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Student opinion in England about science and technology

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An earlier paper in this Journal (Jenkins & Nelson, 2005) drew upon the findings of the Relevance of Science Education Project (ROSE) to report the attitudes of students in England towards their secondary school science education. The present paper draws upon the same project to explore what the same students, almost all in their penultimate year of compulsory schooling, think about science and technology. It suggests that several basic research questions need to be addressed and answered if the present widespread decline in the industrialised world in the popularity of the physical sciences as subjects of advanced study is to be halted.

The Relevance of Science Education Project is an international questionnaire-based study based at the University of Oslo and directed by Professor Svein Sjøberg. Details of the questionnaire and information about the countries involved can be found in Schreiner and Sjøberg (2004) or on the Project website (http://www.ils.uio.no/forskning/rose). Each of these sources examines a range of technical and methodological issues associated with the rationale, design, piloting and deployment of the ROSE questionnaire, including reliability, validity and credibility and the limitations of the four-point Likert scale used extensively in the questionnaire. Each also provides details of the sampling procedures in each of the participating countries and the instructions given to schools for the completion of the questionnaires. Information of this kind is not, therefore, repeated here and the reader is referred to the sources indicated.

The reader is also referred to the earlier paper mentioned above for an account of the ROSE initiative within the wider context of international comparative studies such as the Trends in Mathematics and Science Study (TIMSS) (Martin & Mullis, 2000) and the OECD Programme for International Student Assessment (PISA) (Schleicher, 2000). The same paper also locates the initiative within the rapidly

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growing body of work concerned with the 'student voice' in education (Rudduck & Flutter, 2000; ESRC 2004; Flutter & Rudduck, 2004).

The ROSE questionnaire

The ROSE questionnaire has ten sections and was developed following a working seminar with an international advisory group held in October 2001 and subsequent piloting and revision during the following year (Schreiner & Sjøberg, 2004). The questionnaire was written in English. Three of the sections invited students to respond, using a four-point Likert-type scale, to a series of statements about what they would like to learn. Other topics explored in the questionnaire include 'My future job', 'My science classes', 'My out-of-school experiences' and 'My opinions about science and technology'. It is with the last of these that this paper is concerned. Attention is focused on the views of students in England with data from other countries being used simply to place the English findings in a wider international context.

The sample

The sample of schools was drawn to reflect as far as possible the geographical distribution and type of secondary schools within the English education system. Participating schools were asked in 2003–2004 whether they wished to receive sufficient questionnaires for a single class or some other number. Most schools choose the former, presumably to minimise the disruption to the normal teaching routine. A total of 1277 usable questionnaires were eventually received from 34 schools (a 60% return). Of the 1277 students (617 boys, 660 girls) who completed the questionnaire, 1180 were 14 or 15 years old and about 7% of them came from independent, that is, fee-paying schools, a proportion that accords surprisingly well, if some what fortuitously, with the wider national picture. For a variety of reasons, including the rapid turnover among science teachers in parts of London, schools in the capital are almost certainly under-represented. The pupils' responses were coded and the data cleaned at the University of Oslo.

Results and discussion

The students' responses to the 16 statements about science and technology are given in Table 1. The 'agreement index' in Table 2 represents the difference in the percentage of agree/low agree and disagree/low disagree responses to each item. Table 3 summarises the responses to the sixteen statements by gender.

Many of the gender differences in Table 3 are statistically significant. In general, girls express less confidence and lower levels of optimism than boys in their responses to the 16 statements, although the differences are not great.

The results of a factor analysis of the responses by gender are given in Table 4 and they reveal some differences in the clusters. Positive views about the role and

Table 1. Distribution of student responses to 'My opinion about science and technology'

Statement No.	Disagree* %	Low disagree %	Low agree %	Agree %	Nil response	Median
1	10.0	17.4	33.6	36.4	2.6	L. agree
2	4.8	10.4	32.9	49.2	2.6	Agree
3	6.3	11.8	33.8	45.3	2.8	L. agree
4	6.9	16.4	37.6	36.4	2.7	L. agree
5	10.0	19.2	35.0	31.8	4.0	L. agree
6	12.7	31.5	34.8	16.6	4.4	L. agree
7	21.0	34.6	29.9	10.5	4.0	L. disagree
8	32.2	36.8	19.5	8.3	3.3	L. disagree
9	26.2	37.4	23.1	8.5	4.8	L. disagree
10	17.7	37.6	29.2	11.9	3.6	L. disagree
11	9.3	20.2	40.0	26.3	4.2	L. agree
12	12.5	23.7	33.8	25.9	4.1	L. agree
13	25.8	37.8	25.2	6.9	4.3	L. disagree
14	47.2	33.4	12.7	3.2	3.5	L. disagree
15	29.2	38.9	20.6	5.9	5.0	L. disagree
16	9.2	15.0	38.9	33.9	3.0	L. agree

* The identifiers disagree, low disagree, low agree and agree do not appear on the ROSE questionnaire.

Table 2. Degree of agreement with statements about science and technology

Statement	Agreement index*
1. Science and technology are important for society	+42.6
2. Science and technology will find cures for such diseases as HIV/AIDS, cancer, etc.	+66.9
3. Thanks to science and technology, there will be greater opportunities for future generations	+61.0
4. Science and technology make our lives healthier, easier and more comfortable	+51.0
5. New technologies will make work more interesting	+37.6
6. The benefits of science are greater than the harmful effects it could have	+7.2
7. Science and technology will help eradicate poverty and famine in the world	–15.1
8. Science and technology can solve nearly all problems	–41.2
9. Science and technology are helping the poor	–32.2
10. Science and technology are the cause of environmental problems	–14.2
11. A country needs science and technology to become developed	+36.8
12. Science and technology benefit mainly the developed countries	+23.5
13. Scientists follow the scientific method that always leads them to correct answers	–31.5
14. We should always trust what scientists have to say	–64.7
15. Scientists are neutral and objective	–41.6
16. Scientific theories develop and change all the time	+48.6

* Agreement index = (agree+ low agree) – (disagree + low disagree)

Table 3. Gender differences in responses to 'My opinions about science and technology'

Statement No.	Girls Agree %	Girls Disagree %	Boys Agree %	Boys Disagree %	Chi Square	K-S*
1	68.3	31.7	75.9	24.1	0.003	0.002
2	88.0	12.0	80.7	19.3	0.000	0.002
3	80.4	19.6	82.5	17.5	NS	NS
4	75.0	25.0	77.3	22.7	NS	NS
5	67.3	32.7	72.0	28.0	0.074	0.053
6	52.4	47.6	55.2	44.8	NS	NS
7	37.3	62.7	47.1	52.9	0.001	0.006
8	22.4	77.6	35.3	64.7	0.000	0.000
9	27.4	72.6	39.2	60.8	0.000	0.000
10	41.3	58.7	44.1	55.9	NS	NS
11	65.3	34.7	73.2	26.8	0.003	0.041
12	58.8	41.2	66.0	34.0	0.010	0.074
13	27.7	72.3	39.6	60.4	0.000	0.000
14	12.7	87.3	20.5	79.5	0.000	0.004
15	24.0	76.0	32.0	68.0	0.002	0.043
16	73.5	26.5	76.9	23.1	NS	NS

*The Kolmogorov-Smirnov test has been used to compare the entire distribution. Chi Square has been used to compare agree/disagree using a 2×2 tableau.

contribution of science and technology are evident in each case (see component 1), although there are differences in the responses to statements 7 and 11.

The data in Tables 1 to 3 present a number of positive messages about the students' views about science and technology. For example, there is a large degree of agreement that science and technology are important for society (statement 1) and there is optimism about the contribution that they can make to curing diseases such as HIV/AIDS and cancer (statement 2). Science and technology are also seen as creating greater opportunities for future generations (statement 3) and as making everyday life healthier, easier and more comfortable (statement 4). There is a lower level of agreement with the assertion that the benefits of science are greater than its possible harmful effects (statement 6), although a majority of both boys and girls hold this view.

Disagreement is most marked with statements 7, 8, 9 and 10. Only a minority of boys (47.1%) and of girls (37.3%) agree that science and technology will help eradicate poverty and famine in the world and that science and technology are helping the poor (boys 39.2%; girls 27.4%). These two findings suggest some lack of appreciation of the contribution that science and technology are able to make to the alleviation of poverty, perhaps allied with an understanding that such alleviation also has financial, political and social dimensions. Likewise, only a minority of boys and girls agree with the somewhat stronger statement that science and technology can solve nearly all problems (boys: 35.3%, girls: 22.4%). Most of the respondents to the

Table 4. Principal Component Analysis of 'My opinions about science and technology for boys and (girls)'*

Item	Component 1	Component 2	Component 3
1. Science and technology are important for society	**0.725 (0.656)**	–0.014(–0.008)	0.193 (0.015)
2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.	**0.771 (0.689)**	–0.068 (0.007)	0.117 (0.008)
3. Thanks to science and technology, there will be greater opportunities for future generations	**0.797 (0.814)**	–0.024 (0.054)	0.123 (0.029)
4. Science and technology make our lives healthier, easier and more comfortable	**0.814 (0.758)**	–0.051 (0.220)	0.20 (–0.009)
5. New technologies will make work more interesting	**0.632 (0.629)**	0.157 (0.354)	0.084 (0.119)
6. The benefits of science are greater than the harmful effects it could have	**0.635 (0.578)**	0.263 (0.337)	–0.065 (0.283)
7. Science and technology will help eradicate poverty and famine in the world	**0.514** (0.215)	**0.530 (0.757)**	–0.237 (0.119)
8. Science and technology can solve nearly all problems	0.216 (0.058)	**0.731 (0.676)**	–0.063 (0.352)
9. Science and technology are helping the poor	0.258 (0.098)	**0.618 (0.791)**	–0.280 (0.141)
10. Science and technology are the cause of environmental problems	0.156 (–0.020)	0.121 (0.193)	**0.537** (–0.036)
11. A country needs science and technology to become developed	**0.525** (0.483)	0.125 (0.141)	0.357 (0.200)
12. Science and Technology benefit mainly the developed countries	0.337 (0.409)	–0.036 (–0.082)	**0.715** (0.197)
13. Scientists follow the scientific method that always leads them to correct answers	–0.051 (0.159)	**0.614** (0.135)	0.399 **(0.699)**
14. We should always trust what scientists have to say	–0.090 (–0.085)	**0.755** (0.160)	0.161 **(0.793)**
15. Scientists are neutral and objective	–0.007 (0.087)	**0.712** (0.183)	0.211 **(0.787)**
16. Scientific theories develop and change all the time	**0.532 (0.511)**	0.101 (0.004)	0.268 (0.004)

* Rotation method: Varimax with Kaiser normalization, significant factors in bold.
Boys: Components 1, 2 and 3: Initial Eigen values are 4.90, 2.43 and 1.22 accounting for 30.7%, 15.2% and 7.7% of total variance respectively.
Girls: Components 1, 2, and 3: Initial Eigen values are 4.85. 2.26 and 1.20, accounting for 30.3%, 14.1% and 7.5% of total variance respectively.

questionnaire do not see science and technology as the cause of environmental problems (statement 10) but there is no majority support among either boys and girls for the statement that science and technology are helping the poor (statement 9). The responses to statements 13, 14 and 15 suggests a healthy degree of disagreement with the three statements about the objectivity of science, the role of scientific methods and the degree of trust that should be placed in what scientists have to say.

The data in Table 4 suggest that boys who are most optimistic about the social benefits of about science and technology ('science and technology can solve nearly all problems', 'science and technology are helping the poor', 'science and technology will help eradicate poverty and famine in the world') also display a high degree of confidence in science, scientists and scientific method (statements 13, 14 and 15). While girls also express a similar degree of optimism, there is no corresponding association with trust in science, scientists or scientific method. That trust is reflected in the third factor for girls, whereas the third factor for boys links science with advantaging the richer countries and with causing environmental problems.

Some of the responses of the students in England to the 16 statements about science and technology mirror those given by their counterparts in other countries participating in the ROSE survey (although there are some significant differences in the extent of the gender differences and in the mean scores on the four-point Likert scale). This is the case with the responses to statements 1, 2, 3, 4, 11 and 16 where the mean score for each country exceeds 2.5 for both boys and girls. The low level of agreement by students in England with statement 9, that science and technology are helping the poor, is also shared by most countries. However, the responses of students in England and other developed countries to some of the other statements differ significantly from those of their counterparts in the developing world. This is particularly the case with statement 13, which asserts that 'Scientists follow the scientific method that always leads them to correct answers'.[1]

The responses presented in Tables 1 and 2 may also be compared with data from other studies, notably the Eurobarometer survey conducted within the 25 member states of the European Union, the candidate countries and the members of the European Free Trade Association. The Eurobarometer data are derived from a total of 32,897 face to face interviews, based upon specific questions (European Commission, 2005, pp. 130–131). A few of the statements in the ROSE study are similar to, or identical with, those used in the Eurobarometer survey, although direct comparison of the findings from the two sources is not straightforward because of differences in sampling, methodology[2] and of the way in which the findings are presented. The Eurobarometer survey shows that most Europeans[3] (88%) are optimistic that scientific and technological progress will help to cure illnesses such as AIDS and cancer and that science and technology will make life healthier, easier and more comfortable (78%). Seventy-seven percent agree that, thanks to science and technology, there will be more opportunity for future generations, but only a small majority, 52%, believe that the benefits of science are greater than any harmful effects it may have. These percentages can be compared with the agreement indices and median positions identified in Tables 1 and 2 in response to statements 2, 3, 4 and 6 respectively. The

Eurobarometer survey (European Commission, 2005, pp. 58–62) also shows that only 21% of Europeans agree that 'science and technology can sort out any problem' (compare the response to statement 8) and that only 39% agree that 'Science and technology will help eliminate poverty and hunger around the world' (compare the response to statement 7). The generally supportive attitude towards science and technology reported in the ROSE and Eurobarometer surveys is also evident in the data collected by the National Science Board in the USA although, in general, such support is stronger than within Europe. For example, more Americans (72%) than Europeans (52%) agreed in 2001 that the benefits of scientific research outweighed any harmful results (National Science Board, 2004, Ch.7, p.4).

The broadly positive messages about science and technology suggested by the ROSE data are also found in a number of more local or regional studies. As an example, Toussaint and his colleagues have reported that students in two administrative regions of Québec see science as 'the *Sesame* for understanding all aspects of the natural world' although the same students also think that 'science and technology can resolve most environmental and social problems' (Toussaint *et al.*, 2001, p. 666).

The optimism about science and technology revealed by the various studies reported above stands in some contrast to the responses of the same students to questions about their experience of science at school and their interest in pursing a science- or technology-related career. For most students, the physical sciences remain relatively unpopular, with girls showing a more marked dislike than boys, and such a career has little appeal for either sex (Busch, 2005; Jenkins & Nelson, 2005). It would, of course, be a mistake to attribute students' choice of career simply or directly to their experience of science at school: many interacting factors are involved, some of which are beyond the control of a school (Lyons, 2003).

What are the implications of these findings for research in school science education? Some caution is needed in replying to this question. The responses given by the students are subject to the general limitations of any questionnaire-based study and to those that follow from using a Likert-type scale for scoring responses. These limitations are well-rehearsed in the methodological literature (Ary *et al.*, 1996; Cohen *et al.*, 2000; Robson, 2002) and are therefore not repeated here, although particular attention is drawn to the debate in the literature that relates to the construction of Likert scales (e.g., Ray, 1980; Weng, 2004) and the manipulation of numerical data derived therefrom. Particular caution is needed when drawing inferences from quantitative data when the assumptions underlying the statistical techniques employed to generate that data may not be fully met. More particularly, the ROSE questionnaire does not define 'science' or 'technology' and it is possible that different students have in mind somewhat different understandings when completing the questionnaire. Indeed for some students, science is hardly distinguished from technology (Toussaint *et al.*, 2001). The word 'science' has different connotations in different countries and in some cases the academic disciplines is known by a different name from the school subject.[4] Science itself now embraces many disciplines, from astrophysics to molecular biology. Technology is readily associated in popular usage with computers and mobile telephones but not so readily with gas cookers, electric irons or simple tools.

In the case of both science and technology, students' perceptions are also likely to be strongly coloured by their experience of the school versions of these enterprises and those experiences are themselves likely to differ to varying degrees. Such perceptions may also be gender-related.

Nonetheless, taken alongside the results of other studies such as the surveys conducted by the European Commission and the National Science Board, the ROSE study points towards some elements of a research agenda for science education. Much more needs to be known about why the broadly positive views about the role of science and technology in society are not reflected more widely in students' attitudes towards science at school and in a greater willingness to study science beyond the point at which it ceases to be compulsory. To what extent, if at all, can the difference be attributed to school-based factors, such as the content of the science curriculum, the way science is taught and/or assessed and the alleged difficulty of the physical sciences as subjects of study? How important are other factors such as the influence exerted by parents, students' peer groups within and outside school, or careers' advisers, and what is the nature and extent of their interaction? How and why do students' attitudes towards, and interest in, science and technology change as they progress through compulsory schooling and how are any changes related to success in these subjects at school and to the factors that influence that success? It might also be asked why students seem to take a rather discouraging view of the contribution that science and technology are able to make to the alleviation of poverty in many parts of the world, while agreeing strongly that a country needs science and technology to become developed (statement 11).

In addressing these and other questions, it will be important to distinguish between the basic scientific disciplines since the differences in students' attitudes towards, and interest in, them are likely to be significant (Osborne & Collins, 2000). Students' attitudes and interests will also change throughout compulsory schooling (Lindahl, 2001, 2005). Most studies, including the Eurobarometer and National Science Board surveys, simply report results obtained at different points in time: the lack of large-scale and genuinely longitudinal studies is therefore to be regretted.

Research methodologies that are more complex, qualitative and sensitive than a questionnaire-based study are thus required, and they will need to allow the relevant issues to be tracked over time. Until some of the basic research questions identified above are addressed and answered, attempts to encourage more students to choose the physical sciences are likely to be at best hit and miss, and at worst, counterproductive.

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Notes

1. International data are available on the Project website.
2. Data were collected from residents aged 15 or over in each of the participating countries.
3. The Eurobarometer survey provides details on a country basis but these are not reproduced here. Some of the differences in response between the countries surveyed are substantial.
4. For example, the Norwegian term for science as an academic discipline is *naturvitenskap* while the term for school science is *naturfag*, the latter also having a strong association in the mind of many teachers with nature study. The ROSE team was well aware of the linguistic difficulties associated with international comparative research and took steps to minimise them (see Schreiner & Sjøberg 2005, pp. 40–41).

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