was to go beyond descriptive data to probe for explanations and insights that, in turn, might point to possible areas to target for action. What, therefore, has emerged from the explanatory (Level 2) data, and what messages emerge for future research, and for policy and practice?

The Level 2 data points to particular features of lessons being important, with younger students citing 'being made to think', variety in activity and seeing how science relates to life as the reasons for this. Many curriculum materials now do contextualise science, but rather less is known about the range of activities teachers use in science lessons and their effects. The notion of what students see as activities that make them 'think' in science lessons would certainly benefit from further exploration, given that older students cite the 'hard' nature of science subjects as a reason for not wanting to study them. It would be useful to have more information on where the boundaries lie between 'being made to think' and 'hard'. As most students study 'science' in the early years of secondary schooling, it is important to explore these dimensions in relation to the different scientific disciplines, as each has a different problem. Interest in physics remains consistently low, interest in biology increases, and the science reported as most interesting at age 11 - chemistry - shows the sharpest decline. The perception of 'hardness' also poses a challenge to policy: if students believe that there are greater rewards in terms of external examination grades for effort put into subjects other than the physical sciences, and reviews of examination grades have confirmed that it is more difficult to achieve higher grades in these subjects, then there is a need to examine carefully the subject content of science curricula, and ways in which national tests and examinations are graded.

32

Other insights to emerge from the explanatory data point to features of the curriculum which might usefully benefit from strengthening or from a different emphasis. Young people, particularly female students, appear to become less clear-cut in their views as they mature, and feel they need more information before they can reach views in relation to, for example, wanting a job involving science, or knowing whether science can help solve environmental and social problems. One area to target for action would be to look carefully at how information about jobs involving science might feature in curriculum materials, both in relation to the jobs themselves and in the context of the view of scientists being seen as 'uncaring'. It may well be that the links between contextualising science, on which students report favourably, and jobs involving science need to be made more overtly, as they are not as apparent to students as they are to those developing materials for use in lessons. Moreover, a factor strongly influencing those students aged 16 who wanted a job as a scientist was a belief that scientists could change the world for the better. Thus it would be useful to provide more information on the contribution scientists make to society.

Looking more widely at the nature of research on attitudes to science, we believe the instrument developed for this study has a number of strengths: considerable care has been taken in its design and validation, it combines the ability of a survey to gather large datasets on general patterns with the explanatory insights normally drawn from interviews into an easy-to-administer pencil-and-paper instrument, its language draws on 'the student voice', and it probes for explanatory insights as well as establishing general patterns. However, the gathering both descriptive and explanatory data in this way does generate extensive data which, in turn, leads to challenges in analysis and reporting.

We also believe that the study points to the future direction of attitude research. Well-designed instruments certainly have a role to play in surveying attitudes, but their principal

33

strength lies in providing the 'board brush stokes' of the picture, rather than providing much

of the detail that might point to action. There is much in the study reported here that suggests

there is little overlap between students' perceptions of science and their perceptions of

themselves and their own identity. This area would be worth probing in more detail. There is

also evidence that some schools that are much more effective than others at encouraging

uptake of particular subjects. For example, Fitzgibbon (1999) established significant inter-

school variations in the UK in numbers of students electing to study mathematics beyond the

compulsory period, and her finding suggested that there might be similarities with the

sciences in factors underlying student choice. Recent reports of studies of schools (Ponchaud,

2006; National Strategies, 2008) suggests that school-based factors, such as enthusiastic

teaching by specialist teachers, and provision of good information about the value and

flexibility of science qualifications, can exert significant effects on uptake of science.

Moreover, some of the factors that may promote more positive attitudes to science may not be

apparent to students and therefore not easily accessible through attitudinal instruments. Thus,

we contend that the priority for research on attitudes to science is to explore in more detail

features of schools that are more - and less - successful at encouraging uptake of science

beyond the compulsory period.

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Storage of the original data

All the original data are stored at [to be added].

The full report and instrument

The full report and instrument may be accessed at: [to be added].

Acknowledgements

[To be added.]

38

Would YOU want to talk to a scientist at a party? High school students' attitudes to school science and to science

Abstract

This paper describes a four-year project involving the development of a new instrument, the *Attitudes to School Science and Science* instrument, and its use to collect baseline attitudinal data from 280 students aged 11, 14 and 16. A key feature of the instrument is that it collects both descriptive and explanatory data in a pencil-and-paper format. The data gathered is probed in detail for explanatory insights into features that have emerged from more recent research on attitudes to science, in particular the suggestions that students view science outside school more positively than their experiences in science lessons, and that the early years of secondary education (ages approximately 11 to 14) are the most crucial in shaping attitudes. The study shows that positive attitudes to school science decline significantly between the ages of 11 and 14, with little appreciable downward change beyond this and, in some cases, a slight upturn. Female students display less positive attitudes and less clear-cut views on a variety of aspects of science. A sense of science being important in general terms, though not having much appeal for individual students, also emerged clearly from the data. The paper suggests that attitudinal instruments have a role to play in research, but that these need to be complemented by studies of detailed features of schools that may influence attitudes, some of which may not be apparent from data collected from students.

Introduction

What views might a class of sixteen-year-olds have about science? Here is a selection of comments from students involved in the study reported here:

1

"We use science for everything. We ARE science."

"Science is important because modern society is built entirely around the scientific

advances of recent centuries."

"Science causes problems in the first place, so how can it get rid of them?"

"Would YOU want to talk to a scientist at a party?"

Most people involved in science education would probably be very pleased if any sixteen-

year-old they knew made one of the first two comments. Sadly, it is the case that far too

many young people are likely to have more empathy with the last two comments. Such

comments also serve only to reinforce the considerable disquiet felt in the science education

community and beyond over the numbers of students taking science subjects, particularly

chemistry and physics, in post-compulsory education in a number of countries. It would seem

that there is widespread disenchantment amongst young people, who are 'voting with their

feet' and turning away from science when they have a choice. In England and Wales, for

example, where the study reported here was undertaken, data from public examination entries

show that the percentage of young people choosing to study physical science subjects at

Advanced level (the first point of choice at age 16+) fell by 2.1% in the period 2001-2005 for

chemistry, and by 14% for physics (Hyam, 2006), continuing a steady downward trend that

has yet to be reversed. Such patterns are not unique to the UK, and it is therefore unsurprising

that concerns about participation in science feature prominently in current debates over policy

and practice in science teaching in a number of countries, as reflected in publications such as

Europe needs more scientists (European Commission, 2004), *Evolution of student interest in*

science and technology (Organisation for Economic Co-operation and Development [OECD],

2006), and *The supply and demand for science, technology, engineering and mathematics*

skills in the UK economy (Department for Education and Skills, 2006). The recent focus on

2

numbers choosing science in the post-compulsory period of study reflects a longstanding

concern about levels of participation. Underpinning this is the notion that *attitudes to science*

are crucial, as they are a major determinant of subject choice.

Research on attitudes to science

The research on attitudes to science is extensive, and the 'broad brushstroke' findings are

well-known: science is perceived as difficult and not relevant to the lives of most people,

interest in science declines over the years of secondary schooling, science is more attractive to

male students than female students, and problems being most acute in the physical sciences.

These findings have emerged as relatively constant features in a number of countries over the

past four decades, and are well-documented in a literature that including several detailed

review articles (e.g. Gardiner, 1975; Ormerod and Duckworth, 1975; Schibeci, 1984; Munby,

1990; Ramsden, 1998; Osborne et al., 2003).

Whilst to a large extent more recent studies confirm earlier findings, some new slants have

emerged that appear worthy of further probing. The most noticeable of these is neatly

encapsulated in the title given by Jenkins and Nelson (Jenkins and Nelson, 2005): "Important

but not for me." Jenkins and Nelson were reporting the UK data from a large and ongoing

comparative international survey of students aged 16, the Relevance of Science Education

(ROSE) project, which began in 2001 and involves over 30 countries (Schreiner and Sjøberg,

2004; Sjøberg and Schreiner, 2005). The ROSE data indicate that a general appreciation of

the value of science outside school is not reflected in responses about enjoyment of science in

school, or a desire to have jobs involving science. This message is echoed in other studies.

Osborne and Collins (2001) showed sixteen-year-old students to believe science was an

important subject in the school curriculum, but more for career purposes for those interested

3

in science than because of intrinsic interest. In a similar vein, Haste (2004) found young

people emerged from compulsory schools with a moderately positive image of science and

technology outside school, but with far less interest in jobs in science.

Newer studies are also contributing to a growing body of evidence that points to attitudes to

science declining most sharply in the early years of secondary education (Galton et al., 2003),

a decline that is more appreciable in for science other school subjects. This period has also

emerged as crucial in relation to the impact of science teachers on students' views of science

and careers involving science (Osborne and Collins, 2001; Cerini, Murray and Reiss, 2004;

Munro and Elsom, 2000).

The literature on attitudes to science has also signalled a number of methodological concerns

about work in the area. Principally, these relate to poor instrument design and analysis,

including failure to address matters of reliability and validity, the plethora of existing

instruments, many of which are limited in use to a single study, and failure to draw on ideas

from psychological theory (e.g. Gardiner, 1975; Ormerod and Duckworth, 1975; Schibeci,

1984; Munby, 1990; Ramsden, 1998; Osborne et al. 1998; Simon, 2000; Osborne et al., 2003;

Blalock *et al*., 2008).   One message emerging from these reviews is that of caution over the

need to develop yet another instrument, given the number that already exists. A further issue

to emerge concerns the nature of the way in which data are gathered. A consistent feature of

attitude research is the use of fixed-response inventories and scaling techniques to gather data.

Of these, Likert-type scales predominate (for example, Haste, 2004; Kelly, 1986; Misiti, *et

al*., 1991; Qualter, 1993; Simpson and Oliver, 1990; Sjøberg and Schreiner, 2005), though

others, such as Thurstone-type rating scales (for example, Johnson, 1987; Smail and Kelly,

1984) and semantic differential scales (for example, Crawley and Koballa, 1994) have also

been used. Much more limited use has been made of interviews (for example, Piburn and

4

Baker, 1993) and, more recently, focus groups (Osborne and Collins, 2001). One outcome of

a heavy reliance on fixed-response inventories is that much attitude data is characterised by an

emphasis on descriptions of 'the problem', with rather less attention paid to possible

explanations.

The purpose of this study

The study reported here involves the development and use of a new instrument to gather data

on attitudes to science, characterised by two particular features in relation to the instrument

design. Firstly, it sought to develop a 'pencil-and-paper' instrument that moved beyond the

largely descriptive data generated by most other survey instruments to probe for explanations

of particular responses. Secondly, steps were incorporated into the development of the

instrument to address a number of common problems the literature has identified in attitudinal

instruments. The nature of the data generated by the instrument does not lend itself to the

rigours of statistical methods often followed in the design and development of attitudinal

instruments. However, probing for explanations offers the potential to yield deeper insights

into areas to target for possible action.

The aims of the study were as follows:

- to design an instrument to enable both descriptive (Level 1) and explanatory (Level 2)

  data to be gathered on students' affective responses, or attitudes, to science;

- to use the instrument to gather baseline data from school students aged 11, 14 and 16.

Within the context of these overall aims, the study also sought to explore in more depth some

of the new slants emerging from more recent work on attitudes by looking, firstly, at possible

differences between responses to science in school and science outside school, and, secondly,

5

at changes in attitudes in the early years of secondary schooling. The study did not set out to look specifically at differences between the responses of male and female students, but the number of significant gender differences that emerged in the analysis suggested it would be important to include these in a report of the findings. Equally, though the study did not set out to look specifically at differences in responses in groups of differing ability, data on ability were collected. This was because a particular concern about levels of participation is the number of able and well-qualified students electing not to study science in the post-compulsory period, and it seemed useful to look for any particular patterns in attitude and ability. However, as none emerged, these data are not reported here, other than in characterising the sample.

The development of the research instrument

The design of the instrument adapted the approach developed in the *Views on Science-Technology-Society* (VOSTS) study, undertaken in Canada in the late 1980s to document the views of upper high school students (aged 16-17) on science-technology-society topics (Aikenhead and Ryan, 1989; 2002). Underpinning the VOSTS approach was the belief that attitudinal survey instruments most usually reflect the perceptions of the developers, rather than the respondents, on the likely influences. Thus an instrument that draws n students' views in its development is likely to generate more valid data.   In essence, the VOSTS approach involved the empirical development of a fixed response item pool based on views expressed by the students. This was achieved through presenting students with a series of statements on aspects of science, technology and society, and inviting free responses. Common themes within these responses then formed the basis of categories for the fixed-response version of the instrument. The VOSTS approach had two particular attractions. Firstly, the options in the fixed-response instrument drew directly on the words of the

6

students, and, secondly, through the use of a pencil-and-paper instrument, it offered the

potential to probe for explanatory data from a large dataset.

The development of the research instrument involved six steps, summarised in Table 1.

Table 1 about here

Stage 1 yielded responses in a number of areas including: response to science lessons (teacher

effects, views of particular activities, views of different branches of science); views of social

implications of science (from school science and experiences outside school); views of

teacher characteristics; views of learning situations; views of science as presented in the

media; views of scientists and their work. These areas were divided into the two broad

categories of responses to school science and responses to science outside school.

Stage 2 involved the development of a series of statements relating to school science and

science outside the classroom. These took the form of *disposition statements*, i.e. responses

were indicative of attitude to science or school science. An initial pool of around 40 items

was reduced to 25 through a series of peer validation meetings involving approximately

twenty-five science educators and teachers. These statements are shown in Table 2.

Table 2 about here

In Stage 3, each of the statements was in a form which invited students to respond on a Likert-

type scale (strongly agree/agree/neutral/ disagree/strongly disagree) to indicate their view,

followed by a request to explain, as a free response, their reasons for holding this view.

The first step in Stage 4 involved the free responses being independently categorised into groups by two members of the research team. There was over 90% agreement on categorisation. Each category of response was summarised in a sentence, drawing as closely as possible on the words used students' written responses. These then formed the basis of the fixed responses to the disposition statements. Typically, an item would have between eight and ten fixed response options. A sample fixed-response item is shown in Figure 1.

Figure 1 about here

Once students had selected their Level 1 response (agree/neither agree nor disagree/disagree), they were invited to select as many of the Level 2 responses as they felt applied to them. The instrument thus enables responses to be gathered at two levels: Level 1 responses indicate agreement or otherwise with the disposition statement, and Level 2 responses probe for explanations.

Validation of the trial fixed-response items took place approximately three months after the collection of the free responses. The process involved asking the same classes of students who had originally given free responses to complete eight fixed-response items, with items being distributed to students in such a way that at least ten responses per item were collected. The responses selected by the students on the fixed-response item were then compared with the original free response. The very good agreement (85%) between free responses and the fixed-response options is a measure of the reliability of the items. Short interviews with students where differences had emerged established that these students had not originally held any particularly strong view.

8

To maximise the validity of the range of Level 2 responses, each item offered the options of not selecting any of the fixed responses offered, but giving "another reason – please say what". The intention was to look for any further patterns emerging in from these options and add them to the options offered. In practice, though between three and five students per item selected "another reason", the reasons were very varied and no consistent patterns emerged. It was decided to leave the "another reason ..." option in the final version of the instrument to allow student to express different views if they so wished.

Stage 5 involved the trial of the instrument. Four classes in two schools participated in the trial, such that data were gathered from 91 students in two classes aged 11 and two aged 16. This enabled the instrument to be tested with students at the upper and lower ends of the target age range.

Content validity was assessed by the following procedure. At the point where their students completed the instrument, the class teacher was asked to indicate their view of each student's attitude to science on a five point scale, where a score of five represented a very positive attitude, and a score of one represented a very negative attitude. A numerical total was then calculated for each student based on their responses to the instrument. Any 'agree' options selected were given a score of three, 'neither agree nor disagree' options were given a score of two, and 'disagree' options a score of one. Whilst there are drawbacks to assigning numerical scores to Likert-type responses, it was felt that these were outweighed by the advantages of having some indicator of the validity of the instrument in gauging attitudes to school science and to science. Visual inspection of the scattergrams of the teacher scores for students' attitude and the students' score on the instrument showed a good line of fit, and there were no instances where the instrument had indicated a negative attitude and the teacher had indicated a positive attitude. In a limited number of instances (10%), the instrument indicated a positive

9

attitude whilst the teacher had indicated a negative attitude. Conversations with the teachers

showed that these cases tended to be students who were seen as not very hard-working by the

teachers, and that this influenced their view of the students' attitude.

Details of the full instrument may be accessed from the web-link at the end of this paper.

The main study: the sample and methods of analysis

The instrument was used to gather baseline data in a survey of 280 school students in four all-

ability (mixed comprehensive) secondary schools in late April 2004. Two of the schools were

in a comparatively small city, one in a town and one in a semi-rural area. For ease of

administration, data were collected from whole-class sets. All the students were following

conventional science courses of similar content prescribed in external, national specifications.

None was following courses linked to any new intervention. The instrument was

administered to three cohorts of students aged 11, 14 and 16. These are the first, third and

fifth (final) years of compulsory secondary schooling in England and Wales, and the study of

science is compulsory throughout this age range.

Data on students' ability levels were obtained based on actual or estimated results from

external tests and examinations, these being the only external measures of ability common

across all schools. Internal measures lack reliability as they are based on tests developed

within schools. These were Standard Assessment Tasks (SATs) at Key Stage 2 taken by

students taken at age 11 or at Key Stage 3, taken by students at age 14, or General Certificate

of Secondary Education (GCSE) examinations, taken by students at age 16. These measures

were used to designate students as high, middle or low ability. Details of the sample are given

in Table 3.

Table 3 about here

Although data were collected from whole class sets, the sample turned out to be balanced in

terms of gender, with just slightly more female students (n=144) than male (n=136). External

measures of ability resulted in the majority of the students in the sample being designated as

middle or high ability. The likely explanation for this is that the external measures used for

ability are not very discriminating in that the majority of student will be placed in one of three

broad bands at age 11 and 14. Overall, however, the sample was felt to be representative of

the group from which it was drawn, as data were collected from classes across the whole

ability range.

Analysis of the non-parametric data was carried out using the SPSS 11 package, and applying

the Chi-squared test to look for significant differences in responses.

Results

The nature of the instrument means that the database developed is extensive, particularly in relation to

the Level 2 responses, and it is beyond the scope of this paper to present and discuss all the findings in

detail. This paper therefore presents the most notable features of the data in six main sections. The

first presents an overview of responses, with the second and third highlighting key features of the data

in relation to school science and science outside school. The next two sections focus on particular

aspects of the data that offer insights into two of the particular foci of the study: differences in

responses to science in school and science outside school, and changes in attitudes in the early years of

secondary schooling. The last section reports a noticeable, though unanticipated, outcome of the

study, a shift in opinion with maturity.

Overview of responses

Figure 2 provides a visual overview of the positive responses to each of the items by showing the percentage of students in each age group who selected 'agree' as their Level 1 response for each item. Figure 3 show the percentages of male and female students who selected 'agree' as their Level 1 response for each item. The figures show a noticeable trend for positive attitudes to items relating to both school science and to science outside school to decrease overall from age 11 to age 16 and, within this, for female students to hold less positive attitudes than male students.

Figures 2 and 3 about here

The items where differences in responses were statistically significant at Level 1 (i.e. 'agree', 'neither agree nor disagree' and 'disagree'), are summarised in Table 4.

Table 4 about here

Science in school: key features of the data

Responses to science lessons

The number of students reporting that science is amongst their favourite lessons decreases significantly between the ages of 11 and 14. Within the group saying that science lessons are amongst their favourite lessons, the Level 2 responses revealed a particularly positive response to chemistry (85% at age 11, 75% at age 14 and 65% at age 16), linked to a liking of practical work. Biology became increasingly important in reporting liking of science (45% at age 11, 75% at age 14 and 77% at age 16), with the difference between ages 11 and 14 being

significant (χ2=8.761, p<0.01). Level 2 responses showed that the significant increase

between ages 11 and 14 in students not reporting science as being amongst their favourite

subjects was associated most strongly with increasing dislike of the physical sciences, and

physics, in particular, being cited as 'hard'.

Responses to individual subjects within science

One particular aspect which generated polarised responses concerned attitudes to the

individual science subjects, probed in items A05 (biology), A06 (chemistry) and A07

(physics).

Each of the subjects appears to have a slightly different problem associated with it.

Interest in biology increases from age 11 to age 14 before decreasing at age 16, though

remaining higher than interest in the physical sciences. In contrast, interest in chemistry and

physics declines between age 11 and 14, and this continues through to age 16. Significantly

more students are interested in chemistry (42%) than in physics (23%) at age 11 (χ2=8.739,

p<0.01). Indeed, chemistry attracts the highest level of interest of all three sciences at this

age. For physics, the problem is that interest is low to begin with, and declines with age,

whereas for chemistry interest is comparatively high initially but characterised by a steep and

statistically significant decline between age 11 and age 14 (χ2=7.713, p<0.01).

Level 2 data showed the most prominent reason for wishing to study biology by two-thirds or

more of students in all age groups at all ages was that students found the subject interesting.

The most common reasons for not wanting to study biology was it not being necessary for the

jobs students had in mind. In common with biology, around two thirds of students in each

age group cited a perceived lack of relevance of chemistry for the jobs they had in mind.

13

However, around two-fifths of students also cited the strategic aspect of obtaining better external examination grades in other subjects. There was a marked reluctance to study physics, and this increased steadily with age. While the proportion who wanted to study the subject did not change greatly, the proportion who disagreed increased significantly. Level 2 responses showed physics being increasingly seen as hard, with significantly more older students feeling they could get better grades in another subject (34% at age 11 and 53% at age 16; χ^2=7.146, $p<0.05$). Studies of grades achieved in external examinations at age 16 (e.g. Coe *et al*., 2008) have indicated that it is more difficult for student to achieve higher grades in the physical sciences than in other subjects, so it would seem that students' perceptions of levels of difficulty are accurate, and exert a considerable influence on their subject choices.

Gender patterns in responses to science subjects were significant, conforming to the widely reported differences of girls being more favourably inclined towards biology and boys towards the physical sciences. Level 2 responses indicated that all three science subjects were perceived as significantly harder by female students than male students. Though significantly more female students than male students felt they did not see the point of the things they did in chemistry, significantly more of the female students who viewed the subject positively did so for carer reasons, suggesting that subject 'hardness' is more likely to be tolerated if it has potential utility for future jobs.

Teacher effects

Two items offered interesting insights into students' responses to their experiences in science lessons: *A03: My science teachers make me more interested in science*, and *A04: The things we do in science lessons make me more interested in science.*

14

A03 elicited a very positive response at age 11, with 49% of students agreeing with the statement, but responses dropped significantly by age 14 to 31% and remained at this level at age 16. Level 2 responses demonstrated a range of ways in which teachers created interest in science. For the two younger age groups, almost three-quarters of students cited a variety of activities as being very important, with "being made to think" being cited by 60% of student aged 11. Explaining things clearly was important for over half of all ages, and was the most common response at age 14, with significantly more female students than male students in each age group citing this as important (F=74%, M=41%; $\chi2$=11.660, p<0.001). Similarly female students were more likely than male students to report their interest in science being influenced by their teachers' enthusiasm (F=48%, M=37%; $\chi2$=3.869, p<0.05).

Item A04 elicited the most positive responses of all the items about school science, with 60% of students aged 11 agreeing that the things they did in their lessons made them more interested in science. This figure remained comparatively high for all age groups. The Level 2 explanation most frequently selected by all age groups was enjoyment of practical work. In contrast interest in investigations tailed off significantly. One striking feature of the responses was the significant decrease in enjoyment of group work linked to presentations (age 11=65%, age 16=30%; $\chi2$=12.917, p<0.01). This may suggest that the introduction of such tasks into science courses and lessons needs sensitive handling if students are to feel the activities are of benefit to them.

Taken together, the responses to these items point to teachers, and the activities they choose to use in lessons, playing a particularly influential role at age 11, and thus having the potential to make a crucial difference in the early years of secondary schooling.

The importance of science in the curriculum

Exceptions to the trend of decreasing overall positive attitudes to school science were the two

items relating to the importance of science in the curriculum, *A10: Everybody should study all*

three science subjects up to age 16, and *A11: When they have a choice, young people should*

be given particular encouragement to study science subjects. Level 2 data showed that over

one-third of students in all age groups agreeing with A10 felt science was an important part of

a good general education. However significantly more of the students agreeing with this item

at age 16 also said that they thought there was too much science on the timetable (age

11=13%, age 16=45%; $\chi2$=11.319, p<0.01). Level 2 data for A11 showed high proportions of

students who agreed with the statement supporting the view that science affects so much in

everyday life. However there was a significant drop in the proportion of students selecting

this option at age 16 (age 11=94% at 11, age 16=63%; $\chi2$=15.065, p<0.001). Almost all

students felt science leads to good jobs, and around half cited the importance of training the

scientists of the future.

One feature these two statements share in common is that they are less personal than the other

statements about science in school. The responses suggest that students approaching the end

of their compulsory period of studying science at school place some general value on the

study of science, whilst not necessarily finding it sufficiently interesting and engaging

themselves to want to pursue their studies of science subjects. This finding is supported by

responses to item *A09: What we do in science lessons is useful whatever you do after you*

leave school. At all ages, this item was one of the top three items about school science to get

a Level 1 response of 'agree'. Level 2 data showed that many students felt science helped

people understand the world they live in, though there was a significant difference in

16

responses that demonstrated a dip in this view from age 11 to age 14 (age 11=84%, age 14=67%; χ2=7.455, p<0.05).

Science outside school: key features of the data

The overall pattern shows that attitudes to science outside school are less positive at age 16 than age 11, with four items (B04, B06, B07 and B08) showing significant decreases in positive responses. With the exception of *B02: I like reading about science in newspapers and magazines*, male students were more positive than female students in their responses to science outside school, with three items (B08, B11 and B14) showing significant differences. Four items (B08, B10, B11 and B13) also showed significant differences in neutral responses, with more female students than male students selecting the 'neither agree nor disagree' options.

Science as presented in the media

Responses to items about science as presented in the media (B01, B02, B03) were not very positive, with less than one-third of students in all age groups selecting 'agree' as their Level 1 response. Level 2 explanations for those students who were positive about watching science programmes on TV (B01) indicated between half and three-quarters of students reported that the programmes made them more interested in science, and similar proportions found that they helped understanding of school science understanding, and seeing how science is used in the real world. Half to three-quarters of the students disagreeing with the statement declared they would never watch a TV programme about science. This lack of interest was also reflected in responses to *B02: I like reading about science in newspapers and magazines,* where the overwhelming majority of students - over 70% in each age group - said that they

17

never read anything to do with science in newspapers and magazines. Of those students who selected 'agree' as their Level 1 response to *B03: News items about science interest me*, the majority thought that it was important to learn about things that could affect them. However, two-thirds of the much larger numbers who disagreed in each age group reported never bothering with news items about science. It is clear from these responses that items in the media about science do little to engage most students.

Reading about science

Item B02 (see above), together with *B04: I like reading science books other than science textbooks*, focuses on reading. Both statements did not elicit particularly positive responses at age 11, and became even less positive with age, B04 significantly so. Around 15% of students aged 11 responded positively to B02, and this figure halved by age 16. The responses to B04 demonstrate that few students are interested in reading science books. What interest there was dropped off sharply between age 11 (26%) and age 14 (9%), declining further by age 16 (6%), where just short of half the students explicitly disagreeing with the statement. Wildlife books were the most interesting for three-quarters of students at age 11 and just under half liked science fiction. Close to half of the students at age 11 also related their extra-curricular science reading to their science lessons, both in terms of helping them understand the science they were studying and seeing the relevance of what they did in science lessons. By age 16, these responses had virtually disappeared, with almost half the students report that they would never choose to read science books because they are so boring. These findings indicate the majority of young people's leisure reading rarely involves books on science.

18

Careers in science

Items B06 and B07 focused on careers in science, with B06 asking about liking a job involving science, and item B07 asking about being a scientist. Both showed significant differences in results. For item B06, students aged 11 were equally divided amongst agree/neutral/disagree. By age 14, there was a very low positive response (15%) and a very high negative response (60%) ($\chi2$=11.863, p<0.01). However this was reversed to some extend by age 16, where close to one quarter of students were positive about the idea and just less than half opposed. The most frequent reason given by three-quarters of students in the Level 2 data, irrespective of age, was that there are good jobs available in science. Around 60% of students at age 11 and 14 explained their Level 1 agree responses by citing enjoyment of science at school, but this was of less relevance at age 16 (39%) than the perception of jobs as well-paid (61%). Finding science 'boring' appears, fairly predictably, to be the most common reason for lack of interest is taking up a science-based job, cited by three-quarters of students in all age groups.

For item *B07: It would be good to have a job as a scientist*, there was a highly significant change of views over the early years of secondary schooling (age 11=41%, age 14=10%; $\chi2$=33.180, p<0.001), a change of view sustained at age 16 (14%). Level 2 data pointed to a range of factors being of influence, particularly at age 11, where students cited the nature of the work, remuneration and the view that scientists can have a positive influence on the world. These responses suggest that younger students have a generally positive overview of science as a job or career. Relatively few students at age 14 or 16 agreed with the statements, though, of those that did, by far the most common explanation (over two-thirds at each age) was that they felt that scientists were people who could change the world for the better. The most common Level 2 explanation for students at age 16 was that scientists had well-paid jobs. The Level 2 data for students disagreeing with B07 showed they had a wide range of negative

19

opinions of scientists, with the two most prominent views in all age groups being that

scientists do boring jobs (two-third or more of students) and are a bit weird (just over half of

students). Scientists were also seen as uncaring by around two-fifths of students in each age

group, with a similar proportion also seeing scientists as causing problems in the world, and

as risk takers. The findings suggest that, for the majority of students, there is little overlap

between their perceptions of themselves and of scientists.

The positive responses to the items about jobs in science point to two rather different factors

being particularly influential for those attracted to jobs in science. For some, the attraction is

linked to altruistic notions of being able to make a difference for the better to the world,

whilst, for others, there is the more pragmatic attraction of seeing jobs involving science as

being well-paid. The perception is of interest in the context of the findings of a survey of

graduate earning potential in a range of disciplines undertaken in the UK for the Royal

Society of Chemistry and the Institute of Physics (PricewaterhouseCooper, 2005). This

showed that graduates with degrees in physics and chemistry, though not necessarily working

in science-related careers, had the fourth and fifth highest earning potential after medicine,

law and engineering. If students' choice of subjects to study is influenced by their beliefs

about potential earnings, as the work reported here suggests, then there would appear to be a

case for ensuring that they are aware of the possible financial benefits of studying science

subjects.

Is science misrepresented?

There was a highly significant drop between age 11 (43%) and age 14 (26%) in the proportion

of students agreeing with *B08: Science is blamed for things that are not its fault*, with little

further change at age 16. There were also significant gender differences in response, with

20

male students being much more likely to agree with the statement than female students. The

percentage disagreeing declined with age, with Level 2 data indicated these changes were

associated with a steady increase over the year groups from one-third at age 11 to well over

half by age 16 who neither agreed nor disagreed. Over 90% of students aged 11 and 14 were

of the opinion that information was often misrepresented in the media and, by implication,

this means science is blamed for things that are not its fault. The drop in this view by age 16

was significant ($\chi 2$=6.389, p<0.05). Half of the respondents in each age group perceived that

it is scientists who are often blamed for (negative) aspects of science that are actually a

consequence of the actions of others. There was a tendency that increased with age for

students to believe that science is bound to get blamed for some things as it is so common in

everyday life (42% at age 11, 65% at age 16), and the opinion that only bad things about

science get reported also rose with age (24% at age 11, 46% at age 16). In contrast, close to

three-fifths of all students in all age groups who chose 'disagree' as their Level 1 response felt

that this was because science helps to create problems, but only the good things about science

are reported. Three-quarters or more of students in each age group were not interested in the

way science is reported, reflecting the lack of interest in science in the media reported earlier.

The somewhat complex data here appear to suggest that, as they mature, students develop a

more sophisticated view of the range of effects of science and how these are portrayed, whilst,

at the same time, becoming more critical of the effects of science.

The personal and impersonal response to science

The views on the importance of science in the school curriculum discussed earlier are

forerunners of the very appreciable trend in responses to science outside school for students to

become increasingly positive about science as the items to which they are responding become

less personalised. Items B09 to B14 sought views of the more general importance of science,

21

and it is clear from Figures 1 and 2 that these elicited a greater proportion of Level 1 'agree'

responses than almost all the other items. Within this, male students were generally

significantly more positive than female students who, in turn, were significantly more likely

than male student to be more cautious in their judgements by selecting 'neither agree no

disagree' as their Level 1 response.

For item *B10: Science can help solve problems*, male students had a significantly more

optimistic view of the beneficial role of science. Level 2 data showed a very high proportion

(over 90%) of students who agreed with the statement felt that scientists could help to solve

problems by inventing things, with close to three-quarters supporting the view that science

can give us the knowledge to sort out problems. Regardless of gender, all students who

disagreed with the statement supported the view that science causes the problems in the first

place and so is unlikely to solve them.

A significantly higher proportion of female students responded in a neutral or cautious

fashion to *B11: Science makes an important contribution to the wealth of the nation* compared

to male students who were much more likely to agree. Level 2 data revealed that 80% of

students believed that science helps to create jobs, with close to 40% of both sexes supporting

the view that science lead to inventions which people then buy. The importance of science to

industry and the economy was recognised by around two-thirds of male and female students.

Most of the students who disagreed with the statement felt that science costs money rather

than generating wealth.

Item *B13: It is important for this country to have well-qualified scientists*, received the most

positive responses of all the items about science outside school from all age groups. Even

though students aged 16 were the least positive, 60% selected 'agree' as their Level 1

22

response, providing a stark contrast to the 14% who responded positively to *B07: It would be good to have a job as a scientist.* Level 2 data showed that a very high proportion of students (95%) who agreed with the main statement did so because they thought science important for certain areas such as medicine. Additionally around two-thirds of students supported the suggestion that scientists in this country can help other countries, and similar numbers feeling that scientists make the country a better place in which to live.

Significantly more male students than female students agreed with *B14: It is important to promote this country as a scientific nation.* This was balanced by a higher proportion of female students who neither agreed nor disagreed. Level 2 data showed over 80% of both sexes thought that promoting the country as a scientific nation would be good for the economy and for employment. Very similar proportions thought that the UK should not be left behind other nations given that people in this country have good ideas. The sizable majority of students disagreeing with the statement thought there were more important things to promote about the UK. These responses add to the evidence from other studies (Osborne and Collins, 2001; Jenkins and Nelson, 2005) that young people's attitudes to science outside school are more positive than their attitudes to their personal experience of science in school.

The 'age 14 dip'

The study provides ample evidence of the particularly sharp fall in positive attitudes between age 11 and age 14, in keeping with the findings of the study by Galton *et al.* (2003). Within the overall pattern of declining positive attitudes, seven items showed a statistically significant decrease in 'agree' responses between age 11 and age 14 with, in some cases, a slight improvement by age 16. No items showed similar significant differences between ages 11 and 14. These items are summarised in Table 5.

Table 5 about here

The explanatory (Level 2) responses to the items offer interesting insights into the 'age 14 dip', some of which have been discussed earlier. The most pertinent of these relate to students views of their science lessons, their responses to what their teachers do, and their perceived value of jobs and careers involving science. In science lessons, an increasing feeling that the subject matter is difficult – science is 'hard' – exerts a very significant influence between ages 11 and 14. Enthusiastic teachers who challenged students to think and provided variety in activity were seen as very influential at age 11. At this age, students were also attracted to careers in science, giving a wide variety of reasons: the nature of the work, remuneration and the view that scientists can have a positive influence on the world. This view has altered dramatically by age 14, with jobs involving science being seen as unattractive because they are perceived as boring, science being perceived as causing too many problems in the world and scientists having to make too many compromises. However, students aged 16 who did want a job involving science gave as their reasons the fact that scientists could change the world for the better, or that jobs involving science were well-paid. It appears that some students at least, as they mature, come to feel that science offers a way of making a positive difference to people's lives.

Shift in opinion with maturity

One unanticipated feature of particular interest in the data is the shift in Level 1 responses from 'agree' or 'disagree' to 'neither agree nor disagree' as students get older. There are examples of items where there was no significant difference with age in the number of agree responses, but a very apparent difference in shift from 'disagree' to 'neither …' responses.

24

For example, in item B07, *It would be good to have a job as a scientist,* numbers disagreeing with this statement stayed roughly constant at around the 40% level. However, the very significant fall in numbers agreeing with the statement (age 11=41%, age 14=11%; $\chi2=33.180$, p<0.001) was mirrored by a corresponding rise in number selecting the 'neither…' option (age 11=22%, age 14=45%; $\chi2=10.384$ p<0.01). A similar pattern in responses may be seen for item B08, *Science is blamed for things that are not its fault*. The majority of neutral Level 1 responses were linked to Level 2 responses in which students said they did not feel they knew enough to have a view. These findings suggest that, as students mature, they feel they need more information to make an informed judgement.

Within this overall shift in opinion with maturity, it is also apparent that a significantly higher proportion of female students chose the 'neither …' option in all cases where there was a significant gender difference in responses. Furthermore, when looking at the reasons why the 'neither …' option was selected, there was a consistent trend for more female students than male students being prepared to admit they did not know enough to make an informed response. One possible explanation for this is that female students may be more cautious than male students in opting for a definite 'agree' or 'disagree' response which, in turn suggests that male students may have firmer opinions or a more 'black and white' view of the world.

Conclusions

Research into attitudes to science often results in feelings of comfort (though very often cold comfort) from reaffirmation of the findings of other work, coupled with frustration at the seemingly intractable nature of the problem. Certainly some of the responses in the study reported here support well-documented findings on the decline of positive attitudes to science and jobs involving science over the period of secondary schooling, with physical sciences

eliciting particularly negative responses and female students less positively disposed than

male students towards science.

The study adds to the growing evidence that attitudes to science outside school are more

positive than attitudes to school science, and that experiences of school science between ages

11-14 are crucial in shaping students' attitudes and subsequent behaviours in relation to

subject choice. Whilst the decline in positive attitudes between 11 and 14 is of considerable

concern, a more positive feature of the findings is the identification of school science as

exerting the greater influence, as what students experience in their science lessons is easier to

control than what they experience of science outside school.

The principal justification for developing the new instrument was to go beyond descriptive

data to probe for explanations and insights that, in turn, might point to possible areas to target

for action. What, therefore, has emerged from the explanatory (Level 2) data, and what

messages emerge for future research, and for policy and practice?

The Level 2 data points to particular features of lessons being important, with younger

students citing 'being made to think', variety in activity and seeing how science relates to life

as the reasons for this. Many curriculum materials now do contextualise science, but rather

less is known about the range of activities teachers use in science lessons and their effects.

The notion of what students see as activities that make them 'think' in science lessons would

certainly benefit from further exploration, given that older students cite the 'hard' nature of

science subjects as a reason for not wanting to study them. It would be useful to have more

information on where the boundaries lie between 'being made to think' and 'hard'. As most

students study 'science' in the early years of secondary schooling, it is important to explore

these dimensions in relation to the different scientific disciplines, as each has a different

26

problem. Interest in physics remains consistently low, interest in biology increases, and the science reported as most interesting at age 11 - chemistry - shows the sharpest decline. The perception of 'hardness' also poses a challenge to policy: if students believe that there are greater rewards in terms of external examination grades for effort put into subjects other than the physical sciences, and reviews of examination grades have confirmed that it is more difficult to achieve higher grades in these subjects, then there is a need to examine carefully the subject content of science curricula, and ways in which national tests and examinations are graded.

Other insights to emerge from the explanatory data point to features of the curriculum which might usefully benefit from strengthening or from a different emphasis. Young people, particularly female students, appear to become less clear-cut in their views as they mature, and feel they need more information before they can reach views in relation to, for example, wanting a job involving science, or knowing whether science can help solve environmental and social problems. One area to target for action would be to look carefully at how information about jobs involving science might feature in curriculum materials, both in relation to the jobs themselves and in the context of the view of scientists being seen as 'uncaring'. It may well be that the links between contextualising science, on which students report favourably, and jobs involving science need to be made more overtly, as they are not as apparent to students as they are to those developing materials for use in lessons. Moreover, a factor strongly influencing those students aged 16 who wanted a job as a scientist was a belief that scientists could change the world for the better. Thus it would be useful to provide more information on the contribution scientists make to society.

Looking more widely at the nature of research on attitudes to science, we believe the instrument developed for this study has a number of strengths: considerable care has been

27

taken in its design and validation, it combines the ability of a survey to gather large datasets on general patterns with the explanatory insights normally drawn from interviews into an easy-to-administer pencil-and-paper instrument, its language draws on 'the student voice', and it probes for explanatory insights as well as establishing general patterns. However, the gathering both descriptive and explanatory data in this way does generate extensive data which, in turn, leads to challenges in analysis and reporting.

We also believe that the study points to the future direction of attitude research. Well-designed instruments certainly have a role to play in surveying attitudes, but their principal strength lies in providing the 'board brush stokes' of the picture, rather than providing much of the detail that might point to action. There is much in the study reported here that suggests there is little overlap between students' perceptions of science and their perceptions of themselves and their own identity. This area would be worth probing in more detail. There is also evidence that some schools that are much more effective than others at encouraging uptake of particular subjects. For example, Fitzgibbon (1999) established significant inter-school variations in the UK in numbers of students electing to study mathematics beyond the compulsory period, and her finding suggested that there might be similarities with the sciences in factors underlying student choice. Recent reports of studies of schools (Ponchaud, 2006; National Strategies, 2008) suggests that school-based factors, such as enthusiastic teaching by specialist teachers, and provision of good information about the value and flexibility of science qualifications, can exert significant effects on uptake of science. Moreover, some of the factors that may promote more positive attitudes to science may not be apparent to students and therefore not easily accessible through attitudinal instruments. Thus, we contend that the priority for research on attitudes to science is to explore in more detail features of schools that are more - and less - successful at encouraging uptake of science beyond the compulsory period.

28

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29

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Storage of the original data

All the original data are stored in the Department of Educational Studies at the University of York.

The full report and the instrument

The full report and the instrument may be found as Paper 8 in the Department of Educational Studies Research Paper series: www.york.ac.uk/depts/educ/ResearchPaperSeries/

Acknowledgements

Table 1

Stages in the development and validation of the research instrument

Stage	Procedure	Data sources
1	Identification of areas to be explored	Literature search plus interviews with 36 students aged 11, 14 and 16 (12 of each age)
2	Composition and peer validation of disposition statements	Initial development by team of three researchers plus two teachers; validation by approximately 25 science educators and teachers
3	Gathering of free responses to disposition statements	Approximately 40 responses per item, 10-15 per age range in two all-ability comprehensive schools
4	Development and validation of trial fixed-response items	Categorisation and validation of responses
5	Production, use and validation of fixed-response version of instrument	Trial with 91 students in four classes, two aged 11 and two aged 16

33

Table 2

The disposition statements

Dispositions towards school science

A01   Science lessons are among my favourite lessons.
A02   I try extra hard in science lessons.
A03   My science teachers make me more interested in science.
A04   The things we do in science lessons make me more interested in science.
A05   If I had a choice I would study biology.
A06   If I had a choice I would study chemistry.
A07   If I had a choice I would study physics.
A08   I enjoy reading science textbooks.
A09   What we do in science lessons is useful whatever you do after you leave school.
A10   Everybody should study all three science subjects (biology, chemistry and physics) up to age 16.
A11   When they have a choice, young people should be given particular encouragement to study science subjects.

Dispositions towards science outside school

B01   I like watching science programmes on the TV.
B02   I like reading about science in newspapers and magazines.
B03   News items about science interest me.
B04   I like reading science books other than school science textbooks.
B05   I would trust something a scientist said.
B06   I would like a job involving science.
B07   It would be good to have a job as a scientist.
B08   Science is blamed for things that are not its fault.
B09   Science has a positive influence on society.
B10   Science can help solve problems (e.g. environmental and social problems).
B11   Science makes an important contribution to the wealth of the nation.
B12   The Government should spend more money on scientific research.
B13   It is important for this country to have well-qualified scientists.
B14   It is important to promote this country as a scientific nation.

Figure 1

Example of final format for multi-choice items

B06   I would like a job involving science.

I agree because…		I neither agree nor disagree because…		I disagree because…	
a	…I enjoy science at school	k	…it depends on what science you would be doing	p	…I find science boring
b	…they are generally well paid			q	…science causes too many problems for the world
c	…science makes the world a better place to live in			r	…they don't get well paid
d	…there are good jobs you can do with science				
x	… another reason – please say what	y	… another reason – please say what	z	… another reason – please say what

(**Bold text** in table = Level 1 responses; plain text = Level 2 responses)

35

Table 3

Details of sample

Age	N	*%* Male	*%* Female	Low ability Male	Low ability Female	Middle ability Male	Middle ability Female	High ability Male	High ability Female
11	104	49	51	2	0	27	25	22	28
14	78	47	53	5	3	13	16	19	22
16	98	49	51	0	3	17	33	31	14
Total	280	136	144	7	6	57	74	72	64

36

Figure 2

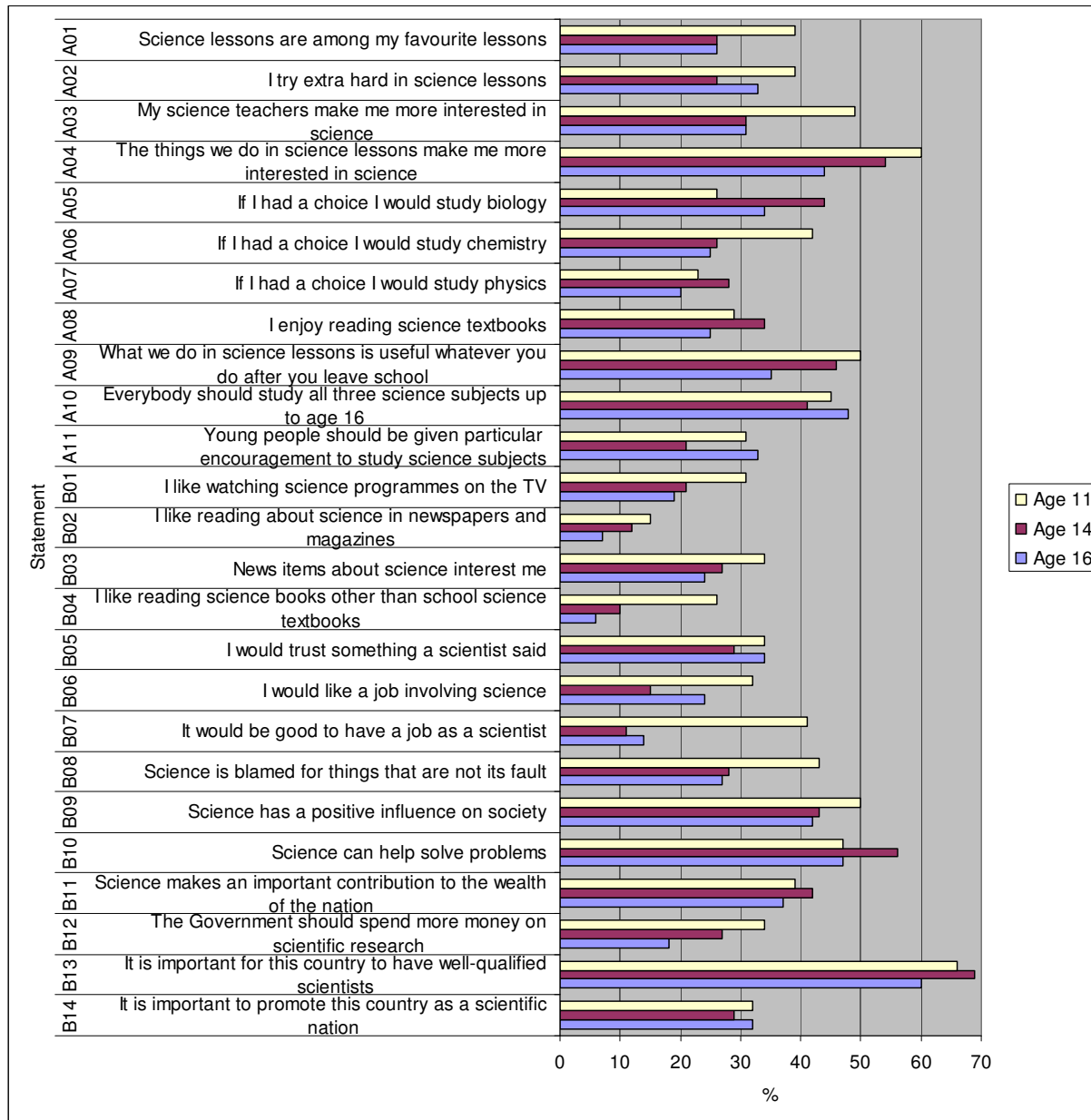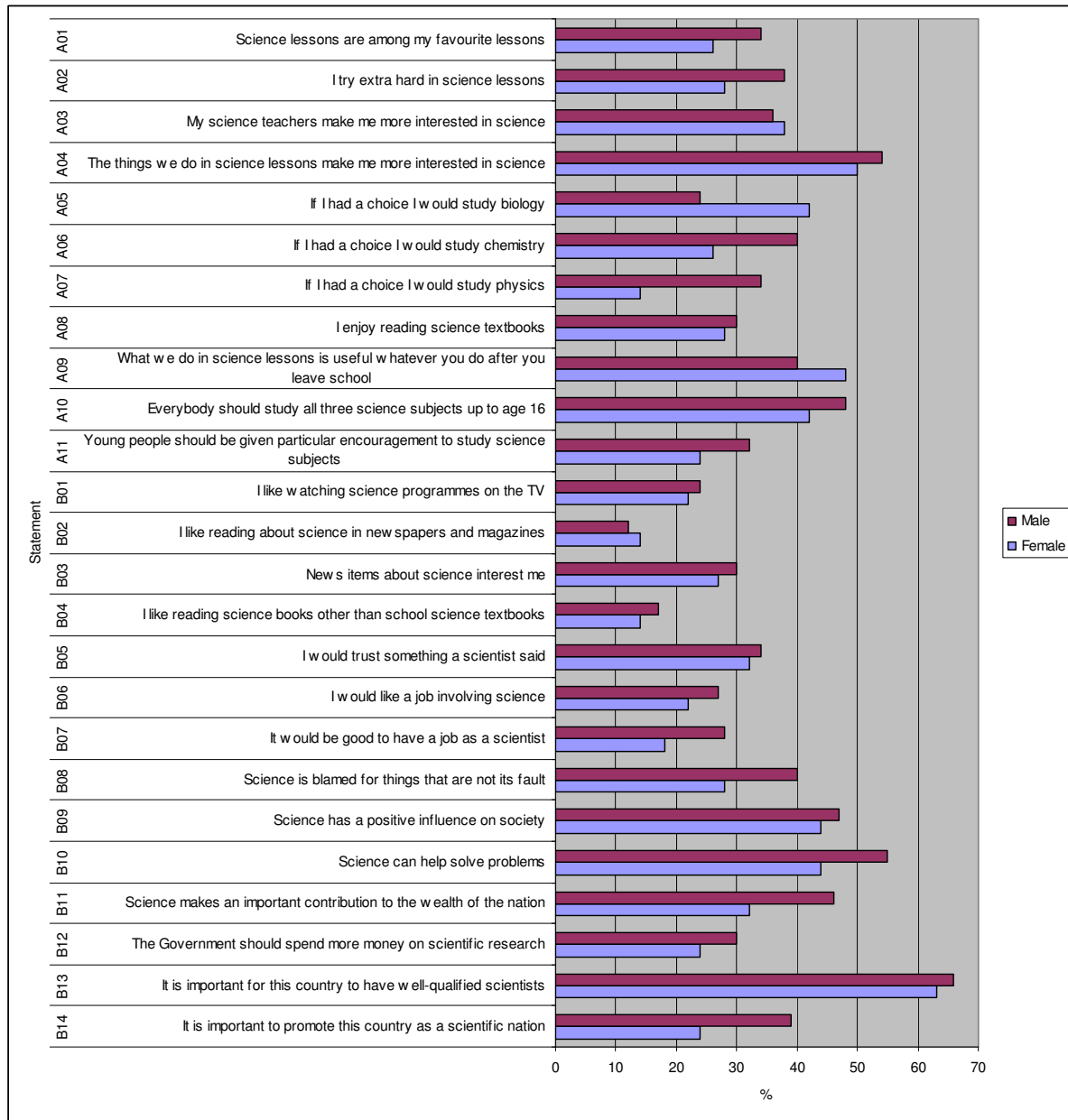*Percentage of 'agree' responses to items (by age)*

Figure 3

Percentage of 'agree' responses to items (by gender)

Table 4

Statistically significant differences in Level 1 responses

	Statement	Significant differences (age)	Significant differences (gender)
A01	Science lessons are among my favourite lessons.	Agree = 39% age 11, 26% age 14 ($\chi2=10.131$, p<0.01) Disagree = 10% age 11, 21% age 14 ($\chi2=8.370$, p<0.05)	None
A03	My science teachers make me more interested in science.	Agree = 49% age 11, 31% age 14 ($\chi2=9.810$, p<0.01)	None
A05	If I had a choice, I would study biology.	Disagree = 37% age 14, 54% age 16 ($\chi2=22.637$, p<0.001)	Agree = 24% male, 42% female ($\chi2=10.120$, p<0.01)
A06	If I had a choice, I would study chemistry.	Agree = 42% age 11, 26% age 14 ($\chi2=26.924$, p<0.001)	Agree = 40% male, 26% female ($\chi2=7.397$, p<0.05)
A07	If I had a choice, I would study physics.	Disagree = 43% age 11, 68% age 16 ($\chi2=18.817$, p<0.001)	Agree = 34% male, 14% female ($\chi2=15.135$, p<0.001)
B04	I like reading science books other than school science textbooks.	Agree = 26% age 11, 10% age 14 ($\chi2=17.906$, p<0.001)	None
B06	I would like a job involving science.	Agree = 32% age 11, 15% age 14 ($\chi2=11.863$, p<0.01)	None
B07	It would be good to have a job as a scientist.	Agree = 41% age 11, 11% age 14 ($\chi2=33.180$, p<0.001)	None
B08	Science is blamed for things that are not its fault.	Agree = 43% age 11, 28% age 14 ($\chi2=14.345$, p<0.01)	Agree = 40% male, 28% female ($\chi2=7.013$, p<0.05) Neither agree nor disagree = 34% male, 51% female ($\chi2=6.203$, p<0.05)
B10	Science can help solve problems (e.g. environmental and social problems).	None	Neither agree nor disagree = 27% male, 44% female ($\chi2=10.042$, p<0.01)
B11	Science makes an important contribution to the wealth of the nation.	None	Agree = 46% male, 32% female ($\chi2=7.592$, p<0.05) Neither agree nor disagree = 37% male, 54% female ($\chi2=7.675$, p<0.05)
B13	The Government should spend more money on scientific research.	None	Neither agree nor disagree = 20% male, 31% female ($\chi2=6.483$, p<0.05)
B14	It is important to promote this country as a scientific nation.	None	Agree = 39% male, 24% female ($\chi2=6.672$, p<0.05)

39

Table 5

Items showing statistically significant decline in 'agree' responses between the ages of 11 and 14

	Statement	Agree at age 11 (%)	Agree at age 14 (%)	Agree at age 16 (%)
A01	Science lessons are among my favourite lessons	39	26	27
A03	My science teachers make me more interested in science	49	31	31
A06	If I had a choice, I would study chemistry	42	26	25
B04	I like reading science books other than school science textbooks	26	10	6
B06	I would like a job involving science	32	15	24
B07	It would be good to have a job as a scientist	41	11	14
B08	Science is blamed for things that are not its fault	43	28	27

40