The ROSE Survey in Scotland – An Initial Report

Views of Secondary 3 Pupils on the Relevance of Science Education

August 2006

A Report from STEM-ED Scotland

supported by

The Scottish Executive
Enterprise, Transport & Lifelong Learning Department

by

Stuart Farmer
Bob Kibble
&
Moira Finlayson
Alan Roach

CONTENTS

Authors' Foreword

This work has been funded by the Scottish Executive Enterprise, Transport & Lifelong Learning Department. The project team was brought together through STEM-ED Scotland, a partnership organisation aiming to champion the development of world class educational provision in Scotland across the STEM disciplines (science, technology, engineering and mathematics). The team members are:

Stuart Farmer: immediate past-Chair of ASE Scotland and PT Physics at Robert Gordon School, Aberdeen

Moira Finlayson: STEM-ED Scotland Researcher and past Head of Science at Kilmarnock College

Bob Kibble: current Chair of ASE UK and Lecturer in Science Education, University of Edinburgh

Alan Roach: emeritus professor of the School of Engineering & Science, University of Paisley

Acknowledgements

We thank the Scottish Executive Enterprise, Transport & Lifelong Learning Department for funding support and wish to acknowledge very helpful advice and encouragement afforded us by Michael Roy and Joanne Ward of the Department's Science & Society Team.

We also wish to thank Professor Svein Sjoberg for permission to use the ROSE Questionnaire in Scotland and for inspiring us and our funders in the Scottish Executive.

We would like in particular to pay tribute to all who assisted in the implementation of our questionnaire, including several ASE Scotland members, officers in Local Education Authorities, and the teachers involved in each of the 92 schools that participated in the survey. The very positive response from schools was immensely encouraging and enabled us to obtain returns from almost 2900 pupils.

Special thanks are also due to Keith Galbraith of the University of Paisley for his patience and perseverance in electronically scanning all the returns, a process that did not always go smoothly.

Finally we would like to thank the young pupils for their efforts in completing this somewhat lengthy survey. We hope that the results will help inform planning for a more relevant and interesting curriculum for their successors in the years to come.

BRIEF OVERVIEW

The Survey

The ROSE (Relevance of Science Education) Survey, developed by an international group led by Prof Svein Sjoberg of Oslo University, has been conducted in over 40 countries. It is a 250 item questionnaire surveying school pupil attitudes, interests and experiences relevant to the study of science and technology.

Funded by the Scottish Executive, and with the ready cooperation of teachers and education authorities, we have applied this survey in Scotland:

- we surveyed class groups of Secondary 3 pupils (most of age 14) across 92 schools
- over 2,700 validly completed returns have been obtained and electronically encoded
- this represents, we believe, the largest sample collected in any country so far
- the sample permits analysis of significant differences in views of different subgroups of pupils
- the sample is geographically, socially and educationally representative

This Report

We were funded to conduct the survey and to provide a short initial exploratory analysis of the results. We believe that the findings from this preliminary study, reported below, suggest that there would be significant value in pursuing more detailed analysis of the rich and extensive data collected. Significant insights, and causes for concern, are provided by the survey evidence, and these could usefully inform new approaches to the school curriculum and public strategies to enhance more general public understanding of science.

MAIN FINDINGS

	Principal Section refs
Overall picture	
• international comparisons: the sample-averaged responses from Scotland are broadly similar to those from developed countries in general, quite close to those from England, and closest of all to those from Northern Ireland	***§15***
• views are net negative overall: the survey reflects what many will regard as, overall, disappointingly negative views of science & technology, and of learning experienced at school	
• there is a diversity of individual views on most issues: whilst we see clear majority views, for pupils as a whole or for pupils in a given gender, course or social group, there are very often significant minorities with contrary opinions	***§6.1***
• variation by gender: girls are on the whole rather more negative about science, and especially technology, and they have somewhat different relative preferences and attitudes	***§6.2*** ***§6.4***
• variation by course of study: pupil opinion is generally substantially more negative for those studying fewer separate science subjects or the lower level curriculum – the subgroup taking all three separate science courses was the only group where a majority agreed: *"I like school science better than most other subjects"*	***§6.2*** ***§10***
Social, economic, domestic and school background	
• significance of the number of books at home: the only question in the survey related to individual circumstances was to estimate the number of books in the pupil's home - the answers given correlate, more strongly than any other indicator we have studied, to very significant differences in attitudes to and interests in	***§5*** ***§6.4*** ***§7.1***

science • limited relevance of school free meals indicator, or geographic area: overall interest in science seems little related to the social catchment of the school as reflected in the percentage of pupils eligible for free meals, and preliminary study reveal little difference between pupils in Glasgow and those in the Highlands • evidence of a 'class effect': some class groups responded much more positively (or negatively) than apparently similar classes in other schools - this might reflect the impact of a teacher, the school, or a particular peer group influence and is worthy of further study	***§13.1*** ***§13.3*** ***§13.1***
Attitudes to science, technology and the environment • doubt whether science is net beneficial: by a small majority, overall, pupils did not agree that "*the benefits of science are greater than the harmful effects it could have*" - the proportion agreeing with the statement varied between two-thirds and one-third for subgroups following different study routes • lack of trust in scientists: under 17% of pupils felt able to agree that "*we should always trust what scientists have to say*" – we regard this as perhaps the crucial obstacle for those seeking to enhance public understanding of science, and a wake-up call to the profession for scientific controversies to be debated in more carefully measured and objective terms • significance of environmental problems: there is a strong recognition of the importance of environmental threats, that addressing these is everyone's business and that actions required may involve *"big changes in our way of living"* • environmental sacrifices are for others: in juxtaposition to the last point, pupils would not support solutions involving *"sacrifice of many goods"* nor is there much interest in learning more about environmental issues, let alone in careers in this area • opposition to animal research: only 36% of pupils agreed that it was right to *"use animals in medical experiments if this can save humans"* and 72% think that animals should have the same rights as people	***§10*** ***§10*** ***§8*** ***§8*** ***§8***
Interest in learning about science • disappointing overall interest: asked about their interest in 'learning about' each of 108 topics covering a very wide range of applications of science, negative ('not interested') responses outnumbered positive reactions • topics with a personal or human interest dimension attract much more positive interest: seven of the 'top ten' most favoured topics concerned human health and condition, and the other three had dimensions related to potentially exciting personal experiences • space topics rated second in overall interest: here there were substantial differences with gender, course of study and the number of books at home – enthusiasm is higher in boys than girls, for pupils taking multiple science subjects or the higher level syllabuses, and for those with more books at home • topics rated as most uninteresting of all included the basis of manufacturing technologies such as detergents or crude oil, the lives of famous scientists, and anything to do with plants or cultivation methods	***§6.1*** ***§6.3*** ***§6.2*** ***§6.4*** ***Fig6.3*** ***§6.2***
Reactions to science at school • not engaging less able pupils: in general, conventional school science topics provide little motivational interest for pupils taking SG Science or Int1 courses • general low rating relative to other subjects: only for those studying the three sciences do a majority *"like school science better than most other subjects"* • impact of the scientific approach: only those studying three sciences, those taking	***§6.2*** ***§9***

physics and chemistry, and in the highest 'books at home' categories have majorities accepting that school science has taught them to think more critically	***§9***
• negative reaction to primary science: pupils rate primary school science as neither interesting nor a good preparation for secondary	***§9***
• support for more practical work: there was very strong support for the benefits of practical work, and a view that expanding practical programmes was likely to increase interest in school science	***§9***
Career ambitions	
• priority attached to job satisfaction: pupils as a whole ranked very highly the importance of a 'meaningful' job, in keeping with their attitudes, making use of their abilities, building their skills and with an element of autonomy – these factors were somewhat less stressed by those with fewest books at home or studying less demanding courses	***§7***
• importance of life outside of work: the only factor outweighing the above issues for almost all groups was making 'lots of money'; also of general high priority was that work should leave plenty of time to spend with family, friends and also on their hobbies and activities	***§7***
• low interest in STEM-based careers: huge overall majorities rejected the idea of becoming *"a scientist"* and girls were equally averse to *"a job in technology"* – for the first proposition only the three science group gave a net positive response and, for the second, only those taking physics plus chemistry	***§9***
• two distinctive factors for boys with fewest books at home: this group ranked *"becoming the boss"* and *"working with machines or tools"* substantially more highly than pupils as a whole	***§7***
Out of school experiences and activities	
• popular activities using modern technology: almost all pupils regularly use mobile phones, play computer games, access the internet, download music, use a word processor and send email - boys are relatively more involved with computer games and girls with mobile phones	***§11***
• practical creative activities: boys more often engage in mechanical pursuits whereas girls engage relatively more with crafts and the natural world	***§11***
• science centres: 82.4% of pupils indicated that they had visited a science centre once or more often; 89.8% of pupils surveyed had visited a zoo	***§11***

THE WAY FORWARD

1. **Messages for curriculum designers**: We believe there are significant messages in the data that could usefully inform reviews of science and technology curricula. Some of these are discernable from the analysis in the Report, but to derive the full potential benefits, significantly deeper and more detailed analysis would be required.	***§16*** ***§6.5***
2. **Further analysis of the data for each school**: We have aggregated the data for each participating school, and each of the supervising teachers has filled in a separately designed questionnaire. Our findings show evidence for significant 'class group effects'. The teacher survey has yet to be analysed, and useful further insights may be gained on integrating its information with the analysis by class group.	***§13.4***

3. **Messages for 'Science & Society' strategy development**: The ROSE evidence could be intelligently used to influence strategy and planning by the wide range of organisations dedicated to the promotion of appreciation and understanding of science. This survey can provide starting evidence and ideas, which in general would probably need to be followed up with smaller scale and more narrowly focussed surveys, covering, inter alia, a wider age range.	***§16***
4. **Strategies to engage those currently alienated:** This can be pursued at various levels. We have looked briefly at different ways of grouping pupils to help inform such strategies and believe that further work along these lines could be useful.	***§14*** ***§16***
5. **Devising approaches to challenge negative attitudes to science:** Some issues that many believe are important to economic and social development attract substantial public hostility, and these also tend to be areas which pupils are intensely uninterested in learning about. We suggest that there may be ways to approach such issues, using topics viewed as much more attractive to introduce them.	***§13.4***

1. Introduction

1.1 Context

In September 2005 two of us (MF & AR) were co-authors of a Report titled *Science Education for the Future* which summarised conclusions from a study of what university academics in Scotland believed was most important in the school education of pupils progressing to degree studies in science, technology, engineering and mathematics (STEM) discipline areas. That work was funded by the Scottish Executive Education Department and the Report can be read or downloaded from our website at http://www.gla.ac.uk/stem.

One of that Report's core recommendations was that it was important that the science curriculum, whilst aimed to build an understanding of core concepts and to develop key skills, should use applications geared to engage the interest and enthusiasm of school pupils. In this context it was recommended that the international ROSE survey should be used in Scotland to throw light on pupils' interests in and attitudes to science, and thus to help inform how a revised curriculum might most productively be contextualised. Subsequently, we were commissioned by the Scottish Executive ETLLD to carry out this survey and to provide this initial Report.

1.2 International School Questionnaires – PISA, TIMSS & ROSE

Two other large scale international surveys have been carried out in recent years concerned with school science and mathematics: these measure pupil achievement rather than attitudes and interests.

PISA, the Programme for International Pupil Assessment, is an internationally standardised assessment that was jointly developed by participating countries and administered to 15-year-olds in schools to assess how far pupils near the end of compulsory education have acquired some of the knowledge and skills that are essential for full participation in society. In all cycles, the domains of reading, mathematical and scientific literacy are covered not merely in terms of mastery of the school curriculum, but in terms of important knowledge and skills needed in adult life. 41 countries participated in the 2003 survey and 58 will participate in 2006. Scotland took part in PISA 2003 as an independent National Centre and their results are reported in an annex to the international report.

TIMSS, the Trends in Mathematics and Science Study, is a project of the International Association for the Evaluation of Educational Achievement and in 2003 this assessed mathematics and science achievement among a sample of pupils aged 9 and 13 in over 50 countries worldwide. Scotland also participated in this survey.

The focus of the ROSE (The Relevance of Science Education) project, on the other hand, is on pupils' attitudes, interests and out-of-school experiences that seem relevant to the study in school of science and technology. ROSE is an international comparative research project[1] based at the University of Oslo under the direction of Professor Svein Sjoberg.

Over 40 countries have implemented the ROSE questionnaire, including England and Northern Ireland, but Scotland did not originally participate. When the "A Curriculum for Excellence" was published in November 2004, with a radical thrust very much consistent with the specific strategy for STEM subjects that had emerged from our own publication, it was thought that the time was right to ask

[1] Project Report and details are available at http://www.ils.uio.no/forskning/rose/

pupils what they thought about their science lessons in school and what their attitudes to science topics outside school were.

We wanted to discover what their interests in science were and what could motivate them to become more involved in science topics. In common with most developed countries, in Scotland pupils are turning away from wishing to study core STEM subjects at university, or to pursue technical career paths through industry.

Professor Sjoberg authorised us to use the ROSE Questionnaire and our data and results will be made available for inclusion in the wider international research effort.

1.3 Structure of the ROSE Questionnaire

The international questionnaire contains nine sections. Individual participating countries are allowed to add country specific questions, an option we took advantage of by adding a short tenth section designed to find out how pupils felt about their educational experience of science as taught in school. Almost all questions in the survey ask pupils to react to particular statements or topics by responding on a four-point 'Likert' scale, signalling their level of agreement/disagreement or interest/disinterest. The questionnaire as implemented is reproduced in Appendix 2.

At the front end of the questionnaire pupils are asked to identify their gender and age, and to name the science subject or subjects they are studying, and the course level. There is also a pre-completed identifier coding for the school concerned. The socio-economic background of the pupils was investigated by a single question, placed near the end of the questionnaire as **Section J**, about the number of books in their homes. This question was also used in the PISA 2000 study and is regarded internationally as a reasonably reliable proxy indicator of socioeconomic status.

Sections A, C and E consist of a total of 108 items, on 'What I want to learn about'. Respondents are invited to respond using the 4-point Likert scale from 'Not interested' to 'Very interested'. The underlying structure of this pool of items was designed by the questionnaire originators to reflect both content and context. The lists below are as described by Camilla Schreiner[1]. It is stressed that the content areas are not mutually inclusive, nor are they comprehensive or equally represented in the survey. The list of contexts was influenced by several factors that include insights from the sociological literature relating to youth culture, research in science education and the views of pupils and teachers expressed during early stages of developing the questionnaire.

Content areas

- astrophysics, the universe
- earth/geo-science
- human biology
- zoology, animals
- botany, plants
- chemicals
- light, colours and radiation
- sounds
- energy and electricity
- technology

Range of Contexts

- environmental protection
- practical use, everyday relevance
- 'hullaballoo', spectacular phenomena, horror
- human biology — health
  - — fitness
  - — issues of particular relevance for youth
- mystery, philosophy, wonder, quasi-science, beliefs,
- beauty, aesthetic aspects
- science, technology and society, nature of science, etc

[1] Exploring a ROSE-garden: Norwegian youth's orientations towards science- seen as signs of late modern identities: C Schreiner (2006) doctoral thesis, University of Oslo, Faculty of Education, Oslo, pp87-91

It seems to us that there are a number of ways in which the 108 items can be classified, and different classifications may be helpful in seeking to derive insights from the pupil returns. Part of our own preliminary study, described in Sec 10 below, categorises the questions alternatively as follows:

Content domain	**Number of questions**
Earth science	11
Physical science	11
Biological science	23
Space	9
Technology	16
Human focus	30
The nature of science	8

Section B (26 items) invites pupils to indicate the importance they attach to a number of issues for their potential future occupation or job. The scale ranged from 'Not important' to 'Very important'.

Section D (18 items) relates to the environment. Respondents are invited to indicate the extent to which they agree or disagree with a series of statements about the environment.

Sections F (16 items) and **K** (9 items) are concerned with pupils' views about their school science education. The former section is that used internationally, and we decided to supplement that with some specific items felt relevant to the current Scottish context, and also with a separate short survey completed by the class teacher (see Appendix 1)

Section G (16 items) invites pupils to indicate their degree of agreement with a series of statements about science and technology. The intention is to probe how pupils perceive the role and significance of science and technology in society. There are close parallels between some of the items in this Section and those used in the 'Eurobarometer' survey, and in a survey by the National Science and Engineering Board in the USA.

Section H (61 items) explores pupils' out-of-school experiences/activities. As might be anticipated from a world-wide study, the range of activities/experiences that were viewed as potentially relevant in influencing a pupil's interests in science and technology is very diverse.

Section I (1 question) involves the only open-ended question in the ROSE study. It invites pupils to imagine that they are 'grown up and work as a scientist'. . 'free to do research (they) find important and interesting'. They are then asked to write a little about what they would do and why. The international recommendation is to analyse responses with the aid of a coding system that was developed for this purpose. The coding reflects the topic chosen by the pupil (e.g., gene technology, psychology, space) and the reasons given for the choice (e.g., help people, get rich, become famous). In this preliminary project time only allowed us to undertake a very superficial an analysis.

1.4 Deploying the ROSE questionnaire in Scotland

Guidance on organising and conducting the ROSE study was provided by Schreiner and Sjoberg in a *Handbook*[2] for participants. The text below is based on the relevant sections which set out more fully the procedures summarised here.

Participating countries were allowed to add a number of 'background' questions relating, for example, to region, school district, family background or school type. It was also possible to add other country specific items relating to one or more sections of the questionnaire.

In each participating country, the ROSE sample was drawn from a defined target population and the sampling unit was a school class group, rather than randomly selected individuals.

Pilot testing of the ROSE questionnaire, in Norway, suggested that it could be completed in about 40 minutes, i.e., within the time available in most school lessons. However, no time limit was set for the completion of the questionnaire which, it was suggested, should be presented by the normal class teacher. There was no bar to explaining to pupils any question that they found difficult to understand. It was emphasised to pupils that the ROSE questionnaire was not a test and that all returns were anonymous.

Several encouraging comments on the questionnaires were returned to us from the class teachers in Scotland. Some said that it had stimulated class discussion and several said that they hoped that the results from the questionnaire would be put to good use to influence the design of an improved curriculum. A few, mainly overseeing Access / Intermediate 1 classes, reported that their pupils could not complete the survey in the time and that several had found it too long and rather tedious. As the questionnaire has over 250 questions in it this is not entirely surprising, though it was reassuring that this seemed to be a reaction from a small minority of classes, and that we received quite usable responses from the majority of pupils even in these cases.

2. Nature and Distribution of the Survey Sample

2.1 The target pupil population and their studies in science

Schooling in Scotland starts at age 5. The first 7 years are spent in Primary education, followed by up to 6 years in Secondary schools. Primary teachers are mainly generalists, teaching the whole curriculum for a particular year group, whilst in Secondary subject classes are taught by specialist teachers. The curriculum for the first nine years of education is organised under a number of themes through a progression of six levels, labelled A to F. One of these themes is titled Environmental Studies, and this embeds Science as one of its three major strands. Throughout these 9 years all pupils follow the same curriculum, though there will be individual differences in progression through the levels.

---

[2] Schreiner, Camilla & Sjøberg, Svein (2004). *Sowing the seeds of ROSE. Background, Rationale, Questionnaire Development and Data Collection for ROSE (The Relevance of Science Education) - a comparative study of pupils' views of science and science education (pdf)* (Acta Didactica 4/2004). Oslo: Dept. of Teacher Education and School Development, University of Oslo. (Appendix B, also called the *ROSE handbook*).

Our survey has been directed towards pupils in their third year of Secondary (S3) which is the first year of study where pupils take different subject combinations dependent on choice and ability. Subject courses from this point on are in general offered at two different levels of difficulty. Courses at this stage are designed to be taught over 2 years, and are subject to nationally set examinations taken towards the end of the S4 year. Most schools follow long established 'Standard Grade' courses (SG), with the more demanding curricula examined at levels labelled 'Credit / General', with the lower level curricula at 'Foundation / General'. There are four different subject courses in science: specialist Physics, Chemistry and Biology courses are offered, though only at Credit / General level, alongside a multi-disciplinary 'Science' course, with almost all of its pupils following the lower level Foundation / General track.

In the 1999/2000 year new curricula were launched in Scotland primarily for the S5 and S6 years, with S5 subject courses provided at three levels, Intermediate 1 (Int1), Intermediate 2 (Int2) and Higher. The lowest of these, Int1, was targeted at an achievement level comparable to 'General', whilst the Int2 course paralleled 'Credit'. The Higher course advances beyond Credit with an examination set at what is recognised as the standard university entrance level for Scotland. In a significant minority of schools the more recently designed Int1 and Int2 courses have been adopted in place of Standard Grade for teaching science subjects over S3 and S4. These courses are only available in the specialist subjects, namely Physics, Chemistry and Biology.

Almost all pupils in Scotland take at least one science course over the S3 and S4 years. Approximately 26.5% take two science subjects, and a small fraction, around 3.3%, take three[3]. Our survey collects information from each pupil on their choices, and on the level of curriculum being followed.

Pupils were surveyed half way through their S3 year. Their subject selection at this point should be expected to reflect their progress and interests towards the end of their previous nine years under a common curriculum. Whilst their experience of their S3 courses may well have further influenced their views, it is important when analysing responses to the survey to bear in mind that their move into a diverse range of selected subject curricula was relatively recent.

2.2 Approach and overall sample size

Our initial minimum intention was to aim for a sample cohort of at least 1300 well-completed survey responses. We sought to recruit participating schools and to ask each school if possible to survey two S3 class groups, ideally representing groups taking different science subjects and / or following science curricula pitched at different ability levels.

In many cases contact was initiated through direct contact with interested teachers, many of whom had learned of the project through the ASE Scotland network. In many other cases contact was arranged through very helpful local authority education officers. We were greatly encouraged by the very positive response we experienced regarding participation, and by the very high proportion of pupil response forms that had clearly been quite earnestly completed. This has allowed us to collate over 2750 validated pupil responses.

The healthy size of our survey sample opens the potential to make meaningful analysis of the variation in pupil opinion:

- across class groups studying different science disciplines
- for those studying science curricula designed for different ability levels
- in schools with pupil populations differing in social background
- across different geographical regions and environments in Scotland

[3] SQA figures for 2006

With these factors in mind, and also mindful of the comprehensive '3 – 18' school curriculum review under way in Scotland, we planned to augment the data collected by:

- adding the short Section K of 9 items to the pupil survey, sampling opinions and preferences about the style and progression of the science education they have experienced
- adding a short additional survey to be completed by the teacher of the class, sampling their views of the state and context relating to science provision in their school (Appendix 1)

2.3 Sample characteristics

A total of 92 secondary schools participated in the survey, returning an average of 30 valid pupil responses per school. The schools were drawn from 31 of the 32 local authority areas in Scotland[4]. The great majority of Scotland's schools are government financed and are managed through local authorities, but there is also a small independent sector that provided 7 of the schools surveyed.

The remaining 85 schools are from the local authority sector (LA), approaching a quarter of the total of 392 LA secondary schools. These 85 schools account for 25.4% of the total pupil population of the LA sector.

We surveyed two S3 class groups in most participating schools. The total return collected amounts to just over 4% of the entire age group in Scotland's schools.

Other characteristics of the survey sample were as follows:

Gender Balance: 46.9% of pupils taking part in the questionnaire were boys and 53.1% were girls.

Age of participants: The vast majority of pupils were 14 years of age with 81.4% being this age. 12% were 13 years of age and 6% were 15 years old. A very few pupils were just 12 years old, because one school was piloting an accelerated programme and surveyed a class who were following the S3 curriculum a year earlier than elsewhere.

Qualifications being studied: Approximately two thirds of those surveyed were studying courses in the specialist science subjects at the higher academic level, with 58.2% taking the Standard Grade and 7.2% the Int2 versions. The remaining pupils were studying courses at the lower academic level, with 11% following Standard Grade Science and 23.6% taking a specialist science at Int1 level.

Number of science courses being taken: 7.4% of our pupils were taking three sciences at Standard Grade, 23.4% were taking two sciences at SG, and 40.4% were following a single science subject at this level. This compares with the national SQA figures for 2003 where 2.5% of the S4 cohort were taking three sciences, 24.5% were taking two sciences and 47.2% were following one science at this level. Our sample over-represents the small three science group, but is otherwise well balanced.

Social mix: The survey itself contains one measure of social significance at the individual pupil level, namely the pupil's estimate of the number of books in their home. We are unable to assess how representative the survey sample is of how the entire school population at S3 level might have responded to this question. On the other hand, in Scotland another measure has been widely

[4] The single local authority area not represented is the Orkney Islands, an omission partially compensated in that the neighbouring Shetland Islands were very strongly represented.

used to reflect the relative social prosperity of a school's population: this is the proportion of pupils eligible under government guidelines to receive free school meals. We have done some analysis of the schools sample for three different ranges for this statistic:

- band 1: under 10% of the school roll eligible for free meals
- band 2: 10% - 25% of the school roll eligible for free meals
- band 3: over 25% of the school roll eligible for free meals

Our sample includes: 37 schools in band 1 (24% of all Scottish schools in this band)
38 schools in band 2 (22% of all Scottish schools in this band)
10 schools in band 3 (16% of all Scottish schools in this band)

More detailed inspection shows that the subgroup of schools within each band is representative of the range of meals eligibility for all schools in the same band.

2.4 Regional distribution of survey sample

Local Authority Area	Total of school rolls S1-S6	Total no Surveyed (S3)	Percent of total school nos in sample	Total no surveyed (S3) incl. indep. sch.
Aberdeen City	10265	100	0.97%	179
Aberdeenshire	15492	175	1.13%	175
Angus	6909	90	1.30%	90
Argyll & Bute	5567	26	0.47%	26
Clackmannanshire	2924	23	0.79%	51
Dumfries & Galloway	9379	29	0.31%	29
Dundee City	8185	94	1.15%	94
East Ayrshire	7862	29	0.37%	29
East Dunbartonshire	8413	182	2.16%	182
East Lothian	5541	88	1.59%	88
East Renfrewshire	7400	35	0.47%	35
Edinburgh, City of	19351	186	0.96%	217
Eilean Siar	1887	39	2.07%	39
Falkirk	8856	32	0.36%	32
Fife	21796	62	0.28%	62
Glasgow City	28960	269	0.93%	304
Highland	14575	152	1.04%	152
Inverclyde	5348	22	0.41%	51
Midlothian	5315	33	0.62%	33
Moray	5843	30	0.51%	30
North Ayrshire	8784	90	1.03%	90
North Lanarkshire	21352	21	0.10%	21
Orkney Islands	1422	0	0.00%	0
Perth & Kinross	7649	21	0.28%	52
Renfrewshire	11211	96	0.86%	96
Scottish Borders	6868	43	0.63%	43
Shetland Islands	1664	78	4.69%	78
South Ayrshire	7130	199	2.79%	199
South Lanarkshire	19265	164	0.85%	164
Stirling	6044	8	0.13%	8
West Dunbartonshire	6149	56	0.91%	56
West Lothian	10319	54	0.52%	54
Totals	307725	2526	0.82%	2759

3. Validation and Processing of Returns

We had made arrangements to have the completed survey forms electronically scanned directly into a SPSS spreadsheet, so as to avoid manually inputting all of the data. A batch of 150 were in fact input by hand initially and this effort gave a "feel " for the expected results and what to look for in the way of scripts that may not have been treated seriously. All scripts were in fact eventually inspected quite closely to help speed up the scanning process and to avoid problems such as when chewing gum on a script gummed up the scanner and put it out of operation for over a week. Scripts where the response circles had been scored through had to be shaded so as to scan properly and a page location blob at the top of each sheet had to be inspected as this was sometimes shaded, again causing problems with the scanning.

A number of survey return forms were rejected, mainly due to inadequate completion. In several instances a pupil appeared to have missed out two pages (ca 30% of the full survey) by turning over two sheets at a time; if this happened the paper was rejected. If sections H, I, J and K were not reasonably fully completed, again the paper was rejected. Papers where the responses appeared chosen to present patterns on the page were also rejected. In all 140 papers were rejected, just under 5% of the total.

However we should note that papers where very many of the responses in Sections A, C and E selected the same left-most option, indicating extreme lack of interest in science topics, were **not** rejected, provided that a wider mix of responses had been selected for items in other sections of the survey. Originally we felt that such returns might represent a frivolous response, but our subsequent judgment is that these responses seem to be from pupils who genuinely regard science as a deeply uninteresting subject. We then noted that those analyzing the Norwegian survey reached a similar conclusion. Reviewing responses to the section on "myself as a scientist" where the pupil was asked what they would like to research if they were a scientist reinforced our own conclusion. Several answered that they did not wish to be a scientist under any circumstances as they found the subject too 'boring'. This extreme negative response to sections A, C and E was provided in 2% of the returns.

The breakdown of the returns rejected by course of study is perhaps significant. The Reject rate is highest for the Intermediate1/Access category, then for the SG in Science followed by the Discrete Science Standard Grade.

Course level studied	Total	Rejects	Percentage
SG Credit	1622	47	2.9%
SG Foundation	347	27	7.8%
Intermediate 2	201	1	0.5%
Intermediate 1	727	65	8.9%
Total	2897	140	4.8%

The coding of the responses to the questionnaire was designed to be as straightforward as possible, with participating countries being given a detailed coding book. As a general rule, the actual position of a pupil's response to an item in the questionnaire was the value to be entered. Thus, a tick in the first box opposite each item was entered as '1', in the second box as '2' and so on. The following examples illustrate what this meant in practice.

Questions A01 to A48: stem question: 'What I want to learn about'
Measurement variable: ordinal
Value labels: 1 not interested, 2 low not interested, 3 low very interested, 4 very interested
Missing value: 9

Questions G01 to G16: heading: 'My opinions about science and technology'
Measurement variable: ordinal
Value labels: 1 disagree, 2 low disagree, 3 low agree, 4 high agree
Missing value: 9

Section I: the open ended response question: 'Myself as a Scientist'
Required a brief summary to be typed into the spreadsheet

Files prepared to accept data in the appropriate form, in SPSS and Excel formats, were provided by the project organisers in Oslo. The SPSS file was modified by us so that the results could be fed in direct from electronic scanning of the forms. The adopted format is such that it would be relatively easy to paste our data into the official ROSE spreadsheet.

3.1 A Secondary SPSS File – Aggregated Results at School Level

Each return includes a field identifying the respondent's school. Having entered the source data into the SPSS statistical analysis package, we have also been able to produce a secondary file that provides an aggregated return for each school. For the LA schools we have been able to add some further information from published sources. This includes a measure of the size of the school (its total pupil roll in the current year) and the free school meals eligibility indicator of the social mix that the school caters for.

Details are carried through to this file of the gender balance in each school sub-group, and of the range of responses given to the Section J question on the number of books at home.

Beyond these measures the data for each school gives the mean Likert score for returns to each of the 254 questions in Sections A-H, and in our added Section K. Where a school has surveyed class groups studying at the two academic levels commonly offered in S3 and S4, two separate records are included, one for the group at each level. The number of pupils in each group is also included.

The additional Teacher Survey (Appendix 1) provides further data that could usefully be integrated with this analysis by school. We were unable to tackle this task within the initial review pursued for this Report.

4. Interpreting the Likert Scoring System

In a preliminary study it is convenient mostly to review the 'mean Likert score' for an item or a group as a single measure of responses. The four point scale gives information on both the direction and the intensity of each pupil's view. If one is looking for policy responses that might better engage pupils' interest, or seek to challenge their opinions, it is helpful to know not only the 'average response', but also how strongly views are held, and whether opinion is polarised. The volume of information at our disposal makes it impossible at this stage in general to explore the information in such detail.

Hence the 'mean Likert score' is the evidence most heavily referred to below. Preliminary analyses published internationally also refer mainly to these values. It is therefore important for the reader to appreciate the significance of the range of values that this quantity might take.

On the 4-point scale the lowest two values (1.0 and 2.0) represent negative responses, whilst the highest two values (3.0 and 4.0) are weak and strong positive responses. If opinion on an item is evenly divided, and if negative views are held as strongly or weakly as are positive views, then the mean Likert score will be 2.50. So values above 2.50 can be interpreted as 'net positive' and values below 2.50 as 'net negative.'

In a survey such as this it is common for most mean Likert scores to lie quite close to the central value of 2.5, and values above 3.0 or below 2.0 tend to occur relatively rarely. In most other surveys familiar to non specialists, questions of opinion tend to be asked on a 2-point scale: the respondent is asked whether they agree or disagree with a given view, or whether they support or oppose a particular policy direction. In these 'opinion poll' terms, the balance of opinion is judged on the relative scale of the majority attributed to the prevailing view.

We chose to analyse Sec G in this manner. Individual Likert scores of 3 or 4 were counted as representing 'agreement', and scores of 1 and 2 as 'disagreement.' Figure 4.1 compares the 'percent agreeing' and the 'mean Likert score' for each of the Sec G items.

A difference of 0.10 in the mean Likert score for an item corresponds approximately to a 10% change in the margin of the 'majority vote', for or against the proposition concerned. We think this plot is representative of the survey as a whole.

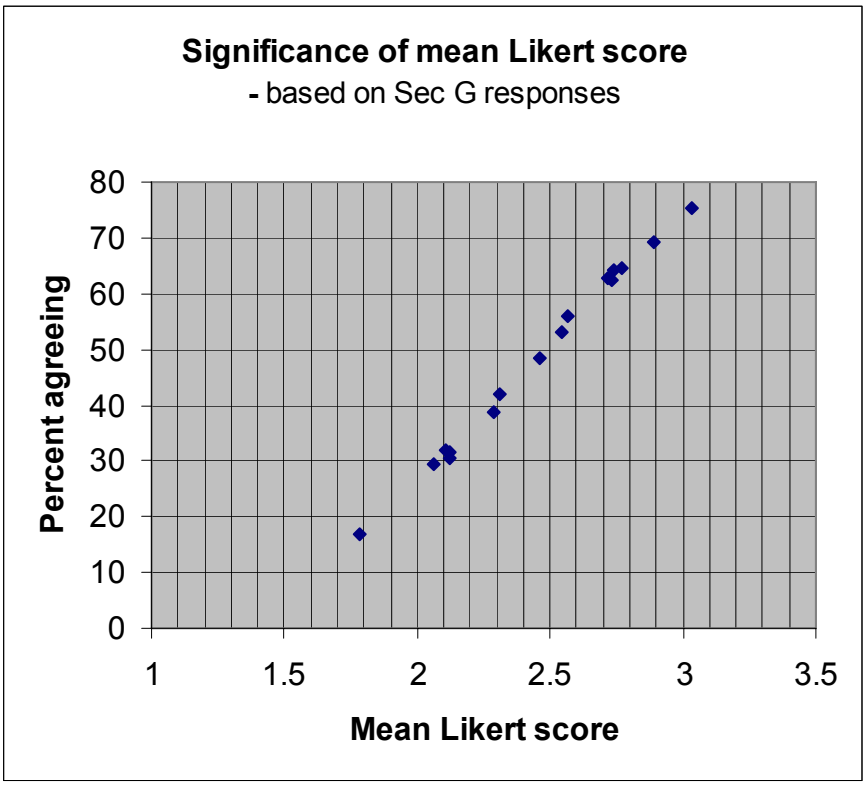


Figure 4.1 mean Likert score versus percent agreeing (from Sec G)

5 Review of Responses - Section J: "How Many Books are in your Home?"

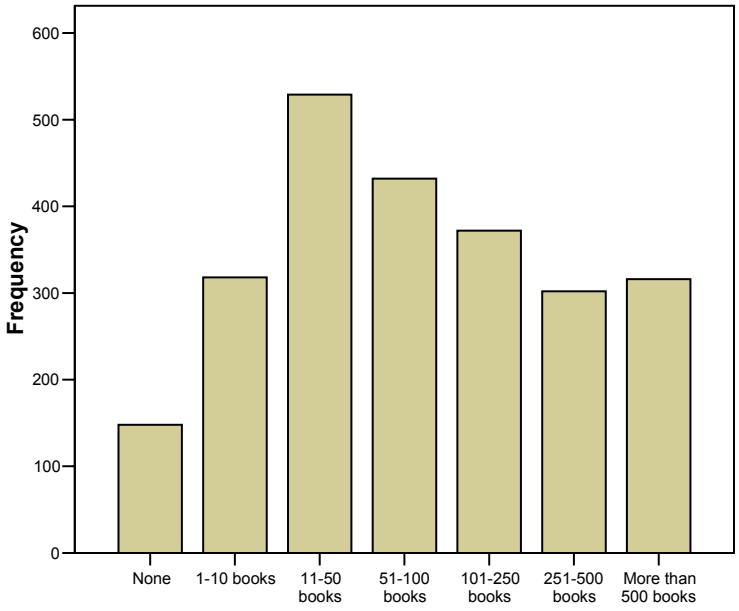
We review the responses to this question first for it turns out to correlate more strongly with differences in views and attitudes among pupils than does any other single factor considered. Its significance came to our attention repeatedly as we reviewed the survey responses.

There is strong research evidence of a relationship between educational achievement and the economic, social and cultural capital of a pupils' parents[5,6]. This has been explained on the basis that the parents of higher socio-economic status (SES) are more involved in the education of their children than parents with lower SES, and that they stimulate more positive attitudes and greater motivation to learn. Given that quite diverse countries are participants in the ROSE survey it was not easy to identify questions which were similarly applicable worldwide. It was decided to include just one question relating to this factor. The selected question: "How many books are in your home?" had also been used, along with other socio-economic questions, in the PISA 2000 survey. The number of books in a household is regarded as an indicator of a household's SES and a correlation between number of books in the home and reading literacy in the G8 countries has been found[7].

In our survey a little over 6% of pupils reported that there were no books at all in their homes, whilst 13% estimated that there were over 500. The full distribution of responses is shown in Fig 5.1.

The standard indicator used in Scotland to reflect the social and economic catchment of a school is the percentage of pupils entitled to free school meals. The 'meals' indicator reflects the average economic background of pupils across the whole school rather than for the particular class groups responding to the survey; however class groups should on average be representative of their schools, so if a strong correlation existed between social & economic background and attitudes to science we would expect this to show through.

Fig 5.1 How many books are in your home?



In Sec 13 of this Report we find that the free school meals indicator seems to have surprisingly little bearing on the average level of pupil interest in science On the other hand there is a significant correlation between a 'mean book score' for a class, and the level of interest in science. We are left to speculate that the 'books' measure may have additional significance beyond being a measure of household SES; perhaps it may more specifically capture something of the family ethos, reflecting general interest and inquisitiveness in relation to the wider world?

---

[5] Ho Sui-Chu and Williams, Effects of Parental Involvement on 8th Grade Achievement: *Sociology of Education, 69, pp106-141*

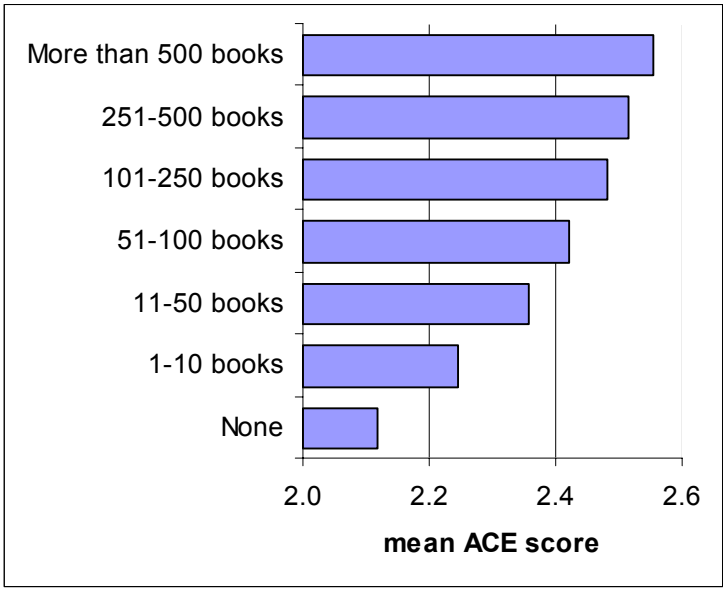
[6] Socio-economic status relates to "an individual's or group's position within a hierarchical social structure." It "depends on a combination of variables, including occupation, education, income, wealth, and place of residence. Sociologists often use socioeconomic status as a means of predicting behaviour." *New Dictionary of Cultural Literacy, 3rd Edition. 2002.*

[7] Comparative Indicators of Education in the United States and Other G8 Countries:2004:. *Anindita Sen, Lisette A. Partelow,David C. Miller. U.S. Department of Education, Institute of Education Sciences. NCES 2005-021.*

To demonstrate our point, in survey Sections A, C & E, pupils are asked to indicate their level of interest in learning about each of 108 specific topics involving science. The average score from their responses to these items gives a crude overall measure of their level of interest in science. Fig 5.2 shows that, when these scores are in turn averaged for all pupils who gave the same estimate for the number of books at home, greater interest is expressed by those reporting higher numbers.

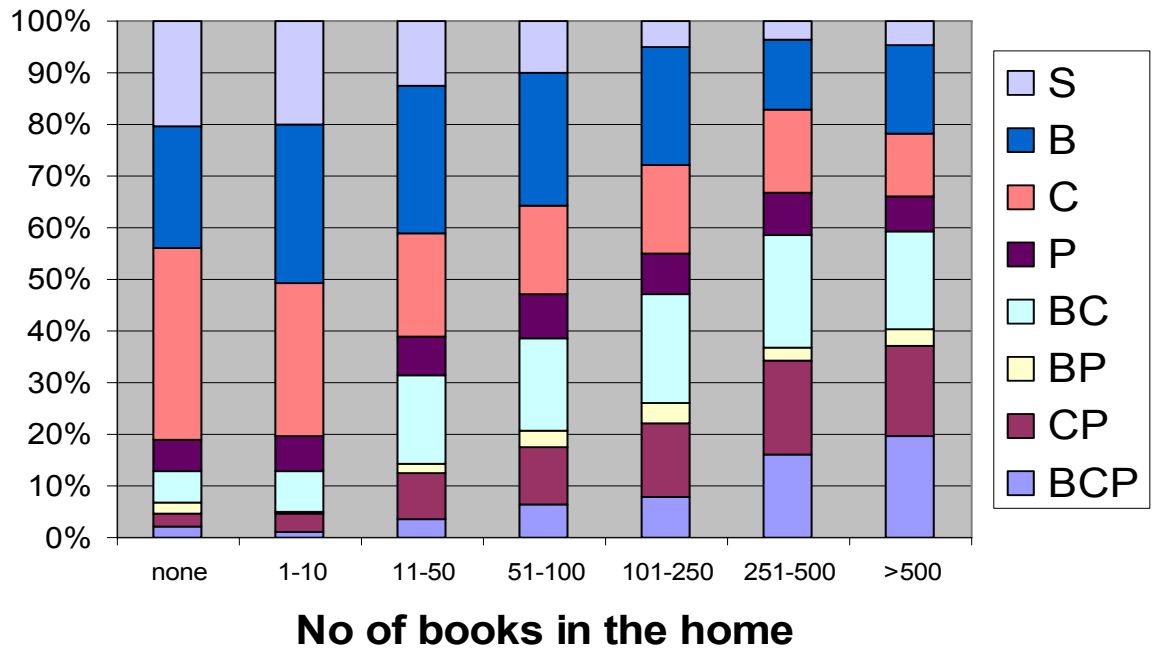
All but the top two groups are 'net negative' (the 'neutral' score is 2.50). The bottom group's score (2.12) reflects a strongly expressed lack of interest in learning about science.

Fig 5.2 Mean ACE score vs no of books at home



A parallel trend is found in responses to Section G, on the perceived importance and value of science and technology for society (see Sec 10 below). In reporting on the ROSE survey in England E.W. Jenkins[8] demonstrated a similar conclusion on the strong correlation between interest in science and the books indicator, based on responses in Section F.

Fig 5.3 Subjects studied vs no of books



Subject labels: B = biology, C = chemistry, P = physics, S = science

[8] Jenkins& Pell (2006) The Relevance of Science Education Project in England: a summary of findings, University of Leeds p38.

Answers given to the books question also correlate strongly with the course progression which pupils have followed in science. Fig 5.3 above shows the percentage of those in each book group category taking each subject combination.

Comparing the extreme categories, pupils reporting that there are no books at home and those reporting over 500 books, the former is 10 times less more likely to be studying three sciences and 4.5 times more likely to be studying the SG science course. More generally, the proportion studying two or three sciences increases at every step up between book categories (and by a factor of five overall). Conversely, the proportion taking the single science of biology or chemistry or SG science decreases as the number of books in the home increases. The proportion taking physics alone, on the other hand, appears to be almost independent of books in the home. (The single subject groups in biology, chemistry or physics in Fig 5.3 include both those taking the relevant SG or Int2 courses and those following the lower level Int1 course. The Int1 pupils account for 51% of the single subject chemistry group, 36% of the biology group, and 16% of the physics group. Those with fewer books are relatively more heavily represented in the Int1 numbers.)

6 Review of Responses - Sections A, C & E: "What I want to learn about"

Sections A, C and E amount effectively to a single extended section of 108 questions. Each asks: 'How interested are you in learning about' a particular topic. There is a great deal of quite complicated information embedded in the responses. Here we review only some necessarily preliminary studies.

In addition to the aspects discussed below there is discussion in Sec 13 on how responses varied in different schools and regions, and in Sec 15 on how responses in Scotland compare internationally.

6.1 General distribution of the responses

The mean Likert score, averaged over all 108 topics and all 2760 pupils, was 2.40. This is a net negative response, indicating approximately a 55 : 45 preponderance of 'not interested' over 'interested' responses.

Pupils differed greatly in their overall level of interest. Fig 6.1 shows the distribution of the mean scores for each pupil, together with the standard deviation of each pupil's scores across the 108 items.

One pupil responded '1' (viz strong disinterest) for every topic. At the other extreme one pupil's mean was 3.9, implying a great preponderance of '4' responses. The figure shows, however, that the vast majority of pupils spread their responses much more widely. The quite high standard deviations values in general signal that the full range of responses was used by most individuals.
In terms of the mean scores, it is clear that there is a very wide variation in the overall interest levels of different pupils.

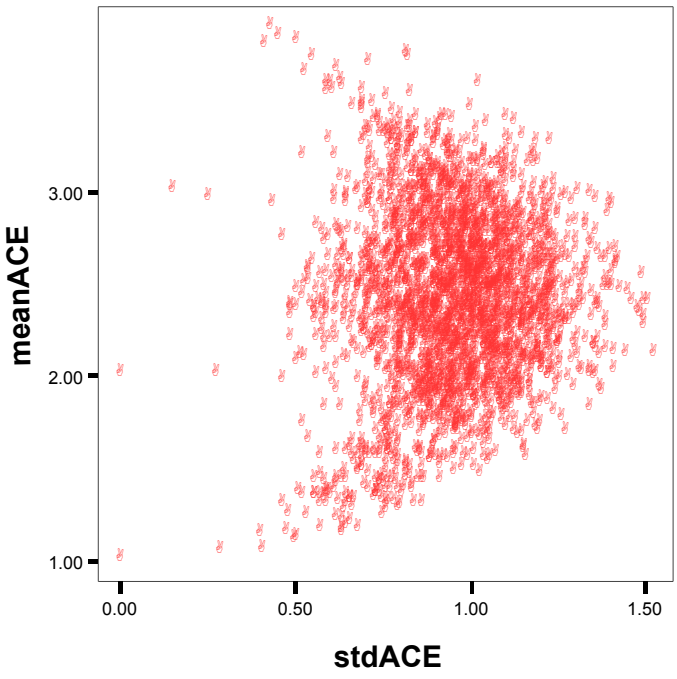


Fig 6.1 Scatterplot of mean and standard deviation scores in Secs A, C & E for each pupil

6.2 Relative popularity of different categories of topics

As reported in Sec 1.3 above, the 108 topics have been classified by their Norwegian originators[9] under various headings describing content and context. Many topics map to two or three such categories. We believe there are a number of ways in which items could in principle be grouped, and for our immediate purposes in this section we have created seven groups, each representing a particular content domain, as in Table 6.1 on the next page.

[9] Exploring a ROSE-garden: Norwegian youth's orientations towards science - seen as signs of late modern identities: C Schreiner, doctoral thesis, 2006, University of Oslo, Faculty of Education, Department of Teacher Education and School Development ,

Content domain	Selected questions
Earth science	A(3, 4, 5, 6, 14, 24,23 25), C18, E(19, 33)
Physical science	A(2,17,19,21,31,36,43), C17, E(2,26,27)
Biological science	A(7,8,9,10,11,12,13,15,20,27,28,32,), E(1,16,17,18,22,23,24,25,31,32,35)
Space	A(1,22,34,35,44), C(8,10,16) , E29
Technology	A(30,45,46,47,48), C(1,2,3,4,5,6,7), E(14,20,21,28).
Human focus	A(16,18,26,29,33,37,38,39,40,41,42) C(9,11,12,13,14,15), E(3,4,5,6,7,8,9,10, 11,12,13,15,30)
The nature of science	E(34,36,37,38,39,40,41,42)

Table 6.1: Seven content 'domains' for the '*what I want to learn about*' questions

In devising this structure there were a few questions which might have occupied more than one domain. We selected the most appropriate domain in such cases, for example question A48 on how a nuclear power station functions, was placed in an applied science (Technology) domain. It is appreciated that such domains have been imposed on the data to facilitate the interrogation of a large number of data points. The chosen content domains have different numbers of questions in total.

The overall mean and standard deviation scores for these content domains is presented in Table 6.2.

Domain	N	Mean	Std Dev
Space	2756	2.51	0.74
Technology	2756	2.32	0.65
Physical sciences	2756	2.28	0.54
Biological sciences	2756	2.38	0.51
Human focus	2756	2.55	0.53
Nature of science	2756	2.21	0.77
Earth science	2756	2.28	0.56

Table 6.2: Whole population mean scores

It appears that space, biological science and human focus issues are at the forefront of pupil preferences for learning in science. However, apart from the Human Focus sciences domain, all mean values fall beneath the 2.5 (choice neutral) value. Might this be an indication that the content of school science is not particularly motivating to this cohort?

Gender differences

A closer analysis of these results by gender reveals a distinct difference between male and female responses. Males, see Table 6.3, show a much flatter mean response than is evident in the female cohort.

	N (female)	Mean score	Std Dev		N (male)	Mean score	Std Dev
Space	1449	2.40	.73		1282	2.64	.72
Technology	1449	2.12	.59		1282	2.55	.64
Physical science	1449	2.24	.55		1282	2.33	.52
Biological science	1449	2.42	.51		1282	2.34	.50
Human focus	1449	2.65	.52		1282	2.45	.51
Nature of science	1449	2.09	.76		1282	2.34	.75
Earth science	1449	2.24	.56		1282	2.34	.54

Table 6.3: Gender differences in mean scores

Table 6.3 indicates significant gender differences in relative preferences for different categories of topic. Males show a greater preference for studying space and technology topics, with mean values above the 2.5 value. Females show a preference for studying topics with a 'human focus', mean 2.65, whilst not being well disposed to any of the other domains, and particular not to the nature of science or to technology. These results seem to reflect the gender differences in subject choice post-16 sciences with girls generally preferring to follow the human/bio sciences and boys the more technological. However there seems to be a unanimous rejection of those topics which have been grouped within the 'physical science' domain.

Differences by 'qualifications' variable

The cohort included pupils who were following Standard Grade courses (SG), Intermediate 1 courses (Int1) and Intermediate 2 courses (Int2). Table 6.4 shows mean scores for the seven topic domains by these three 'qualifications' variables and also for pupils taking SG in discrete sciences.

	SG B,C,P,S N=1905	Int1 Mean N=651	Int2 Mean N=200	SG. B,C,P N=1602
Space	2.55	2.32	2.72	2.61
Technology	2.34	2.24	2.40	2.37
Physical science	2.30	2.23	2.26	2.32
Biological science	2.41	2.27	2.49	2.44
Human focus	2.60	2.41	2.63	2.64
Nature of science	2.24	2.01	2.55	2.28
Earth science	2.31	2.16	2.43	2.35

Table 6.4: Mean scores analysed by target qualification variable

Notable differences are the lower mean values for Int1 respondents across all categories. It seems that pupils following an Int1 course are not particularly motivated by science topics. The Int2 group is significantly the most positive of the three; their response to the 'nature of science' domain is strikingly more positive than for either of the other two groups, and this finding might bear further examination in terms of curriculum differences compared to SG. However, we note that the Int2 group includes 76 who are taking the three sciences and the three science group are notably more positive in their views on science topics. The average Likert score for the whole ACE section is 2.65 for 3 science SG pupils and is 2.64 for those taking 3 sciences at Int 2. In this analysis the SG group includes pupils taking the Science course and the separate analysis below shows that this sub-group scores topics very similarly to the Int1 group. If the 'science' pupils are subtracted from the SG group, to leave just those taking the higher level routes in the separate science disciplines, the lag in scores relative to the Int2 pupils still persists, but is reduced overall by just over a third.

Figure 6.2 (overleaf) gives a graphical representation of the gender and qualification differences reported in tables 6.3 and 6.4

Differences by 'subjects studied' variable

Pupils were following a variety of science subjects, some taking only a single science and others studying two or three separate sciences. Tables 6.5 and 6.6 offer evidence that subject choices are related to the 'what I want to learn about' responses. This is only to be expected of course. However there are some surprises.

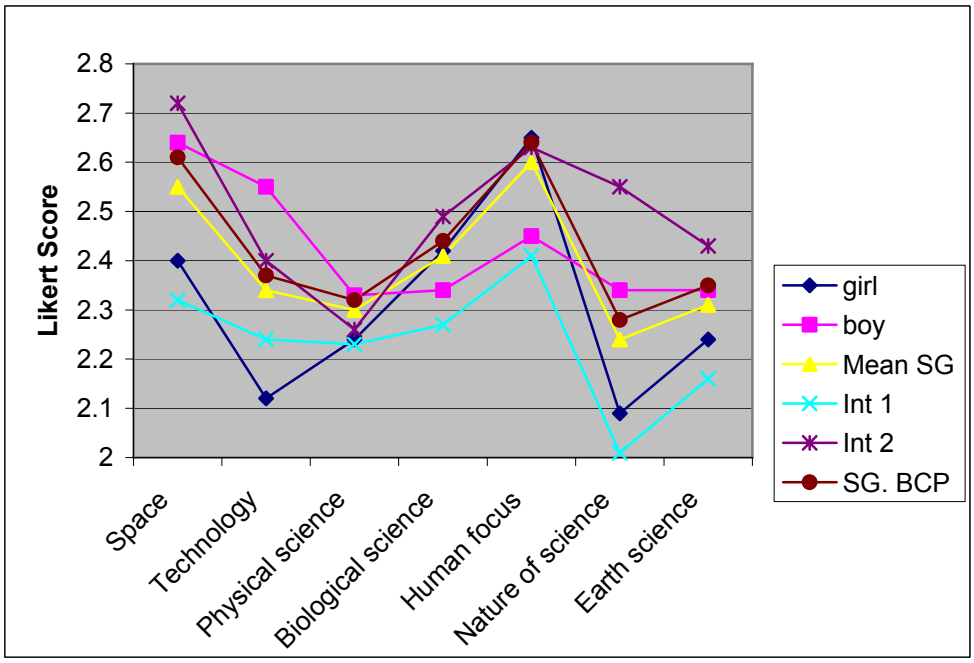


Fig 6.2 Graph of Likert score for ACE in different categories

	Physics only (N=199)	**Biology only (N=669)**	**Chemistry only (N=561)**	**Science only (N=303)**
	mean	**mean**	**mean**	**mean**
Space	2.73	2.32	2.39	2.23
Technology	2.50	2.13	2.29	2.20
Physical science	2.26	2.14	2.30	2.19
Biological science	2.21	2.35	2.29	2.25
Human issues	2.41	2.54	2.46	2.41
Nature of science	2.35	1.99	2.12	2.05
Earth science	2.30	2.19	2.22	2.11

Table 6.5: Mean scores for pupils following a single subject in science

The 'human issues' domain scores relatively (though not absolutely) well among all subject groups whereas the 'nature of science' and also 'earth science' score low for all groups. 'Space' appears to be the only domain with a mean significantly above the 2.5 neutral value, and that only for the physics group.

When pupils taking two or three subjects are considered, the picture changes a little.

	Phys + Chem (N = 302)	Phys + Biol (N = 61)	Chem + Biol (N = 451)	Phys + Chem + Biol (N = 205)
	mean	mean	mean	mean
Space	2.88	2.80	2.59	2.82
Technology	2.70	2.42	2.27	2.54
Physical science	2.47	2.25	2.33	2.43
Biological science	2.39	2.44	2.59	2.65
Human issues	2.57	2.64	2.72	2.78
Nature of science	2.57	2.26	2.25	2.56
Earth science	2.46	2.34	2.37	2.52

Table 6.6: Mean scores for pupils following two or three subjects in science

Table 6.6 shows higher mean scores for all domains, reflecting a more positive attitude towards the complete range of science topics. For the two science groupings, 'earth science' and 'physical science' domains are given uniformly net negative scores, lagging far behind the popularity of 'space' and 'human issues'. There is an encouraging island of interest in 'technology' (and less prominently in the 'nature of science' domain) from the 'Phys + Chem' group. The 'Chem+Biol' and 3-sciences groups are the only groups scoring net positively for the 'biological science' domain. The 3-sciences group, on average, score the highest of all subject groups. 'Space' and 'human issues' still feature most prominently. Only one domain is scored net negatively by this cohort but, worryingly, this is 'physical science.' In contrast, this is the most positive of all groups about the 'biological sciences' domain.

6.3 The most and least popular specific topics

In rank ordering the mean values of all section A, C and E questions it is interesting to note those questions which occupy the very extremes of this order. Tables 6.7 and 6.8 show this information.

Highest mean values			
Code	topic	mean	St.D
C13	Human: dreams and sleep	3.11	1.02
E08	Human: cancer, knowledge and treatment	3.10	0.98
A34	Space: experiencing weightless	3.09	1.03
A40	Human: exercise and fitness	2.99	0.99
A31	Physical Science: explosive chemicals	2.99	1.06
E10	Human: basic first aid	2.93	1.00
E12	Human: alcohol and tobacco	2.87	0.98
A27	Biology: brutal, dangerous and threatening animals	2.84	1.03
A33	Human: electric shocks and lightning	2.82	1.00
A37	Human: healthy eating	2.82	1.04
A29	Human: poisons and our body	2.82	1.01

Table 6.7: Questions which ranked with the highest mean scores

There is a clear message here concerning motivation towards issues relating to personal and human experiences. Apart from questions A31 'explosions', A34 'weightlessness' and A27 'threatening animals' the top scoring questions all relate to the human condition. (These three exceptions however do relate to potentially exciting personal experiences.) Learners are clearly motivated to learn about what might affect them personally. This message offers an interpretation of the often voiced call to make science 'relevant'. At age 13-15, learners' interests are weighted towards an egocentric preference.

In contrast to table 6.7, the lowest ranking questions in Table 6.8 show an absence of any human issues topics. In terms of our classification, there is no pattern to this set of questions. However, they all focus on objects and effects that are beyond 'self'. Six of the topics relate to plants and agriculture. Crude oil, telescopes, detergents and dead scientists appear also to have little immediate interest.

We examine on the next page how answers to the question on the 'number of books at home' affect the identification of the most and least popular topics, and in Sec 13 we look for school and geographic influences. Some international comparisons are made in Sec 14.

Lowest mean values			
Code	topic	mean	St.D
E01	Biology: patterns in flowers	1.50	0.77
C01	Technology: crude oil and plastics	1.76	0.87
E33	Earth Science: hazards of farming	1.76	0.88
A15	Biology: plant reproduction	1.77	0.86
E37	Nature of science: lives of famous scientists	1.80	0.94
E25	Biology: plants in my area	1.83	0.94
E17	Biology: improving harvests	1.91	0.93
E19	Earth Science: organic farming	1.92	0.98
E26	Physical science: detergents	1.94	0.92
A05	Earth science: weather	1.97	0.88
C02	Technology: optical instruments	2.02	0.95

Table 6.8: Questions which ranked with the lowest mean scores

6.4 Influence of the number of books in the home

It was decided to look at the 20 least and 20 most popular questions with the different groups characterised by the pupil's estimate of the number of books in their home, to look for similarities and differences in responses. The mean score on the Likert scale was again used to measure the degree of interest in a topic.

For the purpose of analysis all seven categories for the number of books at home were distinguished, and these groups were further sub-divided by gender. Because of our sample size this still gave reasonable numbers in all sub-groups.

As described above in Sec 5, overall mean Likert scores for the seven groups increased consistently with the number of books in the household. Between the first and last category there is an average difference of 0.44, a very substantial effect. This indicates that pupils from homes where there are many books have a greater interest in science topics but does not tell us here if they have a greater interest in science than other topics at school. We examine that point in Sec 9. The remaining question is whether the 'books' factor is associated with different judgements about which topics are most or least interesting.

For the current discussion we will concentrate on the two extremes of the sample better to identify similarities and differences. The groups looked at were those where pupils reported no books at home (Books Group 1) and those estimating that there were over 500 books (Books Group 7). This sort of study could help identify strategies better to engage pupils from different kinds of domestic backgrounds. The results for the 'top ten' and 'bottom ten' topics for each of these groups is presented in Tables 6.9 and 6.10 respectively.

Most popular topics

Table 6.7 listed the topics with the highest scores for pupils as a whole. There is no single topic in the top ten for all groups although several are mentioned in three categories. Both girls and boys in Group 1 (0 books) include 'dreams', 'cancer', 'exercise' and 'alcohol' from the overall list, with girls also embracing 'first aid' and boys 'dangerous animals'. The new topics introduced by girls in this group all reflect an interest in health and beauty at the expense of somewhat less personal more threatening phenomena. The boys' list, by contrast, shows relatively more preference for threats.

Item	TOP TEN: GIRLS with NO BOOKS at home	LS
A37	What to eat to keep healthy and fit	2.82
A40	How to exercise to keep the body fit and strong	2.80
E10	How to perform first-aid and use basic medical equipment	2.74
E12	How alcohol and tobacco might affect the body	2.74
E08	Cancer, what we know and how we can treat it	2.67
C13	Why we dream while we are sleeping, and what dreams mean	2.63
A31	Explosive chemicals	2.60
E23	How my body grows and matures	2.56
E11	What we know about HIV/AIDS and how to control it	2.53
A39	The ability of lotions and creams to keep the skin young	2.52

Item	TOP TEN: GIRLS with >500 BOOKS at home	LS
C13	Why we dream while we are sleeping, and what dreams mean	3.50
E08	Cancer, what we know and how we can treat it	3.40
A34	How it feels to be weightless in space	3.33
E10	How to perform first-aid and use basic medical equipment	3.21
A29	Deadly poisons and what they do to the human body	3.13
C08	The possibility of life outside earth	3.11
E16	How to protect endangered species of animals	3.11
C15	Thought transference, mind-reading, sixth sense, intuition, etc.	3.10
C11	Life and death and the human soul	3.10
E42	Phenomena that scientists still cannot explain	3.09

Item	TOP TEN: BOYS with NO BOOKS at home	LS
A31	Explosive chemicals	3.18
A09	Sex and reproduction	3.17
A34	How it feels to be weightless in space	2.82
A40	How to exercise to keep the body fit and strong	2.80
C13	Why we dream while we are sleeping, and what dreams mean	2.77
E08	Cancer, what we know and how we can treat it	2.77
A32	Biological and chemical weapons and what they do to the body	2.76
A27	Brutal, dangerous and threatening animals	2.67
E12	How alcohol and tobacco might affect the body	2.67
E09	Sexually transmitted diseases and how to be protected	2.67

Item	TOP TEN: BOYS with >500 BOOKS at home	LS
A31	Explosive chemicals	3.49
A34	How it feels to be weightless in space	3.39
A33	The effect of electric shocks and lightning on the body	3.29
A32	Biological and chemical weapons and what they do to the body	3.29
A30	How the atom bomb functions	3.25
C08	The possibility of life outside earth	3.19
A22	Black holes, supernovas and other objects in space	3.16
A29	Deadly poisons and what they do to the human body	3.13
A23	How meteors or asteroids may cause disasters on earth	3.11
A27	Brutal, dangerous and threatening animals	3.09

Table 6.9: The 'top ten' topics, by gender, for groups reporting 'No books at home' and 'More than 500 books at home'

Item	BOTTOM TEN: GIRLS with NO BOOKS at home	LS
C01	How crude oil is converted to other materials, like plastics and textiles	1.35
A22	Black holes, supernovas and other objects in space	1.42
A03	The inside of the earth	1.48
E19	Organic farming without use of pesticides and fertilisers	1.48
E37	Famous scientists and their lives	1.51
C02	Optical instruments and how they work	1.54
A45	The use of satellites for communication and other purposes	1.56
A04	How mountains, rivers and oceans develop and change	1.56
E33	Benefits and possible hazards of modern methods of farming	1.57
E25	Plants in my area	1.58

Item	BOTTOM TEN: GIRLS with >500 BOOKS at home	LS
E01	Symmetries and patterns in leaves and flowers	1.74
C01	How crude oil is converted to other materials, like plastics and textiles	1.79
E37	Famous scientists and their lives	1.82
A47	How petrol and diesel engines work	1.87
A48	How a nuclear power plant functions	1.99
A15	How plants grow and reproduce	1.99
E33	Benefits and possible hazards of modern methods of farming	1.99
A45	The use of satellites for communication and other purposes	2.06
E26	Detergents, soaps and how they work	2.06
E25	Plants in my area	2.09

Item	BOTTOM TEN: BOYS with NO BOOKS at home	LS
E01	Symmetries and patterns in leaves and flowers	1.31
E04	The greenhouse effect and how it may be changed by humans	1.55
A15	How plants grow and reproduce	1.58
E33	Benefits and possible hazards of modern methods of farming	1.59
E03	The ozone layer and how it may be affected by humans	1.64
E02	How the sunset colours the sky	1.68
E25	Plants in my area	1.73
E39	How scientific ideas sometimes challenge religion and authority	1.76
A35	How to find my way and navigate by the stars	1.77
A21	How different musical instruments produce different sounds	1.78

Item	BOTTOM TEN: BOYS with >500 BOOKS at home	LS
E01	Symmetries and patterns in leaves and flowers	1.36
A15	How plants grow and reproduce	1.73
A39	The ability of lotions and creams to keep the skin young	1.75
E33	Benefits and possible hazards of modern methods of farming	1.77
E26	Detergents, soaps and how they work	1.83
E25	Plants in my area	1.85
C12	Alternative therapies (acupuncture, homeopathy, yoga, healing etc)	1.89
C01	How crude oil is converted to other materials, like plastics and textiles	1.89
E19	Organic farming without use of pesticides and fertilisers	1.91
E37	Famous scientists and their lives	1.92

Table 6.10: The 'bottom ten' topics, by gender, for groups reporting 'No books at home' and 'More than 500 books at home'

There is a slightly larger gender division between girls and boys in Group 7 (>500 books). Each group has five 'top ten' choices not in Table 6.7, representing for both groups a relative shift in favour of more abstract and less directly personal matters. However, there is a distinct difference in emphasis with girls expressing interest in unknown and mystical topics relevant to the human condition, whereas boys tended more to select natural physical phenomena, including threatening technology such as atom bombs. The relative ordering within each group's lists tends further to reflect the above gender preferences.

The actual Likert score values reflect overall interest levels. As previously noted, Books Group 7 give substantially higher scores in general, and there is little difference at this level between girls and boys. For Books Group 1, however, girls express even lower levels of interest than boys, by a significant margin.

If scrutiny is extended to the top 20 items for each group we find

- boys in Group 1 show interest in how engines, CDs, DVDs, mobile phones and computers work (of these only computers feature for Group 7 boys) as well as health and fitness.
- boys in Group 7, apart from their interest in the violent and dangerous, are more interested in space related topics.
- Group 1 girls, on the other hand, are more similar to the Group 1 boys in that they are more interested in their body, how it works and how to keep it fit and healthy. Unlike the boys, girls also express an interest in lotions and plastic surgery, presumably so as to keep a youthful appearance.
- Group 7 girls also show interest in keeping fit and healthy but also show some of the boys' interest in violent and dangerous events.

Least popular topics

In their 'bottom ten', boys in Books Group 1 selected just four of the overall least popular topics listed in Table 6.8, all of these related to plants and agriculture. Their other six least popular topics were all unique to this group, and included both the greenhouse and ozone environmental issues alongside other issues presumably viewed as only of remote and abstract significance (possible conflict between science and religion, colour of the sky, navigation by the stars, and how musical instruments work).

Girls in Group 1 shared six items from the overall list. Four of these are agricultural but (in common with both high books groups) they signal strong disinterest in oil and in the lives of famous scientists. The replacement items in their bottom ten involve astronomy and earth science.

Group 7 girls included seven items from Table 6.8 in their 'bottom ten,' replacing three others by technology topics, on how engines, nuclear reactors and satellite communications work. Group 7 boys shared eight topics with the overall bottom ten, with just two substitute 'personal health' topics on body lotions and alternative therapies. 'The ability of lotions and creams to keep the skin young' has the distinction of being the topic of most divided appeal, being in the top ten for Group 1 girls group but in the bottom ten for Group 7 boys.

Looking more widely at the bottom 20 items, two points seem worth adding

- The topic of 'atoms and molecules,' central to chemistry, appears on the list.
- Question C09 on astrology and horoscopes is included by Group 1 boys and girls and by Group 7 boys, but it is much more popular with Group 7 girls.

The designers of the ROSE survey included a number of questions at and beyond the boundaries of science, ranging from the meaning of dreams, through the occult and mystical, to issues of

meaning and religion. Understanding dreams was the top ranked topic of all in terms of interest (see Table 6.7 above), and most of the other topics in this category also ranked reasonably highly. The exceptions were two questions about the relation or conflict between science and religion, which were ranked in the bottom 20. Pupils were not explicitly asked whether they considered such topics as 'science'. Beyond their indications that the less philosophical of such issues are thought inherently interesting, and we must be left unsure as to whether many pupils view such topics as equivalent to science.

One case in point is the subject of astrology, which is addressed by two questions. One (C09) asks how interested a pupil is in learning about "*Astrology and horoscopes and whether the planets can influence human beings*" and the other (H02) asks how often pupils have "*Read (their) horoscope (telling the future from the stars).*" At first sight similar responses might be expected. The response from boys is unenthusiastic for both with Likert scores for different subgroups in the range 1.84 to 2.21, and with no clear relationship between these values and the number of books at home. With girls the situation is different. Likert scores are (with one exception) significantly higher, and particularly so for girls with at least a reasonable number of books at home. The data is given in Table 6.11 below.

Mean Likert scores	C09: interested to learn about astrology		H02: frequently read their horoscope	
	girl	boy	girl	boy
0 books	1.61	1.88	2.28	2.00
1-10 books	2.13	1.99	2.70	2.14
11-50 books	2.32	2.07	2.94	2.04
51-100 books	2.49	2.08	2.95	2.05
101-250 books	2.61	2.21	3.01	2.01
251-500 books	2.52	1.91	2.94	1.84
> 500 books	2.55	1.98	2.88	1.90

Table 6.11 Mean Likert scores for two questions on astrology

Pattern of interest levels in the different categories of topics

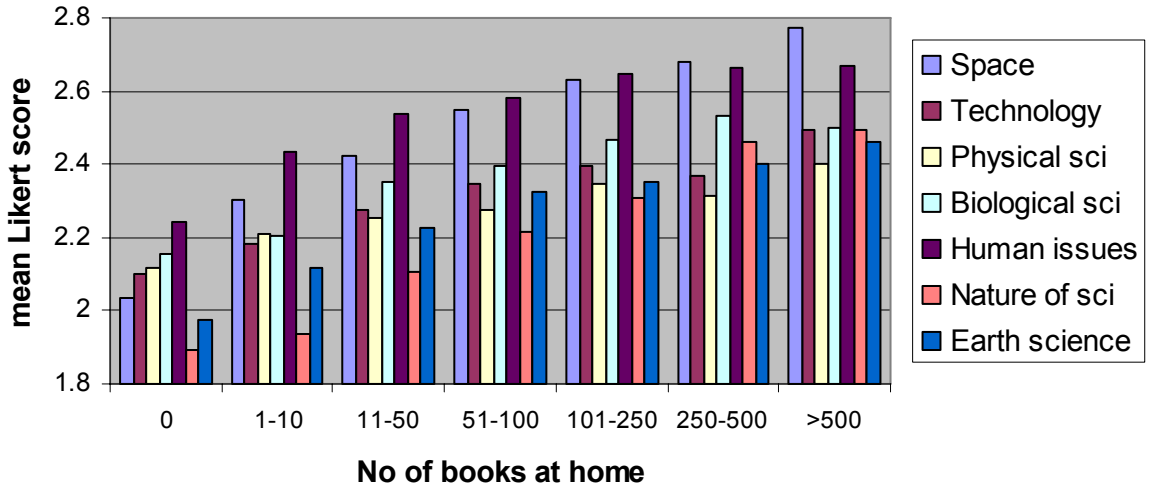
We have discussed above the specific topics that are in relative terms most or least popular with different book groups, and we drew attention in Sec 5.2 to the absolute differences in mean scores for these groups over all 108 topics. Fig 6.3 below shows separate mean scores for each book group for each of the seven categories of 'content domain' identified in Table 6.1.

This figure reveals

- interest in every separate domain increases step-by-step across the series, with three minor exceptions where there is a small 'dip' for Group 6 or Group 7
- growth in 'interest' is a relative matter: for Groups 1 & 2 no domain exceeds the 'neutral' mean score of 2.50 and even for Groups 6 & 7 only 'human' and 'space' issues score above 2.53
- there is a significant increase in interest in 'space' topics for pupils with more books at home, rising from the third least popular area to the 'top' interest over the series

- there is a corresponding and almost linear rise in interest in 'nature of science' topics, from being clearly the most unappealing area of all for the lower groups to attain a close to neutral reaction from Group 7

Fig 6.3 Interest in categories of topic vs books



6.5 Messages for a new curriculum

The numbers participating in this survey are large enough for secure messages to emerge. What appears to be clear is that:

- In general, conventional school science topics provide little motivational interest for young people in this age range
- Pupils following Intermediate 1 or General Science courses find little to inspire them across the range of science related topics.
- Topics which have a personal or human interest dimension are considered to be more interesting.
- There is a distinct gender preference in evidence with boys preferring space and technology related domains and girls preferring those topics with a human focus.

It is interesting to consider how the messages emerging from this survey articulate with the recently published A Curriculum for Excellence[10]. That report presents a framework to steer a curriculum review embracing how and what young people are to be taught. Four key purposes provide a structure against which the curriculum will be reviewed. They are to develop successful learners, confident individuals, responsible citizens and effective contributors. At the time of writing this Report, the review team for science has presented a rationale for a revised science curriculum for all learners 3-15. The rationale articulates two main purposes for science education:

[10] SEED. *A Curriculum for Excellence*. (2004) Scottish Executive

- To enable young people to develop as scientifically literate citizens, able to hold and defend informed views on social, moral, ethical, economic and environmental issues related to science; and
- To prepare young people for further, more specialised learning by developing their secure understanding of the 'big ideas' and concepts of science.

The review group present the 'big ideas' of science as: 'our living world', 'our material world' and 'our physical world'. A cynical view of this structure might see these headings as little more than biology, chemistry and physics re-packaged. If that were to be the case then our evidence would suggest that the downturn in interest in science would be unlikely to be reversed. However what might be critical in the new curriculum is an emphasis on the word 'our'. With the latent interest in what appears to be more 'human' issues, a revised curriculum which builds ideas around the interests and experiences of learners as individuals might have a motivational effect and attract interest in science. Perhaps this is no more than what has been previously seen as making science 'relevant' to learners, but perhaps relevant to their own personal condition – i,e, their own health, their own safety, their own vulnerability, their own future prospects. The review team's aspiration to reduce curriculum content and thereby allow for some more extended project work provided in real life contexts will serve to make the curriculum experience more engaging for learners.

However the introduction of ideas about how science works or what might be called the nature of science needs to be handled sensitively. Introducing historical contexts and case studies is unlikely to be a profitable way forward unless well written and personally engaging for learners. However by allowing learners to engage in extended project work, involving elements of collaborative research and then sharing their outcomes with others, perhaps in other schools, would place learners in an environment which includes many of the features of the real science community. Such initiatives as the Pupil Researcher Initiative or Researchers in Residence would provide a stimulus for showing learners just how real science makes progress, albeit unsteady, uncertain and partial progress.

In considering the context for a revised curriculum it is important to consider how children are taught science. Much of the ROSE survey looks at what is to be taught. There are messages in section K about the role of practical work and these messages tend to be positive. Research into teaching and learning styles and strategies, in particular those found in formative assessment studies[11], offer teachers clear messages about the value of collaborative learning activities, of the importance of allowing learners to find their own voice and the power of skilled questioning. It is likely that the 'assessment is for learning' movement, being embraced by most of Scotland's schools in some way or another, will have a positive effect on the learning experiences of all children. A further development of the ROSE survey might look at attitudes towards learning and teaching styles and in particular those relating to formative assessment and also to extended practical projects. What is apparent is that research is providing important messages about teaching and learning which sit alongside messages about the realignment of science curriculum activities. Together these messages offer the potential to revitalise the experience of science offered to Scotland's young people.

[11] Black, Wiliam et al. *Assessment for Learning* (2003). OU Press

7 Review of Responses - Section B: "My future job"

In this section pupils are asked how strongly they rate the importance of each of 26 features concerning their future occupation. Pupils in general regarded a majority of these factors as important for themselves: girls recorded mean Likert scores of above 2.50 for 16 of the 26 issues, and boys for 21 of the issues. Underlying this, different individuals (within both gender groups) varied significantly in their ratings for most items: standard deviations in the responses to each question averaged well over 0.9.

7.1 Importance attached to different issues by pupils

In this preliminary study we thought it helpful to consider the questions under various categories, as shown in Table 7.1. The individual issues are listed amongst the analysis explained later in Table 7.2.

Nature of issue	Questions
Work nature and context	B3,B4,B5,B6,B7,B19
Creativity at work	B8,B10,B11
Personal satisfaction from the job	B9,B13,B15,B16,B25
Relationship with other people at work	B1,B2,B14,B21,B24,B26
Work life balance	B12,B17,B18,B23
Fame and fortune	B22 and B20, respectively

Table 7.1 Categorisation of the questions in Section B

Fame and fortune

The issue attracting the most positive response was B20: 'earning lots of money'. 90.6% of pupils agreed that this was important, although girls had a slightly lower average Likert score than boys and the group least likely to consider it as very important were the girls who were studying the three sciences. The standard deviation for most sub-groups in other questions was in the range 0.88-1.20 but this question had by far the lowest SD, in the range 0.59-0.64. 'Becoming famous' (B22) was not such a priority for pupils. Only 50.1% overall rated this as an important factor. There was significantly lower mean Likert Score for girls at 2.40, compared to 2.67 for boys. Again those studying the three sciences were less likely than other groups to consider this important (with mean scores of 2.07 for girls and 2.44 for boys).

Work nature and context

Overall Likert scores for girls were very low in this section (the 6 questions provided their 5 lowest average scores for Section B). They particularly recoiled from 'working with machines', 'repairing objects', 'working in environmental protection', or 'easy and simple' work, and a substantial majority were uninterested in 'working with animals'. They were much more positive about working 'where something new and exciting happens frequently' a question less context specific than the others. Boys were on average significantly less negative, though not on 'working with animals' or in 'environmental protection.' A majority of boys were attracted by 'working with machines', though in overall ranking for Section B this came 13th in net priority. For both this and the 'repairing objects' questions the mean Likert score for boys is a whole unit greater than for girls. Boys taking SG Science are the most positive of all, and girls taking SG Physics either alone or in combination with SG Chemistry, are significantly less negative than girls as a whole. Those taking physics, both girls and boys, were the least keen to work with animals. Stereotypical expectations are probably in accord with this finding. Again in accord with stereotype, the SG Science subgroup is much more attracted than average to 'easy and simple work' a prospect which most strongly repels the three sciences group.

'Working in the area of environmental protection' yielded the lowest combined score (1.93) and was equally unpopular with boys and girls. Also there was no significant difference of opinion between groups taking different science courses. Elsewhere in the survey pupils support the view that caring for the environment is important, and that their personal actions can make a difference, but here they show no enthusiasm for working in the area. This brings to mind the conclusion: *'Important but not for me'* with which Edgar Jenkins headed his article reviewing his application of the ROSE survey in England. Jenkins used that phrase to epitomise attitudes of pupils in England towards science in schools. Here we reach a similar conclusion about attitudes to the environment.

Work life balance

Pupils indicate think having 'lots of time' for family, friends and hobbies is an important issue when considering a future occupation. It is rated just below personal satisfaction with a job. Boys tend to place more importance on time for hobbies than girls, but both genders want 'lots of time' with family and friends. No significant divergence in opinion emerges when comparing different groups. Reactions are guarded, particularly among girls, to work 'that involves a lot of travelling'.

Creativity at work

The three questions assigned to this heading all generate high standard deviations. Both gender groups respond negatively, strongly so in the case of boys, to 'working artistically and creatively in art'. This might reflect individual judgements of their own artistic talent and reactions are most negative of all from the three sciences group. Girls deliver an overall neutral score on 'making, designing or inventing something', which boys are significantly more positive about. On this issue the group studying the two sciences of chemistry and physics have the highest score. 'Coming up with new ideas' is higher up the list of job role priorities for both girls and boys, but again with boys giving the higher rating.

Relationship with other people at work

Girls attach high importance to working with 'people rather than things' and 'helping other people.' Boys also rate these issues positively, but significantly less strongly so. The three sciences subject group rate both these factors more highly than other groups. Both genders are net positively disposed towards 'becoming the boss', a marginal conclusion from girls but a much stronger one from boys (though still only 12th in their overall ranking for Section B as a whole). Boys also express net interest in 'controlling other people', where girls are distinctly more diffident. All groups give their highest rating across this group of questions to 'working as part of a team'.

Personal satisfaction from the job

It was reported above that 'earning lots of money' was judged the single strongest issue for a future job. Excluding only that, the five questions relating to personal satisfaction from the job itself category yielded the 5 highest mean Likert scores, for all girls and all boys alike. The mean scores were all very strongly positive, ranging from 3.16 to 3.37. The five factors were 'using my talents and abilities', 'making my own decisions', 'working with something that fits my attitudes and values', 'working with something I find important and meaningful' and 'developing and improving my knowledge and abilities'. Gender differences were relatively small for these questions, as were differences between different course groups. Generally speaking, however, those taking three sciences rated the issues somewhat more highly than did those taking SG Science, though all seemed equally keen to make their own decisions.

7.2 Variation with respect to numbers of books in the home

The 'books' question has proved significantly related to pupil responses in several areas of the survey, and it was decided to test its relevance in relation to future job ambitions. To simplify this initial analysis we have again decided to focus on the two groups at either end of the spectrum, comparing Group 1 (no books at home) with Group 7 (more than 500 books). We have retained a further subdivision by gender, giving four sub-groups in all. We also organise the analysis using the same categorisation of questions as above. Rather than consider the absolute mean Likert scores for each question, we have looked at the order of importance of the 26 issues raised as reflected in the rank order within each group's mean scores.

		RANK ORDER by mean Likert score			
Qu	**Work nature and context**	Girl Gp1	Girl Gp7	Boy Gp1	Boy Gp7
B03	Working with animals	22	19	24	25
B04	Working in the area of environmental protection	26	23	26	26
B05	Working with something easy and simple	15	24	22	23
B06	Building or repairing objects using my hands	25	25	14	22
B07	Working with machines or tools	24	26	7	21
B19	Working where something new & exciting happens often	17	9	17	7

Qu	**Fame and Fortune**	Girl Gp1	Girl Gp 7	Boy Gp1	Boy Gp7
B20	Earning lots of money	1	10	1	2
B22	Becoming famous	13	21	9	18

Qu	**Work life balance**	Girl Gp1	Girl Gp7	Boy Gp1	Boy Gp7
B12	Having lots of time with my friends	3	6	6	11
B17	Having lots of time for my family	5	11	5	9
B18	Working with something that involves a lot of travelling	17	9	17	7
B23	Having lots of time for my interests, hobbies and activities	13	12	3	8

Qu	**Relationship with other people at work**	Girl Gp1	Girl Gp7	Boy Gp1	Boy Gp7
B01	Working with people rather than things	6	7	16	14
B02	Helping other people	4	8	18	16
B14	Working independently of other people	14	16	19	17
B21	Controlling other people	20	22	20	19
B24	Becoming 'the boss' at my job	16	18	4	13
B26	Working as part of a team with many people around me	10	13	12	12

Qu	**Creativity at work**	Girl Gp1	Girl Gp7	Boy Gp1	Boy Gp7
B08	Working artistically and creatively in art	21	17	25	24
B10	Making, designing or inventing something	19	15	21	15
B11	Coming up with new ideas	18	14	16	10

Qu	**Personal satisfaction from the job**	Girl Gp1	Girl Gp7	Boy Gp1	Boy Gp7
B09	Using my talents and abilities	9	1	8	1
B13	Making my own decisions	2	2	2	6
B15	Working with something I find important and meaningful	8	3	13	5
B16	Working with something that fits my attitudes and values	7	4	10	3
B25	Developing or improving my knowledge and abilities	11	5	11	4

Table 7.2 My future job: ranking of issues by gender and books in the home

* Note Book categories are based on pupil estimates of the number of books in their home:
Group 1: zero books reported. Group 7: more than 500 books estimated

Work nature and context

The rankings for the questions in this category re-emphasise the relatively low enthusiasm attached by pupils as a whole to these issues. Three new specific points that emerge from Table 7.2 are

- Group 1 boys are starkly different from the other groups in interest in working with machinery, and significantly more interested in working with their hands
- Group 7, both boys and girls, attach significant importance to working in an environment where 'new and exciting' things happen, a feature ranked unimportant by Group 1 boys and girls
- Group 1 girls, alone, are reasonably sanguine about 'easy and simple' work

Fame and Fortune

- 'Earning lots of money' (the top overall priority if all pupils are considered) is less emphasised by Group 7: however it still rates 2nd overall with Group 7 boys, but is relegated to 10th place by Group 7 girls
- 'Becoming famous' is more lowly ranked in general, but is more of an issue for Group 1, especially for boys

Work life balance

The previous conclusions re-emerge, but

- Group 1 emphasise, much more significantly than Group 7, their wish for 'lots of time' for friends, family and, in also the case of boys, leisure activities
- Group 7 pupils see travelling in the course of work positively, in stark contrast to Group 1

Relationship with other people at work

Again the previous conclusions come through, particularly the high relative priority given by girls to working with people rather than things and to helping other people. The book grouping seems have little bearing on views in this area, with one striking exception

- Group 1 boys give a very high rating (4th overall) to the prospect of 'becoming the boss', whilst this is a middle ranking priority for Group 7 boys

Creativity at work

The rankings reinforce the relatively low interest in these issues. We feel that these results will be regarded as disappointing in a country placing considerable emphasis on creativity and enterprise as core interests to nurture in the interests of the future economy. It can be argued that the structure of the current school curriculum does not particularly encourage 'coming up with new ideas' and we wonder to what extent this might contribute to these ratings. One point of marginal encouragement emerges

- Group 7 pupils rate the factors slightly more highly than Group 1

Personal satisfaction from the job

As noted above, overall the five factors in this category were rated 2nd to 6th by both girls and boys, below 'earning lots of money'.

- Group 7 pupils place 'using my talents and abilities' as their overall top priority; for boys 'earning lots of money' still rates 2nd, with the other job satisfaction factors placed 3rd to 6th, whilst Group 7 girls relegate earnings to below all of the satisfaction factors
- Group 1 pupils, both genders, only place one of the job satisfaction factors in their top 6; they retain 'making my own decisions' in 2nd place overall

8 Review of Responses - Section D: "Me and the Environmental Challenges"

This section consists of 18 questions, reviewed here briefly in four ways to assess

- the overall balance of opinion
- the differing opinions of boys and girls
- the views of the three sciences group versus those taking SG Science or one science at Int1
- differences between groups reporting different numbers of books in the home

The questions have been grouped as follows:

ASPECTS COVERED	Questions
Importance and global consequences of environmental issues	D2,D3,D4,D7,D8,D9,D14
Personal and national responsibilities in addressing problems	D1,D5,D6,D10,D11,D12,D13
Views on animal rights and human intervention in the environment	D15,D16,D17,D18

Table 8.1 Categorisation of the questions in Section D

The actual questions are collected, in the above groupings, in Table 8.2, where mean Likert scores and rank order (in terms of strength of agreement) are also given, for all pupils, for each gender group, and for those in each of Group 1 and Group 7 in terms of the number of books in their homes.

Importance and global consequences of environmental issues

All groups reject the proposition that '*environmental problems are exaggerated*" and, overall, pupils also disagree with the suggestion that *'people worry too much'* about them. On the latter question, however, opinion is more ambivalent among boys as a whole, and among all pupils in book Group 1, where opinion is more or less evenly divided. Among pupils taking three sciences 69% believe people do NOT worry too much. Further, 55.9% of all pupils agree that *'environmental problems make the future of the world look bleak and hopeless'*, with little difference in overall view for most of the different subgroups.

In apparent contradiction to this last view, pupils are almost uniformly *'optimistic about the future',* presumably feeling that what **looks** 'bleak and hopeless' can and will be turned around. Group 1 pupils were the single exception in their views for the last two questions: they are not so concerned about environmental problems but on balance, and perhaps partly for other reasons, they are net pessimistic about the future. All other groups, and most notably the Group 7 and three sciences pupils, combine concern about environmental threats alongside optimism that these will be overcome. This is reinforced by their very strong agreement that "*we can still find solutions to our environmental problems'* (with a 85 : 15 margin in favour among the three sciences group). However, the questionnaire does not entirely clarify why they think this as the proposition that *'science & technology can solve all environmental problems'* is roundly rejected by all boys, and overwhelmingly so by girls. The group taking three sciences were a bit more charitably disposed; they were equally divided on the matter! There is however a stronger hint in that a smallish majority in all groups signal their view that '*big changes in our way of living' may be required'.*

Personal and national responsibilities in addressing problems

The strongest margin of rejection for any of the statements in Section D is for the proposition *'threats to the environment are not my business'.* Girls are in even stronger disagreement than boys. However, there is a more substantial variation of opinion across different 'book groups'.

Group 7 are strongest of all in disagreeing with the statement, whilst the Group 1 view is much weaker: discrepancies between these two groups, of the order of 0.5 in mean Likert score, run right through Section D. The views expressed for this question are reinforced by reactions to the statement that *'people should care more about protection of the environment',* where the Likert score pattern is almost a mirror image of that for the previous question, as are the trends in strength of view.

Qu	IMPORTANCE and GLOBAL CONSEQUENCES	ALL		Girls		Boys		Group 1		Group 7	
		score	rank	score	rank	score	rank	score	rank	score	rank
D02	Environmental probs make the future of the world look bleak & hopeless	2.63	7	2.65	7	2.61	7	2.38	7	2.62	8
D03	Environmental problems are exaggerated	2.21	14	2.15	15	2.27	12	2.25	13	2.14	15
D04	Science & technology can solve all environmental problems	2.09	17	1.95	17	2.25	14	2.04	16	2.08	16
D07	We can still find solutions to our environmental problems	3.02	1	3.03	3	3.01	1	2.35	9	3.25	1
D08	People worry too much about environmental problems	2.42	10	2.32	10	2.53	9	2.50	2	2.20	14
D09	Env probs can be solved without big changes in our way of living	2.44	9	2.44	9	2.44	10	2.23	14	2.42	11
D14	I am optimistic about the future	2.83	5	2.83	5	2.83	5	2.38	6	2.94	5
	PERSONAL AND NATIONAL RESPONSIBILITIES										
D01	Threats to the environment are not my business	2.01	18	1.94	18	2.08	18	2.27	11	1.77	18
D05	I'm willing to have env probs solved even by sacrificing many goods	2.22	13	2.22	13	2.22	16	1.91	17	2.46	10
D06	I can personally influence what happens with the environment	2.26	11	2.26	12	2.26	13	1.87	18	2.52	9
D10	People should care more about protection of the environment	3.01	3	3.06	2	2.96	2	2.46	4	3.21	2
D11	Rich countries should solve the world's environmental problems	2.61	8	2.54	8	2.69	6	2.48	3	2.74	6
D12	Each of us can make a significant contribution to envir protection	2.91	4	2.97	4	2.86	4	2.36	8	3.14	3
D13	Environmental problems should be left to the experts	2.20	15	2.16	14	2.24	15	2.41	5	1.93	17
	ANIMAL RIGHTS AND HUMAN INTERVENTION										
D15	Animals should have the same right to life as people	3.02	2	3.14	1	2.88	3	2.61	1	3.09	4
D16	It's right to use animals in medical expts if this can save humans	2.14	16	1.97	16	2.33	11	2.08	15	2.33	12
D17	Nearly all human activity is damaging for the environment	2.23	12	2.26	11	2.19	17	2.26	12	2.22	13
D18	The natural world is sacred and should be left in peace	2.65	6	2.70	6	2.61	8	2.35	10	2.72	7

Table 8.2 Mean Likert scores and relative rankings for questions on the environment

The next strongest view in response to questions in this category is in agreeing with the statement that *'each of us can make a significant contribution to environmental protection'.* This provides reinforcement, in more strongly expressed terms, for the hint referred to earlier

that future optimism went alongside accepting '*changes in our way of living*'. However, any suggestion that the rising generation might be *'willing to have environmental problems solved even by sacrificing many goods'* is rudely scotched (though less definitively so by Group 7 pupils). There is reasonable support, stonger among boys and all in Group 7, that *'rich countries should solve the world's environmental problems',* but general scepticism that pupils could *'personally influence'* matters. One is left with the impression that pupils in general recognise the severity of global environmental issues, believe they must take a direct interest in these, and support international action to address them. They expect such efforts to generate solutions, but are determined that these should have minimal impact of their own future life styles. 'Important, but not requiring too much of me' might be a summary of opinion.

Views on animal rights and human intervention in the environment

The four last questions of Section D would not normally be classified as 'environmental'. Two are concerned to survey views on animal rights. Overall 70% of pupils agree that *'animals should have the same right to life as people*', with girls more strongly in agreement than boys (76% as opposed to 64%). The response to the companion statement *'it's right to use animals in medical experiments if this can save human lives'* to a degree mirrors the opinions on the first question, though a little less strongly. Only 30% of girls agree with this statement, and only 33% of all pupils taking SG Science. There is somewhat higher acceptance of medical experiments on animals from boys (42%) and from those taking three sciences (44%).

Only 33.7% agreed with the statement *'nearly all human activity is damaging for the environment'* with no significant differences between boys, girls or groups taking different science subjects. On the other hand 56% agreed that *'the natural world is sacred and should be left in peace',* again with no appreciable differences between different groups. In our view the precise meaning and scope of this last question is rather open to interpretation.

9 Review of Responses - Sections F and K: "My Science Classes" & "How I feel about Science in School"

Sections F and K probe pupil reactions to the science education they have experienced. They are asked to what extent they agree with each of 25 statements. The first 16 questions (Sec F) survey their general views about their overall experience in terms of difficulty, interest, usefulness and educational impact. The remaining 9 questions (Sec K) were added by us specifically for the Scottish survey to gather views about practical work and facilities, and about the style and progression of the science curriculum over Primary School and the first three years of Secondary.

The initial analysis for these questions was done by sorting the responses by gender, science subject(s) studied, and socioeconomic background based on the indicator of the number of books in the home. Average Likert scores were calculated. There was a reasonably wide spread of responses for all statements, with the standard deviation for most statements being in the range 0.85 to 1.00. Patterns and trends in the data were then identified along with some relationships between variables.

A general observation across the 25 questions, perhaps unsurprising but also reassuring, was that the responses of pupils who have chosen to study all three separate sciences in S3 were more positive than those studying SG Science or only one of the separate sciences. Generally those studying SG Science only or Biology only have more negative views than those studying Chemistry or Physics only, and significantly more negative views than those studying both Chemistry and Physics or all three separate sciences.

The responses from those with 100 or more books in the home were also more positive towards science than those with 11-100 books which in turn were more positive than those with 0-10 books. This is consistent with our findings elsewhere and may be part of a broader phenomenon where those with more books at home are more positive towards education and learning in general.

Table 9.1 lists the mean Likert scores for all questions with columns for all pupils together, and for selected subgroups separated by gender, by 'book score' and by 'course'. Under the books indicator only the two extreme groups are included, Group 1 (zero books) and Group 7 (>500 books). Under COURSE in Table 8.1 five subgroups are listed, including the two most positive and the two most negative in their responses, and the 'Phys' group in the middle, as the most positive of the 'single science course' groups. (Of the whole year group only a minority take two or more courses.)

For most statements the difference in response between the two genders is relatively small, though girls are fairly consistently a little more negative. Responses are more dramatically different across different 'book' groups. The difference between mean Likert scores for Group 1 and Group 7 is typically of the order of 0.5, representing a considerable divergence in the balance of opinion. There are even larger differences between course subgroups, with differences as extreme as 1.0 or more in six cases.

Item	STATEMENT	ALL	BOOKS		GENDER		COURSE				
			Gp1	Gp7	Girl	Boy	3Sci	P+C	Phys	Biol	SGSci
F01	School science is a difficult subject	2.25	2.39	2.11	2.26	2.23	2.00	2.27	2.48	2.33	2.07
F02	School science is interesting	2.80	2.27	3.07	2.75	2.87	3.27	3.16	2.81	2.52	2.55
F03	School science is rather easy for me	2.35	2.03	2.50	2.28	2.43	2.70	2.46	2.24	2.21	2.48
F04	School science has opened my eyes to new and exciting jobs	2.34	2.03	2.51	2.25	2.44	2.97	2.66	2.37	2.00	2.11
F05	I like school science better than most other subjects	2.16	1.78	2.31	2.06	2.28	2.99	2.47	2.05	1.81	1.94
F06	I think everybody should study science at school	2.55	2.05	2.87	2.52	2.58	2.89	2.93	2.57	2.35	2.29
F07	The things I learn in science at school will be helpful in my everyday life	2.66	2.29	2.87	2.65	2.68	3.07	2.99	2.66	2.49	2.40
F08	I think the science I learn at school will improve my career chances	2.90	2.31	3.28	2.87	2.93	3.67	3.34	2.96	2.57	2.45
F09	School science has made me more critical and sceptical	2.30	2.00	2.53	2.22	2.40	2.68	2.51	2.38	2.09	2.08
F10	School science has increased my curiosity about things we can't explain	2.59	2.02	2.84	2.55	2.63	3.10	2.97	2.70	2.38	2.21
F11	School science has increased my appreciation of nature	2.31	1.92	2.45	2.33	2.29	2.61	2.29	2.20	2.21	2.12
F12	School science has taught me the importance of science to our way of living	2.44	2.05	2.66	2.39	2.49	2.87	2.70	2.51	2.24	2.18
F13	School science has taught me how to take better care of my health	2.45	2.27	2.46	2.46	2.43	2.63	2.32	2.38	2.43	2.49
F14	I would like to become a scientist	1.77	1.60	2.02	1.63	1.92	2.52	2.10	1.77	1.48	1.59
F15	I would like to have as much science as possible at school	2.09	1.84	2.34	2.02	2.16	2.77	2.45	2.08	1.77	1.94
F16	I would like to get a job in technology	1.96	1.89	2.00	1.61	2.35	1.96	2.62	2.36	1.68	1.84
K01	In science I would rather learn a lot about fewer topics than a little about a lot of different topics	2.58	2.33	2.62	2.58	2.57	2.69	2.81	2.57	2.54	2.44
K02	Doing practical and experimental work helps me to understand science topics	3.18	2.77	3.39	3.15	3.21	3.48	3.43	3.19	3.04	2.96
K03	Doing practical and experimental work with good modern apparatus makes me want to study science	2.88	2.39	3.07	2.78	3.00	3.29	3.25	2.92	2.63	2.66
K04	My school science rooms are exciting places in which to work	2.14	1.97	2.28	2.08	2.20	2.41	2.24	2.05	2.00	2.16
K05	If the practical content of the course were increased it would give me a greater enjoyment of science	2.77	2.40	2.96	2.68	2.88	3.13	3.09	2.86	2.58	2.46
K06	I found science at Primary School interesting	2.00	1.79	2.11	1.98	2.03	2.18	2.05	2.00	1.95	1.82
K07	Science at Primary School prepared me well for science classes in Secondary School	1.79	1.76	1.73	1.77	1.81	1.79	1.70	1.79	1.79	1.78
K08	I find science in Secondary School more interesting than science in Primary School	3.05	2.32	3.35	3.01	3.11	3.66	3.42	3.12	2.69	2.75
K09	What I learned in S1 and S2 science helped me with the science course I now take	2.89	2.33	3.06	2.87	2.91	3.31	3.05	2.95	2.66	2.60

Table 9.1: Mean Likert scores for Sections F and K

Statements F1 and F3 investigate pupil views of the difficulty of science. Pupils, with the sole exception of the group studying all three sciences, disagreed with the statement that *"school science is rather easy for me"*. However, all groups rejected also the view that *"school science is a difficult subject,"* a slightly contradictory view. However, for each question about 40% of pupils selected score '2', indicating mild disagreement, and it is not inconsistent to feel that school science is not truly difficult whilst its study still presents a reasonable personal challenge. The data in the Table show that, overall, more girls than boys rated the subject as difficult for themselves personally. Variation is much larger across the different 'book' and course groups.

Statements F2 and F5 investigated pupils' interest in and liking for school science. Overall, there was majority support for the proposition that *"school science is interesting"* whilst only a minority *"like school science better than most other subjects."* We probe this juxtaposition of views more fully in Sec 14 below, where we look at correlations between these responses for different individuals, and the views they express elsewhere.

In terms of the variation in views across different groups, the common trend appeared. Both males and females studying all three sciences were most positive, followed at some distance by those studying chemistry and physics, whilst those studying biology only and science only were very much more negative. Those reporting no books in their homes recorded the lowest scores on both questions.

Statements F4, F7 and F8 investigated the perceived usefulness of school science education for everyday life and career prospects. Again those studying all three separate sciences were distinctly more positive than those studying one science, particularly science only or biology. The highest mean Likert score for any category in sections F and K (3.79) was obtained for girls studying all three sciences agreeing with the statement *"I think that the science I learn at school will improve my career chances"*. This is in huge contrast to the views of girls studying SG Science only, who registered majority disagreement (mean score 2.39).

Statements F9 and F10 investigated whether pupils thought school science made them more critical, sceptical or curious. School science appears to have little impact in this regard, where even those studying all three sciences showed only marginal agreement.

The final three statements in section F: *"I would like to become a scientist," "I would like to have as much science as possible at school"* and *"I would like to get a job in technology"* obtained the most negative overall mean scores over all statements in the section. Only those studying all three sciences registered net agreement with the first statement, and that by the barest of margins.

There was a very strong gender difference on the third issue, with girls overwhelmingly unattracted to *"a job in technology",* whilst males, though still net negatively disposed, rated this substantially more favourably than becoming a scientist. The apparent low interest with which both these career routes are viewed will be a cause of concern to many policy makers. Most girls seem to view both career tracks with equal anathema, whilst boys are a little less averse to a science career, and much less so for technology.

Interestingly, the three sciences group as a whole strongly disfavour a job in technology, whereas there is actually a net positive interest from the subgroups taking physics and chemistry, physics and biology or physics only. This is a quite striking departure from the normal trend in response across these groups, and in particular it is a mirror image of their relative views about becoming scientists.

Statement K1 asked whether or not pupils would prefer to study a few topics in depth or a little about lots of topics. Although there was a significant spread of responses the overall view was close to neutral. This question was included because many teachers and external commentators have criticised the science curriculum in Scotland as "cluttered." It is clear that this has not registered as a significant issue among pupils, at least not at the S3 level.

Statements K2, K3, K5 investigated the impact of practical work as perceived by pupils. The view that "doing practical and experimental work helps me understand science topics" won

strong backing from all pupil groupings. There was general agreement also that *"doing practical and experimental work with good, modern apparatus makes me want to study science"* and *"if the practical content of the course was increased, it would give me a greater enjoyment of science"* Agreement was strongest from those studying two or three sciences, but there was also a small gender difference with boys agreeing with both statements more strongly than girls.

All groups disagreed with statement K4 *"My school science rooms are exciting places in which to work".* Further analysis at the class group level, alongside the returns from the teacher survey, might reveal the extent to which there is a more positive reaction from schools where labs have recently been refurbished.

The last four questions investigated views of the science education experienced at earlier stages. Among all categories of pupils a majority agreed that what they learned in the earlier years of Secondary *"helped me with the science course I now take."* The majority was slim for the biology only and SG science groups but quite substantial for those studying biology and chemistry, chemistry and physics and all three sciences. Pupil responses regarding Primary school science were quite negative. All groups disagreed quite strongly with statement K6 *"I found science at Primary school interesting".* For statement K7 *"Science at primary school prepared me well for science in Secondary school"* all categories of pupils disagreed very strongly, giving uniformly very low Likert scores close to 1.75. All course groups agreed with statement K8 *"I find science at Secondary school more interesting than Science in Primary school".* Agreement ranged from mild for the biology-only group, to very strong indeed for the three sciences group.

In conclusion, it can be seen that pupils who have already chosen to study all three sciences or the two sciences of physics and chemistry have a significantly more positive attitude to the study of science and its impact on their everyday life and career prospects than those studying one science, particularly biology only and science only. A more positive predisposition towards science would of course be consistent with the choice of studying two or three science subjects at S3/4. In addition, pupils choosing two or three science subjects at S3/4 come from higher socioeconomic backgrounds making them more likely to value education and learning generally and as a result consider careers such as medicine or engineering where there is an advantage to studying more than one science in S3/4. However, the vast majority of pupils do not see themselves as scientists or having jobs in technology.

Pupils value practical work in terms of helping understanding. Good, modern apparatus and more exciting school science laboratories would appear to motive pupils. Primary science, or perhaps the relationship between primary and secondary science, is rated poorly.

As SG science is the only subject offered at Foundation Level, its pupils will tend to be lower achieving than for those studying the separate sciences. Historically biology has been perceived, perhaps inaccurately, as the easiest of the three separate sciences, and this may explain why those studying only biology give responses more similar to the SG science group than those studying chemistry and/or physics, as the biology course may also attract pupils of lower average ability.

10 Review of Responses - Section G: Opinions about Science & Technology

This section surveys pupil views about the importance and value of impacts of science & technology on life and society, and about the reliability of science and of scientists.

Pupils are asked, on the 4-point Likert scale, to record the extent to which they agree or disagree with each of 16 statements covering this ground. 2747 questionnaire returns included answers to this section. This is a preliminary analysis of their responses.

General nature and quality of the responses

For 14 of the 16 statements a high score response (indicating agreement with the statement) represents a positive view of science and technology[12]. The mean Likert score of all an individual's responses thus gives a crude measure of how positively that pupil views science as a whole. The mean overall score over all pupils was 2.45, marginally to the negative side of the 'net neutral' value of 2.50. The mean scores for different pupils varied considerably, indeed across the entire possible range, though ca 70% lay within the central range from 2.0 to 3.0. So the survey evidences a very wide range of opinions.

Confirmation that pupils on the whole considered each statement individually is provided by the standard deviation of the Likert scores provided by each individual: these values average 0.80, consistent with most pupils making use of the full 4-point scale[13].

Whilst the 16 individual statements attract significantly different overall levels of agreement, it is also the case that there is significant diversity of opinion in all instances. The standard deviation in the Likert scores for each of the 16 items all lay between 0.81 and 1.00, so it is important to recognise that overall views reported below are not unanimous. The spread of responses is further reflected in the mean Likert scores for individual statements: these lay between 2.0 and 2.9, with two exceptions (one each at 3.03 and 1.78).

For our analysis we chose to focus on the 'percentage agreeing' with each statement, representing the percentage of valid responses scoring each item at level 3 or 4. These data correlate quite closely with mean Likert scores, but they perhaps express conclusions in more familiar terms for the non specialist reader.

We have chosen to omit analysis of the responses to item G10, on science and environmental problems. This is the single item where agreement signals a more negative view of science and the data suggests that a significant proportion of pupils may have misinterpreted the sense of the question[14]. For pupil views on science and the environment we prefer instead to rely on Section D: *Me and the Environmental Challenge* which is reviewed in Sec 8 above.

Some overall conclusions

The strongest expression of pupil agreement (75.2%) is that *science & technology will find cures to diseases such as HIV/AIDS, cancer, etc.* This is also the **only** statement agreed by a majority within every subgroup of pupils reviewed below.

---

[12] In one statement only a high pupil score represents a negative view. This is item G10: *Science and technology are the cause of the environmental problems.* One other statement is neutral in this respect, viz G16: *Scientific theories develop and change all the time.*

[13] There were 90 pupils who used only one score for all items answered in this section, 60 of these using uniformly the most negative score of 1. We left these pupils in the sample as analysed: they represent just 3.3% of the whole sample and do not seem to be overly concentrated in a single sub-group, so their impact on our conclusions is marginal.

[14] Taking the responses to item G10 at face value would suggest for instance that the trends in opinion between different pupil subgroups run in reverse in this instance.

There is also a quite positive net response to statements that science and technology will provide *greater opportunities for future generations* (69.4%), that it will *make work more interesting* (64.6%), that it is *important for society* (62.8%), and that it makes *our lives healthier, easier & more comfortable* (62.5%). In each of these cases, however, there are significantly more negative responses among some groups of pupils

Given the immense impact that science has had on human prosperity and modern life, it might seem somewhat disappointing that slightly fewer than half of pupils (48.5%) agree that *the benefits of science are greater than the harmful effects it could have*. Whilst there might be some room for comfort in that the comparison invited might be between (actual and past?) *benefits* and (conceivable and future?) *harmful effects*, it is unlikely that many pupils would have thought about the issue in quite such careful terms[15]. In our view the response to this item indicates that there could be significant perception issues to address if Scotland is to realise its ambition to become a society welcoming and enthusiastically engaged with science.

Even fewer believe that science & technology will *help eradicate poverty and famine* (42%) or that it is *helping the poor* (32%), let alone that it *can solve nearly all problems* (29.5%). There was also rather limited confidence that the scientific method *always leads to the correct answers* (32%).

By far the most striking negative view was that fewer than 17% of pupils agreed that *we should always trust what scientists have to say*. This arguably presents the biggest single challenge to those aiming to enhance public respect for science, and could act as a barrier to tackling other more specific issues of perception. The reputation of science may have suffered considerably where scientists have been employed as paid agents to defend sometimes questionably grounded but corporately sensitive positions, and when others may have engaged too vociferously one-sidedly in scientific controversies, particularly where there are also ethical dimensions. It is central to the whole self-belief system of scientists that they SHOULD be able to be trusted as objective and reasoned: an expression of such distrust from the upcoming generation is from a professional's point of view deeply disappointing. Learned societies might reasonably consider reviewing their guidelines on professional conduct in relation to scientific advocacy and controversy, making these more stringent and highlighting them as conditions for accredited membership.

Variations among pupil views

There is quite striking divergence in the predominant views of different subgroups of pupils. As has been common internationally, we have looked at gender differences. Our survey, however, also provides scope for a study of differences in views by geographic, social and school environment, and by the different subject options being studied at S3 level. In this preliminary review of Section G, we have compared the reactions of pupils on different study routes, and this reveals much larger differences on average than those associated with gender.

Comparisons by gender show close correlations in the statements the two groups agree or disagree more or less strongly about. However, boys as a group are generally more positive about science, with 5% more on average agreeing with each statement. The only significant exception to this is in the statement attracting strongest agreement from both sexes: 76.6% of girls agree that science & technology *will find cures to diseases such as HIV/AIDS, cancer, etc*, compared to 73.8% of boys. At the other extreme there are three statements where girls are more negative than boys by as much as 10%: these relate to the benefits of science being

[15] Pupils had an average time available of less than 10 seconds to consider each question in the ROSE survey.

outweighed by negative effects, to scepticism as to whether science can solve nearly all problems, and to doubts about the efficacy of the scientific method.

More striking were differences between pupils taking different science course options, or studying science at different levels. At a first level of analysis we have separated pupils into four groups. The first three of these are all studying science at the higher level (Credit/General or Int2), but taking three, two or one science subjects. The fourth group consists of those taking a single science subject at the lower level. We were able to identify, respectively, 204, 780, 806 and 913 pupil returns for these groups.

We find a very pronounced trend that pupils studying fewer science subjects, or a lower level curriculum, are more likely to hold negative views of the importance and value of science and technology. Thus, running through the four groups, the proportions agreeing that science & technology *are important for society* were 88%, 78%, 62% and 45% respectively. The proportions believing that *the benefits of science are greater than the harmful effects it could have* were 64%, 57%, 49% and 37% respectively. If public policy is to aim to enhance appreciation of science, it is clear that significant emphasis will be required on initiatives that will impact on that majority of the population who currently take only one science option, and particularly those not recruited on the higher level of courses.

Divergences are much narrower on statements about science helping the poor, being able to solve nearly all problems, and about the scientific method always leading to correct answers. The proportions agreeing with these statements were close to 30% in all four groups!

There was just one item where the trend across the groups was significantly in the opposite direction to the norm. This was on the issue of whether *we should always trust what scientists have to say.* Whilst for every group this attracted a more negative response than any of the other 15 statements, the three sciences group were the most negative of all. The agreement rates for the four groups were 10%, 14%, 14% and 23% respectively. Scientists will have to work to convince the most engaged and positive group of 14 year old pupils of the integrity of science as a profession!

We have also divided each of the four groups into smaller subgroups, depending on which specific science subjects were being studied. Of those taking two sciences, those taking chemistry and physics are nearly as positive as the group taking all three sciences. Of those taking a single science at the higher study level those taking physics were significantly the most positive and those taking biology the most negative. It might be that all of these differences could correlate with the average overall educational ability of pupils found in the different groupings, but such a conclusion can only be speculative in the absence of other evidence.

Some tabulated results

Attached are two tables giving somewhat more detailed data. Both focus on the percentages agreeing with each of the 16 statements. Table 10.1 gives results for the entire sample, and for sub-groups broken down either by gender, or by the number of subjects and level of study. Table 10.2 gives results for subgroups broken down first by gender and then by course of study. The latter table for instance shows that the small difference whereby girls are typically a little more negative on average than boys is, by and large, reflected within all the different course sub-groups.

	PERCENT AGREEING																	
	OVERALL			GENDER		no of subjects & level				2 subjects upper			1 subject upper			1 subject lower		
	Likert MEAN	Likert STD	Agree %	GIRL	BOY	3 sub upper	2 sub upper	1 sub upper	1 sub lower	CP	BP	BC	P	C	B	SG Sci	Int1 C	Int1 B
Number in group	**2747**	**2747**	**2747**	**1445**	**1277**	**204**	**780**	**806**	**913**	**286**	**60**	**434**	**165**	**257**	**384**	**301**	**296**	**282**
G1: Science & technology are important for society	2.72	0.992	62.8	59.7	66.1	87.6	77.8	61.9	44.9	87.6	75	71.7	70.6	63.5	57	47.3	45.8	38.7
G2: Science & technology will find cures to diseases such as HIV/AIDS, cancer, etc	3.03	0.909	75.2	76.6	73.8	90.5	85.6	78.8	60.1	85.5	80	86.5	81.2	78.4	78	60.9	58.8	58.4
G3: Thanks to science & technology, there'll be greater opportunities for future generations	2.89	0.959	69.4	68.7	70.3	89	81.3	72.5	51.8	85.5	73.3	79.6	79.1	71.7	70.2	53.4	52.6	46.6
G4: Science & technology make our lives healthier, easier & more comfortable	2.73	0.945	62.5	60.4	64.9	79.2	73.7	62.9	49	81.9	63.3	69.7	69.6	66.5	57.6	45.8	51	50.2
G5: New technologies will make work more interesting	2.77	0.956	64.6	61.4	68.3	83.2	74.9	65.3	50.7	80.1	71.7	72	76.4	69.3	57.6	50.5	51.4	48.2
G6: The benefits of science are greater than the harmful effects it could have	2.46	0.91	48.5	43.7	53.9	64.3	56.8	49	37.1	61.6	50	54.6	51.8	51.8	45.8	36.5	38.2	34.6
G7: Science & technology will help eradicate poverty and famine in the world	2.31	0.935	42	40.9	43.1	51	46.4	40.2	37.9	45.9	45	46.9	42.9	39	39.9	37.5	37.2	37.3
G8: Science & technology can solve nearly all problems	2.06	0.896	29.5	24.8	34.5	29.5	29.3	26.2	32.3	35	30	25.5	31.1	28	22.8	36.3	32.4	29
G9: Science & technology are helping the poor	2.11	0.899	31.9	29.6	34.5	31.7	34	28.3	32.7	39.1	33.9	30.7	29.6	31	25.9	32.6	33.6	32.5
G10: Science & technology are the cause of the environmental problems	2.29	0.895	38.8	37.6	40.3	47.8	40.8	37.8	35.8	40.9	41.7	40.7	36.9	38.4	37.8	36.8	37.2	33
G11: A country needs science & technology to become developed	2.57	0.947	56.1	52.1	60.5	69.8	66.7	57	43.3	74.1	58.3	63.1	60.3	58.3	54.7	45.5	42.1	40.3
G12: Science & technology benefit mainly the developed countries	2.54	0.98	53	51.1	55.4	67.2	64.8	56	37.6	69.4	61.7	62.2	57	55.8	55.7	39.8	36.5	34.1
G13: Scientists follow the scientific method that always leads to the correct answers	2.12	0.886	31.6	26.9	36.9	31.8	31.6	29.5	33.4	37.6	32.2	27.6	31.4	32.1	27	33.3	35.7	31.4
G14: We should always trust what scientists have to say	1.78	0.814	16.9	14.7	19.3	9.9	14.2	14.4	23.2	17.7	15	11.7	17.1	14.3	13.2	25.9	21.3	20.6
G15: Scientists are neutral and objective	2.12	0.834	30.6	27	34.7	40.3	31.3	26.5	31.7	31.4	36.7	30.4	36.8	25.3	22.6	34.7	29.1	30.7
G16: Scientific theories develop and change all the time	2.74	0.984	64.1	64.3	64.2	84.7	77	64.8	47.5	81.4	68.3	75.3	64	64	65.6	49.8	48.8	41.2
MEANS	2.45	0.921	48.6	46.2	51.3	59.8	55.4	48.2	40.6	59.7	52.3	53.0	52.2	49.2	45.7	41.7	40.7	37.9

Table 10.1 Percentage agreeing with each statement: overall, by gender, and by course of study

PERCENT AGREEING	GIRLS											BOYS												
Level	Standard Grade or Intermediate 2							SG	Int 1			Standard Grade or Intermediate 2							SG	Intermediate 1				
Subject(s)	BCP	BC	BP	CP	Biol	Chem	Phys	Sci	BC	Biol	Chem	BCP	BC	BP	CP	Biol	Chem	Phys	Sci	BC	CP	Biol	Chem	Phys
Number in group	108	321	30	81	284	136	42	159	10	149	124	96	112	30	206	99	126	120	142	10	13	132	166	29
G1: Science & technology are important for society	86.1	71.4	63.3	82.5	54.8	61.1	64.3	45.2	70.0	37.8	41.8	89.4	71.8	86.7	89.7	62.1	66.4	72.3	48.2	70.0	69.2	39.4	49.4	65.5
G2: Science & technology will find cures to diseases such as HIV/AIDS, cancer, etc	92.5	89.2	80.0	91.4	78.1	79.4	83.3	64.1	70.0	53.7	54.5	88.0	78.2	80.0	83.2	78.1	77.8	80.8	57.6	50.0	76.9	63.6	62.8	75.9
G3: Thanks to science & technology, there'll be greater opportunities for future generations	89.7	79.8	66.7	84.0	70.3	68.7	70.7	51.3	70.0	47.6	53.7	88.2	78.4	80.0	86.1	69.1	75.4	82.4	55.9	80.0	69.2	45.5	51.5	72.4
G4: Science & technology make our lives healthier, easier & more comfortable	80.6	68.0	60.0	85.0	54.7	70.2	69.0	39.1	66.7	45.9	51.6	77.7	74.5	66.7	80.7	66.3	63.6	70.7	52.5	50.0	53.8	55.0	50.3	48.3
G5: New technologies will make work more interesting	80.4	71.8	63.3	81.0	53.6	64.1	66.7	49.4	70.0	44.5	52.0	86.3	72.7	80.0	79.8	68.4	75.4	79.2	52.5	70.0	69.2	52.3	51.2	69.0
G6: The benefits of science are greater than the harmful effects it could have	57.5	50.8	34.5	58.2	44.2	48.8	45.2	29.3	60.0	29.5	33.3	72.0	65.1	65.5	62.9	49.5	55.2	54.6	44.2	50.0	61.5	40.2	42.3	51.7
G7: Science & technology will help eradicate poverty and famine in the world	48.1	47.1	43.3	38.8	38.7	41.2	46.2	34	44.4	36.6	36.1	54.3	45.9	46.7	48.8	41.5	37.3	41.2	41.9	50.0	23.1	37.9	37.0	55.2
G8: Science & technology can solve nearly all problems	21.7	23.2	20.0	25.9	21.5	21.5	21.4	31.2	30.0	25.3	34.7	38.3	31.8	40.0	38.6	27.1	35.6	33.6	41.7	40.0	46.2	32.8	29.7	17.2
G9: Science & technology are helping the poor	26.9	30.7	34.5	33.8	23.7	35.4	21.4	26.8	10.0	28.8	41.0	37.2	29.7	33.3	41.3	31.2	26.7	32.5	40.1	60.0	46.2	36.4	27.7	31
G10: Science & technology are the cause of the environmental problems	44.9	41.2	33.3	50.6	37.1	34.6	28.2	31.8	10.0	32.9	37.8	51.1	38.4	50.0	37.1	40.9	43.1	40.7	42	77.8	46.2	32.8	37.2	37.9
G11: A country needs science & technology to become developed	61.7	63.1	60.0	69.6	50.7	50.4	48.7	42.3	11.1	40.0	36.7	79.3	62.4	56.7	75.9	65.2	67.2	64.3	49.2	70.0	58.3	40.5	45.5	58.6
G12: Science & technology benefit mainly the developed countries	66.0	61.2	46.7	66.3	55.4	49.2	52.5	38.9	33.3	31.0	36.4	68.5	64.5	76.7	70.6	56.7	63.4	59.5	40.6	40.0	61.5	36.4	37.4	55.2
G13: Scientists follow the scientific method that always leads to the correct answers	29.9	23.8	23.3	28.6	24.4	31.5	23.1	27.6	10.0	27.0	33.6	34.1	38.7	41.4	41.1	34.8	33.3	33.9	39.4	40.0	30.8	35.9	37.4	28.6
G14: We should always trust what scientists have to say	4.6	10.9	13.3	11.1	12.1	12.3	12.2	21.0	20.0	22.1	26.2	15.8	13.5	16.7	20.4	17.0	16.8	19.2	31.6	10.0	0.0	18.5	17.1	34.5
G15: Scientists are neutral and objective	35.8	30.3	33.3	22.5	18.2	20.2	25	32.3	30.0	28.5	29.8	45.3	30.6	40.0	35.0	35.2	31.4	39.2	38.5	20.0	15.4	32.8	28.7	34.5
G16: Scientific theories develop and change all the time	85.2	76.5	63.3	82.7	63.8	68.9	58.5	47.1	60.0	40.7	50.4	84.2	72.1	73.3	80.9	71.3	58.8	65.8	52.9	77.8	76.9	41.5	47.7	65.5
MEANS	57.0	52.4	46.2	57.0	43.8	47.3	46.0	38.2	41.6	35.7	40.6	63.1	54.3	58.4	60.8	50.9	51.7	54.4	45.6	53.5	50.3	40.1	40.8	50.1

Table 10.2 Percentage agreeing by gender, for each course of study

Number of books in the home

Opinions about Science and Technology show interesting differences when looked at according to the number of books in the home. For some questions the variation in Likert score is over 1.00 and for many it is over 0.5. Pupils from homes with few books have generally a much more negative opinion of Science and Technology with scores on average 0.5 lower than their compatriots from homes with many books.

The average score for pupils from homes where there are no books is only 2.00. The highest score with this group is for question 2, where pupils believe on average that Science and Technology will find cures for diseases with a score of 2.47 for girls and 2.61 for boys. This is also the question which gives the most positive score for all groups.

Generally pupils from homes where there are many books have a much more positive attitude to the benefits of science and technology and agree on its importance, its ability to make our lives healthier and more comfortable etc. Responses to Question 6 *The benefits of science are greater than the harmful effects it could have* are more positive where there are many books but even here there is not a hugely positive score at 2.60 for girls and 2.73 for boys. Interestingly for Question 10 *Science and Technology are the cause of the environmental problems* those from bookish households again score more highly.

There are however five questions where responses are similar for all groups and here the scores are universally low. Generally pupils do not think that *"science and technology can solve nearly all problems"* or that it can *"help the poor"*. They are also sceptical that the *"scientific method always comes up with the correct answers",* do not think that *"scientists are neutral and objective"* nor that *"we should trust what scientists have to say."*

11 Review of Responses - Section H: "My out of School Experiences"

This section comprises of 61 questions on pupils' experiences in science and technology out of school. In each case, pupils are asked to rate how frequently they have engaged in the activity concerned, on a four point range from 'never' to 'often.' The list includes some rather odd activities when looked at from a Scottish perspective but it has to be remembered that this is an international survey and has involved pupils in over 40 countries worldwide. Table 11.2 overleaf show the average Likert scores for all the 61 questions for all pupils and then for all boys and all girls.

For the purposes of this brief review the questions were grouped as follows.

Category	Questions
Modern technology	31,38,44,45,46,47,48,49,50,51.
Outside activities	1, (2),3,4,5,14,15,16,17,18,33.
Practical activities	19,20,21,22,23,24,30,32,34,35,37,39,40,41,42,43, 52,53,54,55,56,57,58,59,60,61.
Medical activities	25,26,27,28,29
Agricultural activities	6,7,10,11
Finding out about nature & science	8,9,12,13,36

Table 11.1 Grouping of the 61 Section H activities into categories

Not surprisingly the nine activities most widely described as frequently performed all involve 'modern technology'. The top nine list is the same for boys as for girls although the order is slightly different with boys playing computer games as their top activity while for girls it is using a mobile phone. Both groups regularly use the internet, download music, use a word processor, use a camera, send e-mail etc. The tenth item in the Modern technology category is use of *"a dictionary, encyclopaedia on a computer":* this comes in as the 14th most frequently performed activity.

Differences in responses between girls and boys.
Beyond the use of modern technology, differences between the genders are more marked, but also conform to a predictable pattern. Boys generally have had a more hands on approach to tools, wiring plugs, mending punctures, lighting a fire etc, although girls seem to have participated almost equally in preparing food on the campfire once lit. As also expected more boys have taken part in fishing, hunting, making bows and arrows and firing air guns. Girls on the other hand have been more interested in sowing seeds, collecting stones and shells and berries. They are also more involved in looking after animals and in knitting.

One of the biggest differences is in the reading of horoscopes, with girls being much more interested in this (Likert score 2.87 for girls and only 2.01 for boys). This interest in the stars is not reflected in an interest in finding star constellations in the sky for either boys or girls, with only 48.5% ever having looked for constellations in the skies.

Finding out about science and nature:
More girls than boys seem to have visited zoos but more boys have used a science kit. Neither boys nor girls show frequent interest in reading or watching nature or science programmes, but many (82.4%) have attended science centres, with 15.2% saying that they visited often. 89.8% of pupils have visited a zoo, with 22.8% saying that they visited often. 45% have never read about nature or science in books or magazines but only 32% have never watched such items on TV. Almost half of all girls have never used a science kit whereas only 38.8% of boys have not.

Item	ACTIVITY	ALL	GIRLS	BOYS
H01	tried to find the star constellations in the sky	1.88	1.90	1.86
H02	read my horroscope (telling future from the stars)	2.47	2.87	2.01
H03	read a map to find my way	2.21	2.12	2.30
H04	used a compass to find direction	1.80	1.68	1.94
H05	collected different stones or shells	2.15	2.33	1.93
H06	watched (not on TV) an animal being born	1.69	1.72	1.65
H07	cared for animals on a farm	1.90	2.00	1.78
H08	visited a zoo	2.75	2.86	2.63
H09	visited a science centre or science museum	2.48	2.50	2.47
H10	milked animals like cows, sheep or goats	1.41	1.39	1.43
H11	made dairy products like yoghurt, butter, cheese or ghee	1.38	1.36	1.40
H12	read about nature or science in books or magazines	1.89	1.90	1.88
H13	watched nature programmes on TV or in cinema	2.23	2.20	2.27
H14	collected edible berries, fruits, mushrooms or plants	1.95	2.07	1.81
H15	participated in hunting	1.54	1.33	1.79
H16	participated in fishing	2.02	1.77	2.30
H17	planted seeds and watched them grow	2.04	2.16	1.90
H18	made compost of grass, leaves or garbage	1.62	1.57	1.67
H19	made an instrument (eg flute or drum) from natural materials	1.50	1.47	1.53
H20	knitted, weaved etc.	1.89	2.12	1.61
H21	put up a tent or shelter	2.61	2.56	2.66
H22	made a fire from charcoal or wood	2.35	2.12	2.61
H23	prepared food over a campfire, open fire or stove burner	2.15	2.03	2.30
H24	sorted garbage for recycling or for appropriate disposal	2.09	2.09	2.08
H25	cleaned and bandaged a wound	2.38	2.43	2.32
H26	seen an X-ray of a part of my body	2.43	2.38	2.50
H27	taken medicines to prevent or cure illness or infection	2.90	3.02	2.77
H28	taken herbal medicines or had alternative treatments	1.75	1.75	1.74
H29	been to hospital as a patient	2.69	2.69	2.70
H30	used binoculars	2.67	2.61	2.75
H31	used a camera	3.43	3.59	3.25
H32	made a bow and arrow, slingshot, catapult or boomerang	2.03	1.74	2.37
H33	used an airgun or rifle	2.08	1.68	2.54
H34	used a water pump or siphon	1.83	1.60	2.10
H35	made a model such as a toy plane or boat etc	2.10	1.85	2.39
H36	used a science kit (like for chemistry, optics or electricity)	1.92	1.81	2.05
H37	used a windmill, watermill, waterwheel etc	1.52	1.44	1.61
H38	recorded on video, DVD or tape	3.23	3.28	3.17
H39	changed or fixed electric bulbs or fuses	2.41	2.20	2.65
H40	connected an electric lead to a plug etc	2.32	2.12	2.56
H41	used a stopwatch	3.03	3.07	2.99
H42	measured the temperature with a thermometer	2.75	2.80	2.71
H43	used a measuring ruler, tape or stick	3.16	3.22	3.09
H44	used a mobile phone	3.70	3.81	3.58
H45	sent or received an SMS (text message on a mobile phone)	3.66	3.79	3.52
H46	searched the internet for information	3.67	3.75	3.59
H47	played computer games	3.55	3.48	3.63
H48	used a dictionary, encyclopaedia etc on a computer	2.88	2.96	2.79
H49	downloaded music from the internet	3.32	3.34	3.30
H50	sent or received e-mail	3.54	3.66	3.41
H51	used a word processor on the computer	3.48	3.57	3.39
H52	opened a device (eg radio, watch, computer etc) to find out how it works	2.40	2.15	2.69
H53	baked bread, pastry, cake etc	2.84	3.11	2.54
H54	cooked a meal	3.05	3.22	2.86
H55	walked while balancing an object on my head	2.22	2.31	2.11
H56	used a wheelbarrow	2.41	2.32	2.52
H57	used a crowbar (jemmy)	1.92	1.58	2.30
H58	used a rope and pulley for lifting heavy things	2.04	1.84	2.26
H59	mended a bicycle tube	1.94	1.57	2.37
H60	used tools like a saw, screwdriver or hammer	2.78	2.53	3.06
H61	charged a car battery	1.64	1.40	1.92

Table 11.2 Mean Likert Score for Section H

Differences in responses in relation to number of books in the home

The number of books in the home does not influence the top ten most frequently performed activities appreciably, although pupils from Group 1 seem to download more music from the internet. *"Using an airgun or rifle"* comes high up the list for Group 1 boys, at 13th, whereas for Group 7 boys it is only 29th.

Table 11.3, however, makes it apparent that pupils from homes where there are many books have more often visited zoos and science centres and more often read and watch nature and science programmes.

Qu	Activity	ALL Pupils	All Girls	All Boys	Girls Gp 1	Girls Gp 7	Boys Gp 1	Boys Gp7
H08	visited a zoo	2.75	2.86	2.63	2.31	2.92	2.33	2.75
H09	visited a science centre or science museum	2.49	2.50	2.47	2.05	2.88	2.12	2.74
H12	read about nature or science in books or magazines	1.89	1.91	1.88	1.50	2.23	1.59	2.15
H13	Watched nature programmes on TV or in a cinema	2.23	2.20	2.27	1.83	2.47	2.01	2.62
H36	used a science kit (chemistry, optics or electricity,etc)	1.92	1.81	2.05	1.65	1.96	1.72	2.15

Table 11.3 Some Likert scores for activities 'finding out about' science

Horoscope reading is far less common with girls in homes where there are no books while it is greater where there are books in the home. Trying to find constellations in the sky was the second least popular activity for boys from Group 1 and was also very low in the Group 1 girls list. It is possible that this question may not have been understood by some pupils.

One might expect different book groups to identify different 'frequently engaged' activities, but it comes as a little bit of a surprise that in this Section, as elsewhere in the survey, those with fewer books at home give lower average scores. This probably reflects that they engage in **fewer** of the activities listed, though we have not had time to investigate this, as opposed to the other possibility that they might on average be more lethargic, or unenthusiastic, about the sorts of activities listed as a whole.

Fig 11.1 shows the average Likert scores in Sec H for pupils in the different book groups. The overall difference in scores between Group 7 and Group 1 is significant at 0.35 with Group 7 pupils being more active in participation in most topics. Average scores for individual questions can vary by large amounts, particularly for girls where there can be a difference in score of over 0.90. For example girls from Group 7 collect shells, knit, sort garbage and bake cakes more frequently than Group 1 girls and Group 7 boys participated more in map reading and compass work than Group 1 boys.

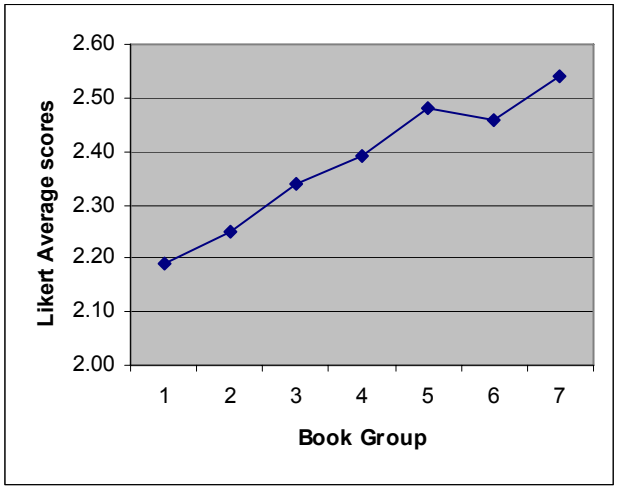


Figure 11.1 Likert scores for Section H against number of books in home

12. Review of Responses - Section I: "Myself as a scientist"

This section asks the pupil to assume that they are grown up and work as a scientist and that they are free to do research that they find important and interesting. They are then asked to write down what they would like to do as a researcher and why. This task comes towards the end of the questionnaire and quite a number of pupils did not attempt it. A few (6) ventured that they found science boring and would not wish to be a scientist under any circumstances. Some also entered a future non-science related career.

Responses to this section had been entered mainly by hand and there has not been time for a detailed analysis and only a brief survey has been done. As there was a very limited time available for the pupil to provide a considered response it might be of questionable value in any event to carry out an in-depth analysis for this section. It appears that quite a few have looked for inspiration to the actual survey itself, as quite a few responses mirror items from the questionnaire.

In all 940 results were entered on the computer and 838 have been put into general broad categories as shown in the table below:

Topic	Number of responses
Cure and treatment of diseases	265
The human body	25
Cloning	33
Study of animals	109
Plants	5
Marine life	7
Evolution and creation	20
Supernatural and dreams	39
Environmental science and pollution	34
Sports science and fitness	25
Chemistry and biochemistry	35
Bombs and explosives	13
Cosmetics and perfumes	6
Physics	5
Alternative sources of energy (including a few nuclear)	17
Forensic science	23
Modern technology/ engineering	32
Alternatives to animal testing	12
Weather related events; hurricanes, earthquakes etc.	5
Space related topics	128
Total	838

Table 12.1 Responses indicating potential personal research interest, by subject area

The most popular response was to research cures for diseases and the most common ambition was to find a cure for cancer, although other diseases were mentioned such as diabetes, HIV/AIDS and the common cold. One respondent mentioned bird flu which was a very topical issue at the time. Some of the responses were quite touching as they sometimes gave as a reason that they had lost a relative to the disease concerned.

Not surprisingly space was next on the list and here topics included discovering new planets, black holes and space travel.

In the light of our analysis of earlier sections, it is perhaps surprising that research involving animals comes third in terms of the number of responses (accounting for 11% of the analysable responses, though this represents under 4% of all of those surveyed). Priorities here included animal behaviour, health and prevention from extinction, though also the study of *"violent and dangerous animals"*.

Beyond this, responses were quite widely spread. Some wished to research the supernatural wanting to find out more about creation and evolution and how humans came to inhabit the planet. Some expressed an interest in finding out about chemicals and carrying out experiments. A few wanted to produce better cars, engines and other devices and looking at alternative forms of energy was considered by a few. Notwithstanding the reluctance of pupils in general to be involved in environmental work a few did show an interest in research in the environment and pollution. Other than for "space" only a tiny number of responses nominated physics topics.

In the time available, no effort was made to separate responses in gender terms or to look at those interested in a particular area and to match this with there responses elsewhere in the questionnaire.

These conclusions are consistent with other studies[16], in that biomedical and space science are the research areas which most interest the 14-15 age range.

[16] Jenkins, E.W. and Pell, R.G. (2006) The Relevance of Science Education Project (ROSE) in England: a summary of findings. Centre for Studies in Science and Mathematics Education, University of Leeds

13 Review of Responses: Grouped by School

A total of 92 secondary schools participated in the survey, returning an average of 30 valid pupil responses per school. The schools were drawn from 31 of the 32 local authority areas in Scotland. 85 of the schools surveyed are managed through local authorities, and 7 in the independent sector. Most schools surveyed two science classes: all surveyed at least one class studying the higher level of curriculum (SG or Int2 courses in biology, chemistry or physics) and 76 surveyed classes studying at the lower level (SG science or individual subjects at 'Int1' level).

We aggregated the data for all pupils studying at a given school at a given level. This gives grouped data for each school surveyed, with two groups for schools that surveyed classes at both levels, giving 168 records in all (92 for classes at the upper study level and 76 for classes at the lower study level). Each record holds the mean Likert score for its group in each of the questions in Secs A – H and Sec K. Other data included are:

- the number of pupils in each group, also broken down by gender
- the numbers estimating the no of books in their home in the ranges 0 – 10, 11 – 100, and over 100 (derived from Sec J)
- the total pupil roll for the school (all year levels) for the 2005/06 session
- the official SEED statistic for the percentage of pupils at the school eligible for free school meals

One of our team (SF) also prepared a Teacher Survey (see Appendix 1) that the class teachers agreed to complete whilst their pupils were completing the ROSE survey. This provides further useful data that can be embedded in the aggregated records to enable fuller analysis of the similarities or differences in pupil views for different class groups. This has not been done, however, for the present Report.

There is considerable scope to study the dependence of pupil opinions and attitudes in relation to their class context. Relevant factors might include the social mix of the group, whether the school is in an urban, suburban or rural area, whether facilities have recently been upgraded, indicators of the school ethos, etc. For this preliminary report we have looked only at a very limited number of factors, and have studied these only at a quite superficial level.

13.1 Variation in overall interest in learning science

The 108 items in Secs A, C and E all seek expressions of interest in learning about particular science topics. The overall mean Likert score across all of these items can be taken as providing a crude overall measure of a pupil's interest in learning science. Across all pupils this score averaged 2.40 (ie 'not interested' responses over the 108 topics somewhat out-weighed 'interested' responses). Across all pupils this summary indicator is slightly influenced by gender (mean score 2.38 for girls, versus 2.42 for boys), and varies more significantly with level of study (mean score 2.47 for pupils studying at the upper level, versus 2.27 for those studying at the lower level).

There is however, a very wide variation in the mean scores for different class groups, ranging from an enthusiastic average score of 2.95 for a class group at one Highland school (Gairloch High School), to an extremely negative average of 1.79 for one group in a South Ayrshire school. The 92 class groups studying at the upper level have average scores ranging from 2.95 to 2.07, while for the 76 lower level classes the range is from 2.86 to 1.79. These ranges represent enormous difference in attitudes for different class groups studying in similar contexts.

Attainment statistics for schools in Scotland are known to correlate strongly with the percentage of pupils assessed as eligible to receive free school meals, a statistic widely used as a measure of the relative social deprivation of the school's population. This measure does not seem, however, to be significant in helping explain the wide variability amongst class-groups in interest in learning science. The Pearson correlation coefficient between 'percent eligible for free meals' and 'Mean ACE score' values is only 0.027. Fig 13.1 shows a scatter plot for the 168 class groups.

On the other hand we do find a significant correlation between interest in learning science and questionnaire responses estimating the number of books in the pupil's home. For each class, as outlined above, we recorded the numbers of pupils giving 'low', 'mid' and 'high' estimates. By giving these weightings of 0, 1 and 2 respectively, we derived an 'average book score' for each class. In this case the Pearson correlation coefficient with 'Mean ACE score' is 0.491, statistically significant beyond the 99% confidence level. The corresponding scatter plot is given in Fig 13.2.

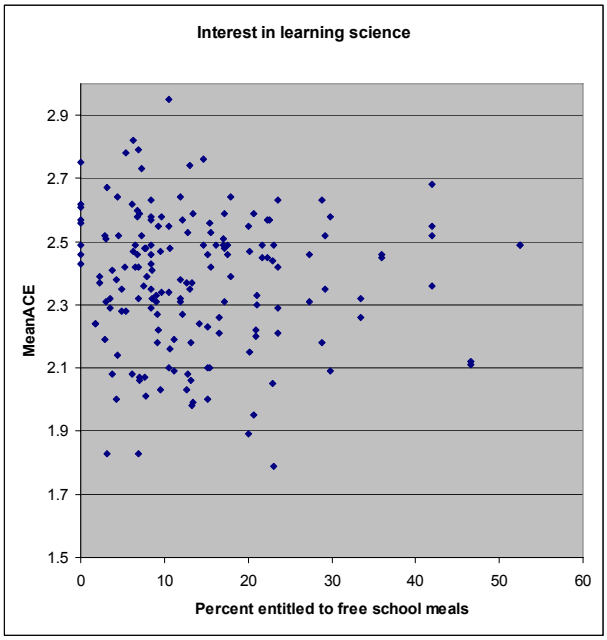


Fig 13.1 **Scatter plot of mean ACE score against % free school meals entitlement**

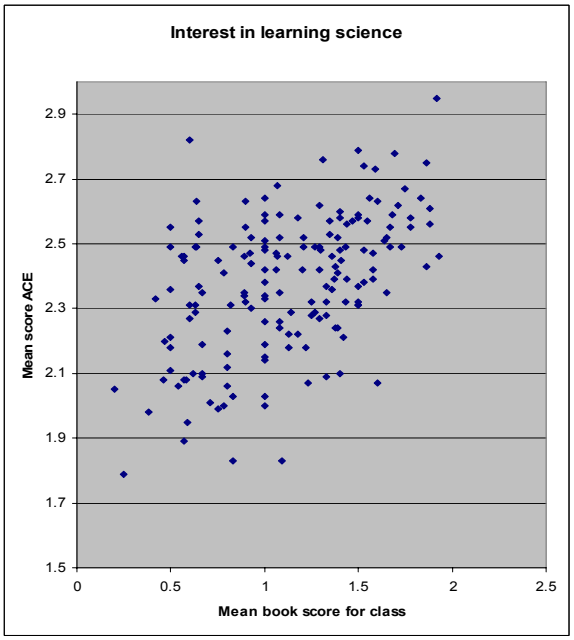


Fig 13.2 **Scatter plot of mean ACE score vs 'mean book score' for class**

We suspect that a number of factors from the social and educational experience of pupils may have a significant influence on their disposition towards science. Researching these could be significant in informing strategies to enhance general interest and engagement with science. We think that our data is indicative that there may be significant 'class cohort effects'.

For those studying the upper level curricula, the 10 school class groups with the **highest** 'Mean ACE score' are widely scattered across Scotland, with one independent and nine managed through local authorities. They include a class group in Smithycroft Secondary School (Glasgow) where 43% of pupils are eligible for free meals. The 10 school class groups with the **lowest** 'Mean ACE score' are similarly widely scattered and seemingly diverse.

Whilst overall the class groups studying the lower level curricula express significantly less interest in learning science, the 72 different class groups vary enormously in enthusiasm. The mean ACE scores of the top five overlap the range for the top 11 'upper level' classes. The 'top' and 'bottom' groups, though very different in disposition towards science, do not look

dramatically different in geography, school meals entitlement or book scores. That said, the group with the lowest mean ACE score of all also has the second lowest recorded average book score.

When mean Likert scores for Sections ACE for individual schools within a Local Authority are examined large differences are found which do not correlate to the school meals entitlement for the different schools. If upper level classes are compared a difference in 0.55 in the Likert score is obtained for one LA and the difference for lower level classes is similar. Generally average Likert scores are lower for the lower level classes although some achieve mean Likert scores over 2.5.

13.2 Variations in opinions about science & technology

Interest in learning about science is one concern, another is recognition of the importance and significance of science to society. This is covered in Sec G of the survey, where pupils are asked to agree or disagree with various statements. For 13 of the 16 items, a high Likert score reflects a positive view of science & technology. We have produced a 'Mean G score' from pupil responses to these 13 items (the Sec G responses excluded from this summary statistic are G10, G12 and G16).

A front line aim of the school science curriculum might be to enhance interest in learning science. A significant public policy agenda is also to encourage positive views about the importance and value of science to society. It is of interest whether these two aims complement and reinforce each other. The ROSE survey suggests that there is indeed a close association (the Pearson correlation coefficient between 'Mean ACE score' and 'Mean G score' for individual pupils is 0.515, significant at the 99% confidence level).

Interestingly, the correlation is even stronger when these measures are averaged over whole class groups; the Pearson coefficient increases to 0.806. We wonder if this might be evidence of a useful 'peer group' or 'teacher influence' effect. Given that overall interest and attitudes are net negative this is not particularly reassuring as things stand. However, it might give hope that working to enhance interest might act to advance attitudes, and vice versa. In addition, there may be an indication that interaction within a class group might serve to enhance positive impacts.

However, though the correlation between interest and attitudes is strong, these remain two separate issues. If the class groups are ordered by mean G score, the ranking in detail does change. For instance for the upper level curriculum classes, the 'top' school in the ACE rankings drops to 22nd in terms of 'Mean G score' whilst the previous 75th ranked school is in 10th place: just three schools are in the 'top 10' under both measures. At present school science curricula do very little indeed to engage directly with issues about the significance of science to society and lifestyle: it would seem important to remedy this.

13.3 Comparison of schools in different geographical areas

One general lesson of this survey is that there tends to be little unanimity in pupil responses. The typical pupil is not represented by the average item scores; there is a wide mix of outlooks and opinions. Any focused curriculum response should ideally work with a basket of topics and issues, aiming to make positive impacts on the majority of pupils in different ways, with some hope that progress, once made, might make further advance easier.

It seemed very possible that there might be very different relative interests in different topics for pupils in geographically different types of area, or in different kinds of school community. To test this we aggregated the data for all pupils surveyed in Glasgow and Highland local authority schools, and also all pupils surveyed at independent schools. We analysed the data separately for those studying the higher and lower level science courses. In the case of the independent schools we only reviewed those studying at the higher level, as for these schools our sample included only one small class studying a lower level science course.

For each group we computed the mean Likert score for each of the 108 items in Secs A, C and E of the survey. These scores reflect the relative interest, or lack of interest, in 'learning about' each specific topic. For each group we ranked the items, from 1 to 108, in order of net popularity. For comparison purposes we also did this ranking for all pupils in the Scottish survey, and for all pupils surveyed in Scotland at each of the two levels of science courses. We have reproduced this extensive list in Appendix 3.

The first point to make is that the different subgroups differed significantly in their **overall** average Likert score (over all 108 items). The average score for the whole survey is 2.40 (representing a net predominance of 'not interested' responses – probably roughly in a majority by about 55% to 45% - see Sec 4 above). Those studying higher level courses were on average more interested, but with overall mean Likert scores ranging from 2.46 in Glasgow to 2.59 in Highland (the higher figure representing roughly a 55% to 45% majority of answers expressing net positive interest). The independent sector group was marginally less positive than the Highland sample (mean overall Likert score 2.56). For pupils studying the lower level courses, both the Glasgow and the Highland groups scored slightly more highly than the national average of 2.26. Interestingly in this group the Glasgow pupils expressed a higher level of interest than their counterparts in the Highlands (2.32 versus 2.28).

On the other hand, in terms of their relative interest in one topic versus another, there is a quite astonishing level of agreement between all of the eight different subgroups analysed. If one selects the ten most popular topics averaged over all pupils surveyed in Scotland, then none of the subgroups has less that seven of these in its own 'top ten.' All 8 subgroups agree as to which is the 'most uninteresting' of the 108 topics (*"symmetries and patterns in leaves and flowers"*). All but one subgroup share at least 8 of their 'bottom ten' topics (the 'lower level' Highland group share just 6 of these).

The most popular topics are nearly all associated with actual or potential personal experiences or impacts, covering topics such as dreams, cancer, weightlessness, exercise and fitness, and the impacts of drugs, poisons and electric shocks. Explosive chemicals and dangerous animals are also topics of high appeal, possibly because of potential personal risks. At the other end of the scale it seems that botanical and agricultural topics are regarded as deeply uninteresting (providing 6 of the bottom ten topics). Pupils do not apparently want to learn about famous scientists and other items on the nature or history of science are mostly ranked towards the bottom of the list.

If one wishes to communicate an appreciation of the progress of science as a whole, the results suggest that a good place to start could be to review 'phenomena that scientists still cannot explain.' This just makes it into the top third in the overall rankings, and indeed into the top ten for upper level course pupils in Highland and independent schools. Whilst looking at unsolved issues might seem a negative starting point, it could be possible easily to move on to a more retrospective view of 'inventions and discoveries that have changed the world,' another topic in

the top half of the overall popularity table. It could be particularly productive to take this approach initially in the context of progress and challenges in medicine.

The survey results seem highly consistent with modern experience that it is difficult to attract interest in pursuing higher level study or careers devoted to the physical sciences. The great majority of items related directly to physics or chemistry are to be found in the lower reaches of the popularity list. The striking exception is 'explosive chemicals.' A number of relatively popular topics would involve some space or earth science physics. Among the items we classed as primarily about physical science the second highest placing goes to *"chemicals, their properties and how they react":* this ranks only 51st in the overall list, but is placed significantly higher than that for pupils following lower level science courses.

Topics related to technology are also concentrated towards the bottom end of the popularity rankings. In relative terms there is significantly more interest in how computers, mobile phones, atomic bombs and medical technologies work. There is much less interest in technologies perhaps seen as less modern or remote from individual impact: how crude oil is the source of materials is regarded as profoundly uninteresting, and there is little enthusiasm to learn about, for instance, satellite communication, nuclear power plants or engines.

13.4 Potential for Further Study

There is much more in detail potentially to be learned from further work on analysis of the survey at the school level. Whilst there are great similarities in the **relative** interest levels of pupils in different topics, there are huge differences in their **absolute** levels of interest. Whilst there are some clear correlations between 'average interest' levels and factors such as the subjects and level being studied, and exposure to books in the home, there seem in addition to be significant differences between similar classes in different individual schools. The teacher survey contains much further useful information at the class level and it would seem well worth while to link this to the data with the aim of seeking out further insights into factors that may positively influence pupil views.

There are topics of inherent importance to understanding the world (eg 'atoms and molecules'), or to judging important social or economic issues (eg factors influencing global warming). When pupils have indicated their lack of interest in learning about a topic that they have already been exposed to, in some cases it could be helpful simply to replace that topic with an inherently more motivating alternative. Where the topic concerned is regarded as of key importance to understanding science, then the response should switch to some reappraisal of the approach taken in introducing it.

When pupils express a lack of interest in a topic they know very little about, this should prompt thinking about strategies that might spark their interest. For instance, the survey reveals a considerable lack of interest in learning about human influence on the greenhouse effect. However it shows relative enthusiasm for issues affecting human life and fitness, and for extreme climatic events; both of these are topics that could set the scene for studying the greenhouse threat.

In summary, the preliminary review given above is only a small first step in mining the schools data set for valuable lessons.

13.5 *A footnote:* Relationship between the school meals entitlement and the mean book score indicators

Fig 13.3 below shows the scatter plot relating our data for the mean book score we computed for each class group in a school and the percentage free school meals entitlement for the school concerned. This plot includes only Local Authority schools. It will be seen that for most schools where the percent entitlement to free school meals is high our mean book indicator for the class is below the average value of 1.20 for all LA schools. When looking at schools where the meals entitlement is lower, however, there is a much wider spread of mean book scores about the 1.20 mean. Thus, for those schools serving more economically deprived catchment areas there are few class groups with high average book scores. On the other hand, there are many classes with low average book scores in schools drawing from seemingly more prosperous catchments.

The average book score for the independent schools in our survey was appreciably higher than the average for LA schools, at 1.80.

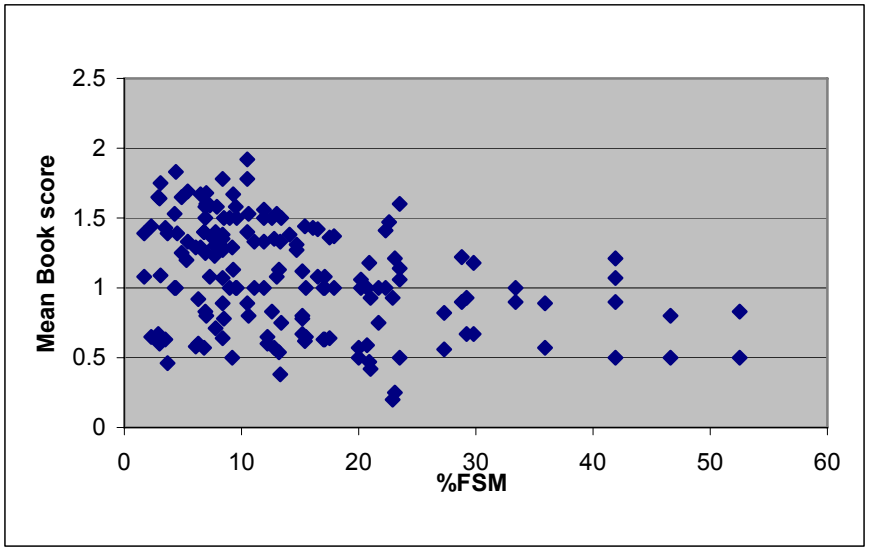


Fig 13.3 Scatter plot of mean book score versus % school meals entitlement

14 Categorising pupils by their overall interest in science

In many areas above we have reviewed differences in pupil responses related to gender, their course of study, and the number of books they estimate are in their homes.

Questions F02 and F05, respectively, ask pupils the extent to which they view school science as interesting and the extent to which they like science better than most other subjects. We reported in Sec 9 above that the overall response was quite positive for the first of these questions, but quite negative for the second. Ogawa and Shimode, of Kobe University in Japan, have suggested[17] using these two questions to divide pupils into four categories:

i. 'pro-science': (Specific priority group[18]) those agreeing both that science is interesting both absolutely and relative to other subjects
ii. 'latent pro-science': (non-positive priority group) those disagreeing that science is interesting absolutely, yet who like it relative to other subjects
iii. 'apparent pro-science': (other priority group) those agreeing that science is interesting absolutely, but who nonetheless rate it low in preference compared to other subjects
iv. 'anti-science': (Poor priority group) those disagreeing on both counts

The suggestion is that if we can identify the characteristics of each group in terms of their interests in scientific topics and their out of school experiences we might be able to find different ways of better engaging some pupils in their science lessons. Table 14.1 cross tabulates the responses to questions F02 and F05 for all pupils who answered both questions. Table 14.2 then derives their breakdown into the above four categories, setting the outcome against the comparable results published for Japan and England[19].

Gender			F05: I like school science better than most other subjects			
			Disagree	Low disagree	Low agree	Agree
Girl	F02: School science is interesting	Disagree	147	17	10	2
		Low disagree	186	100	28	2
		Low agree	157	266	148	36
		Agree	32	57	104	118
Boy	F02: School science is interesting	Disagree	120	19	10	6
		Low disagree	91	79	44	5
		Low agree	97	231	142	35
		Agree	38	59	128	132

Table 14.1 Cross-tabulation, by gender, of responses to questions F02 and F05

	Gender	Pro -science	Latent pro-science	Anti science	Apparent pro-science
SCOTLAND	Girls	28.8%	2.9%	31.9%	36.3%
	Boys	35.3%	5.3%	25.0%	34.4%
ENGLAND	Girls	20.6%	2.5%	42.2%	34.7%
	Boys	36.3%	3.3%	29.5%	31.0%
JAPAN	Girls	26.2%	2.2%	40.8%	30.7%
	Boys	39.4%	2.5%	25.5%	32.6%

Table 14.2 Breakdown into science interest categories, for Scotland, England and Japan

[17] M Ogawa and S Shimode, Journal of Science Education in Japan, Vol. 28, No.4
[18] These are the names given by M Ogawa and S Shimode.
[19] Refs to Japan and England values, presumably ref 1 above and Jenkins

The general pattern is somewhat similar for all three countries. In all three cases significantly fewer girls than boys are 'pro-science' and more girls than boys are 'anti-science'. In Scotland, however, the gender differences are somewhat smaller than in England or Japan, as is the overall 'anti-science' group. The 'apparent pro-science' group holds just over a third of all boys and a third of all girls and, in principle, educational strategies designed to engage these pupils more strongly could be very productive in increasing interest in higher level science courses and science-based careers.

In a preliminary effort to find distinctive patterns of responses we have investigated the mean Likert scores for each of these groups for a number of other questions from the survey. The results are shown in Table 14.3

Disposition towards science	pro-science		latent pro-science		anti-science		apparent pro-science	
Question	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
A17: atoms and molecules.	2.42	2.62	1.66	2.01	1.47	1.73	1.96	2.19
A31: explosive chemicals	3.05	3.55	2.45	3.22	2.45	3.00	2.71	3.31
F14: would like to become a scientist	2.21	2.42	1.69	2.22	1.27	1.43	1.51	1.71
F15: would like as much science as possible at school.	2.70	2.74	1.97	2.13	1.55	1.51	1.89	2.02
G06: the benefits of science are greater than the harmful effects it could have	2.57	2.85	2.20	2.64	2.15	2.15	2.43	2.54
H36: used a science kit (like chemistry, optics or electricity)	2.12	2.30	1.83	2.04	1.55	1.80	1.80	2.04
A36: how the eye can see light and colours	2.60	2.48	2.38	2.15	2.08	2.04	2.51	2.35
C06: how mobile phones can send and receive messages	2.66	2.75	2.43	2.57	2.33	2.41	2.59	2.75
E14: the possible radiation dangers of mobile phones and computers	2.73	2.75	2.56	2.41	2.18	2.12	2.52	2.53

Table 14.3 Likert scores for selected questions for groups differently disposed towards science

The selected questions are such that in every case higher Likert scores reflect a more positive position in regard to science. One would expect the pro-science group to be most positive and the anti-science group most negative, with the intermediate groups in between. Indeed these trends are shown, in most cases with very large differences in the balance of opinion across the groups. There seem to be few new strong clues on how most readily to focus in order especially to engage the middle groups. We do note however that the extent of the differences between different groups is less extreme for some topic areas than others.

This approach of cross-tabulation can be applied choosing different core questions to categorise different pupils. The aim would continue to be to discover the underlying characteristics of the different groups so that their interests and attitudes to scientific topics can be identified, and this information then used to stimulate interest in the school curriculum for the groups at present who are not engaged. We briefly look, below, at one other such approach.

Categorisation by interest in a science career
Pupils were subdivided into four groups depending on their response to question F14; *I would like to become a scientist*, and differences in the mean Likert scores of these groups then reviewed over a series of questions. The results are set out in Table 14.4.

Root question: F14 **I would like to become a scientist**	Disagree Score 1	Low disagree Score 2	Low agree Score 3	Agree Score 4
	N=1458	N=598	N=409	N=214
Cross-tabulated questions				
H12: read about nature or science in books or magazines	1.65	2.00	2.32	2.47
H13: watched nature programmes on TV or in cinema	2.02	2.35	2.56	2.68
H36: used a science kit (like for chemistry, optics or electricity)	1.74	1.97	2.21	2.49
G06: the benefits of science are greater than the harmful effects it could have	2.26	2.55	2.79	2.91
G08: science and technology can solve nearly all problems	1.89	2.15	2.29	2.51
G10: science and technology are the cause of the environmental problems	2.19	2.35	2.48	2.45
G14: we should always trust what scientists have to say	1.63	1.91	2.00	2.05
A17: (learn about) atoms and molecules	1.80	2.25	2.41	2.67
E14: (learn about) very recent inventions and discoveries in science and technology	2.11	2.54	2.76	2.90

Table 14.4 Likert scores for selected questions versus interest in 'becoming a scientist'

Again the expected trends appear, uninterrupted in any of the selected questions. Again, all of the differences are significant and some are very large. The three questions from Section H make it clear that an interest in a science career is very strongly correlated with relevant informal practice in reading, viewing or hobbies.

It was noted, in Sec 10 above, that a small majority of all pupils disagreed with statement G06 about the net beneficial impact of science, and it is interesting that the top three of the above subgroups are net positive: the lowest group (by far the largest numerically) is much more negative than the others.

Trust in what scientists say (G14) is greater among would-be scientists, but the Likert score is still very low. In fact, in terms of the percentage agreeing with the question, only 27.2% of the top group do so.

15. International comparison of results

The ROSE survey has been carried out in over 40 countries. A comparison, in Table 13.1 below, of mean Likert scores for girls and boys in some relatively randomly selected questions indicates that the Scottish results are quite similar to those of England and more particularly to Northern Ireland.

ROSE Question	Scotland		England		N. Ireland	
	Girls	Boys	Girls	Boys	Girls	Boys
A 17 (learn about) atoms and molecules	1.94	2.21	1.80	2.40	1.80	1.95
A22 (learn about)black holes and supernovas	2.33	2.83	2.70	3.15	2.55	2.9
A30 (learn about)how the atom bomb functions	2.22	2.98	2.25	3.25	2.30	3.2
B1 Working with people rather than things	3.17	2.74	3.25	2.75	3.25	2.75
B7 Working with machines and tools	1.63	2.77	1.70	2.55	1.80	2.80
D4 S&T can solve all environment problems	1.95	2.25	1.90	2.35	2.05	2.45
D13 Envir. problems should be left to experts	2.15	2.24	2.00	2.25	2.20	2.25
F5 Like school science better than most other subjects	2.06	2.28	1.80	2.25	2.05	2.25
F9 School science has made me more critical and sceptical	2.22	2.40	2.20	2.40	2.20	2.30
F14 Would like to become a scientist	1.64	1.92	1.55	1.90	1.75	1.90
F16 Would like to get a job in technology	1.61	2.35	1.65	2.45	1.65	2.55
G1 S&T are important for society	2.65	2.80	2.90	3.10	2.80	3.00
G6 Benefits of science are greater than the harmful effects it could cause	2.38	2.55	2.50	2.60	2.50	2.65
G9 S&T are helping the poor	2.06	2.17	2.05	2.35	2.05	2.30
G14 We should always trust what scientists say	1.74	1.83	1.60	1.85	1.75	1.80
H35 Made a model such as plane/boat	1.85	2.39	1.85	2.00	1.85	1.90
H60 Used tools, eg. saw, screwdriver	2.53	3.06	2.60	3.20	2.55	3.30

Table 15.1 Mean Likert scores in selected questions for Scotland, England and N. Ireland

Whilst there are some moderately significant differences (eg boys in England are more attracted to learning about supernovae and black holes whereas boys in Scotland are more likely to have made models), there are no glaring divergences and most of the values for the three UK countries are very closely similar. The overall issues which we have identified earlier in this Report are likely to apply with equal force in England and (especially) in Northern Ireland. This does not seem very surprising, as the science educational curricula followed are broadly similar in style. Data is given in bar chart form in Fig 15.1 below.

Many of the questions in Sections A, C & E do not have high Likert scores and the average for all of the ACE questions in Scotland is 2.40. This is similar to other countries in the developed world and it should be noted that the score for Finland is even lower at 2.3: Finland is widely reckoned to have a strong educational system, although it shares the same concerns as other developed countries in how to attract more pupils to STEM subjects.

Internationally, school science is not seen by pupils as developing their critical abilities, existing courses do not seem to motivate or enthuse them to pursue science related careers, and most say that they do not rate school science among their favourite subjects. Most, however, agree that science is important for society.

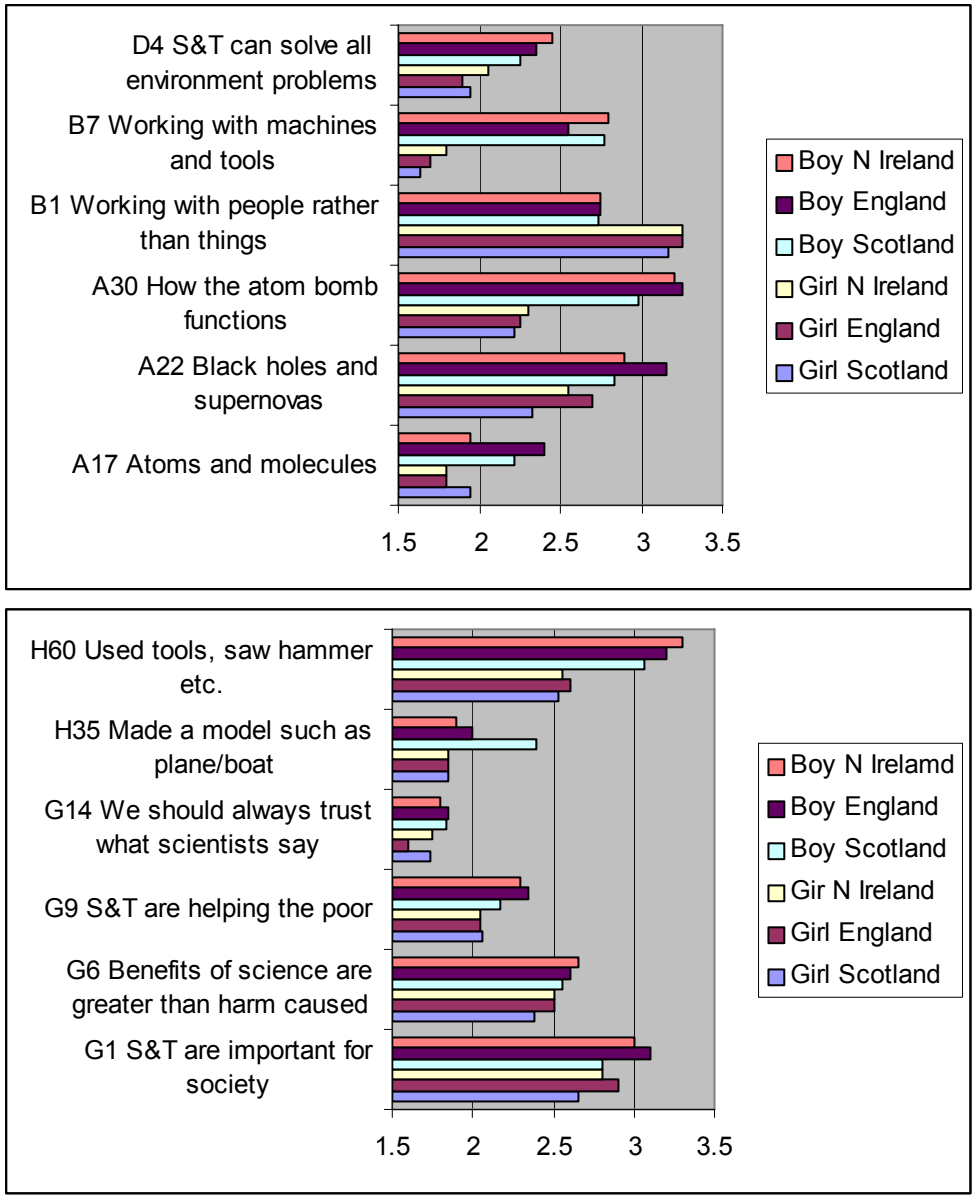
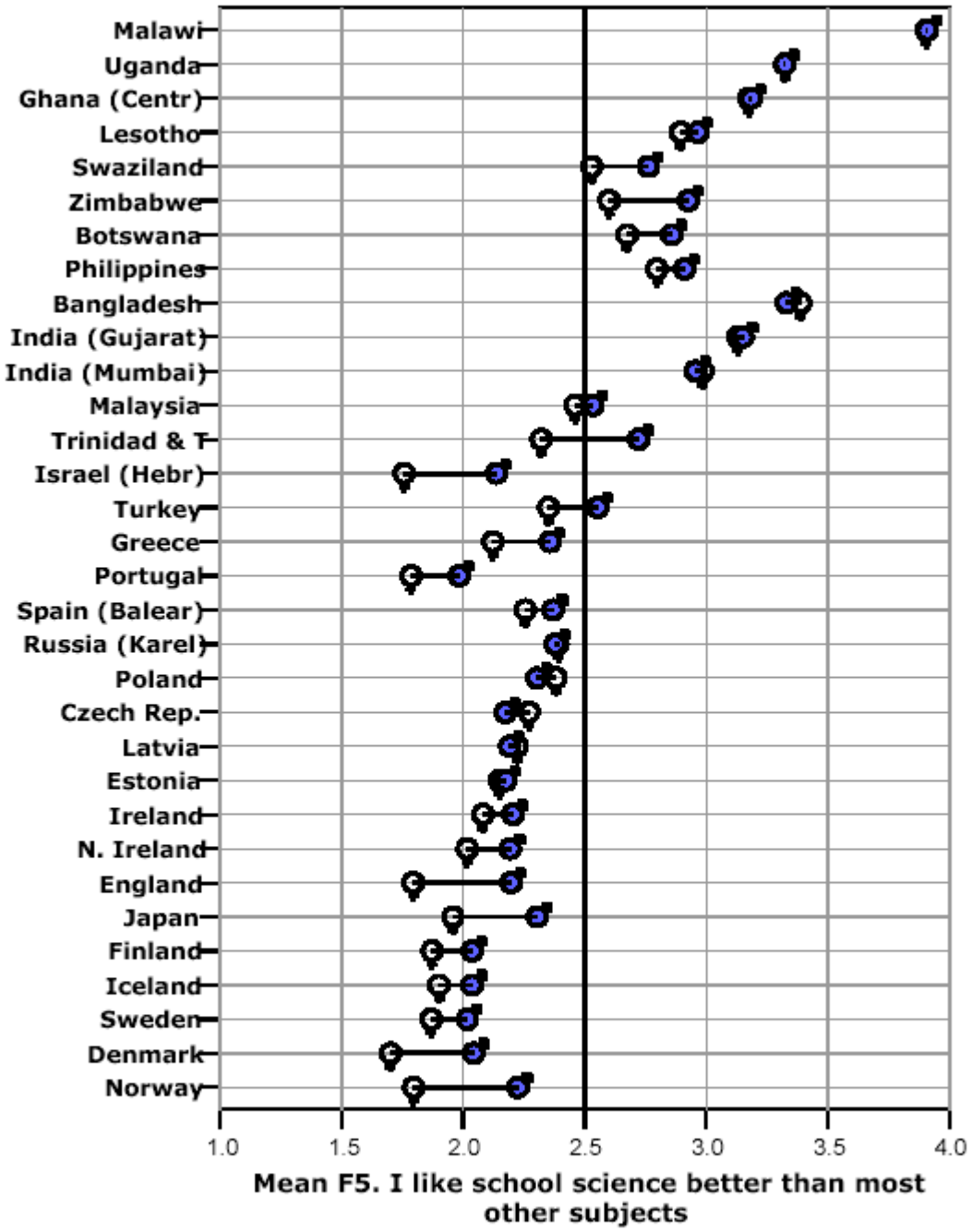


Figure 15.1 Charts of Likert scores for pupils from Scotland, England and N Ireland for selected questions.

Statement F05: *"I like school science better than most other subjects"*, receives a net negative response that is very similar to that of N Ireland. When this question is reviewed internationally[20] it is found that scores are low in most European countries and only exceed the 2.5 mark for the comparatively undeveloped countries such as Malawi, Uganda and India. See Fig 15.2. The mean score for Scotland is 2.06 for girls and 2.28 for boys.

Statement G14: *"We should always trust what scientists have to say"*, is overwhelmingly rejected in many countries according to the results available to date in this international survey with only three African countries and Bangladesh signalling majority agreement with a mean Likert score above 2.50. See Fig 15.3. The mean score for Scotland is 1.74 for girls and 1.83 for boys as shown in Table 15.1 and in Figure 15.1.

[20] Figures obtained from Professor Svein Sjoberg of the University of Oslo



1 = disagree, 4 = agree

Figure 15.2 International comparison of mean scores[21] for item F05: - results from Scotland 2.06 (girls) and 2.28 (boys)

[21] Figs 15.2 and 15.3 are reproduced from SPSS graphs provided by Professor Svein Sjoberg

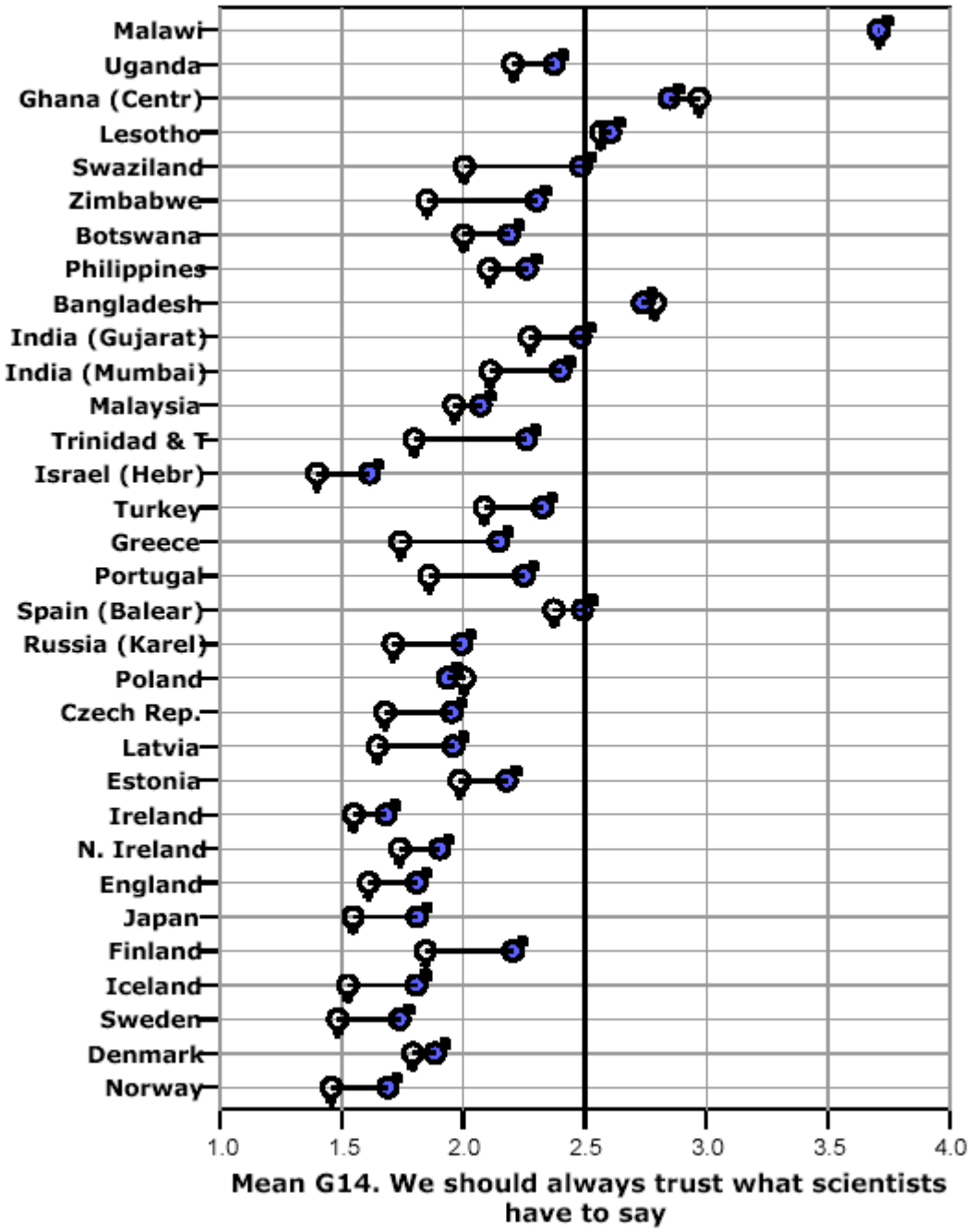


Figure 15.2 International comparison of mean scores[24] for item G14:
- results from Scotland 1.74 (girls) and 1.83 (boys)

16 Recommendations for future work and analysis

The work done for this initial report simply scratches the surface in terms of the analyses that the Scottish ROSE returns could support. On the other hand we believe that this relatively superficial study suggests that there is much of substance to learn from the data. Two distinct lines of application can in our view be profitably pursued.

1. The findings could be used to inform a review of science and technology curricula in schools. This would, we believe, require quite a depth of further study, involving science education researchers and probably justifying a PhD project. The survey suggests topic areas that would readily be well received in the classroom, and it will be important to recognise that somewhat different choices may be appropriate for different groups. Deeper analysis of attitudes might also suggest optimum ways to approach important but less immediately appealing topics. There are also key issues where, to strengthen appreciation of how important it is for society to engage constructively in supporting and helping steer a sensible course in exploiting science, the survey pinpoints obstacles and challenges. When attempting to address these challenges within formal education, careful attention must always be devoted to pedagogic aspects.

2. In support of more general 'science and society' strategies the first call is to promote detailed discussion of the survey results with practitioners in the field, to be followed up by work to tease out how the ROSE evidence can be intelligently used to influence strategy and planning. Again, it will be important to recognise that different approaches may be required for different types of groups. Such an approach is also likely to suggest a number of small scale follow up investigations, to examine broadly how views change (and probably harden) with age, and to throw more detailed light on how best to address some important but difficult issues.

Our data can be further analysed in many ways, of which the following are a selection.

- The data obtained in the teachers' questionnaire has not so far been reviewed, let alone linked with the pupil data. Our analysis of results by schools has shown large variations between class groups of seemingly similar characteristics. An understanding of such variations might usefully inform enhancement strategies, and the teacher returns may well help illuminate the issues.

- We also think there is significant scope for more work on what interests those pupils who are currently 'switched off' from science. It would be useful to consider different ways of grouping pupils in a bid to gain insights into this. Section 14 above represents an initial effort of that nature but it seems clear that much more work might be required to tackle the issue more effectively.

- We believe that interest in science or technology, once engaged at all, may then relatively more readily be amplified through further study: the gradient of the 'uphill struggle' may become less severe as progress is secured. If one starts from a position faced with pupil scepticism and dislike, it is a useful tactic to make the first steps as appealing as possible. Whilst it would not serve the interests of effective education simply to choose topics for study purely on the basis of their likely popularity, there would seem to be many ways to devise approaches geared to attract stronger pupil interest and engagement. Tentative illustrations of such an approach are touched on in Sections 13.3 and 13.4 above, taking as examples possible approaches to discussing the mechanisms of global warming, and to

communicating the profound impact of science on the way we now lead our lives. There is scope for much more analysis of this kind.

- The ROSE data could be analysed to provide evidence for science centres and museums in developing exhibits and events to excite young people and adults, and to encourage more to visit centres. It could also inform strategies they might adopt to address and perhaps challenge the negative views about applications of science and technology that many young people have. The survey could be a starting point towards developing parallel studies of attitudes among different age groups.

The most important messages from the ROSE study are for the review of the school curriculum. In Sec 6.5 above we made some comments on that issue, and we conclude this Report with an extract from the discussion there, which we feel sets the relevance of ROSE in context:

> *In considering the context for a revised curriculum it is important to consider how children are taught science. Much of the ROSE survey looks at what is to be taught. There are messages in section K about the role of practical work and these messages tend to be positive. Research into teaching and learning styles and strategies, in particular those found in formative assessment studies, offer teachers clear messages about the value of collaborative learning activities, of the importance of allowing learners to find their own voice and the power of skilled questioning. It is likely that the 'assessment is for learning' movement, being embraced by most of Scotland's schools in some way or another, will have a positive effect on the learning experiences of all children. A further development of the ROSE survey might look at attitudes towards learning and teaching styles and in particular those relating to formative assessment and also to extended practical projects. What is apparent is that research is providing important messages about teaching and learning which sit alongside messages about the realignment of science curriculum activities. Together these messages offer the potential to revitalise the experience of science offered to Scotland's young people.*

Appendix 1

The Teacher Questionnaire

Teacher Questionnaire

Thank you for agreeing to take part in the ROSE survey and for you arranging for your class to complete the ROSE pupil questionnaires.

In order that a representative sample is obtained some information about your school and the class completing the ROSE questionnaire is required. Although you may not have some of the data immediately available, such as the numbers studying all of the science subjects in S3, it will hopefully not be difficult or time consuming to obtain and will give us useful information regarding the current uptake of science across Scottish schools.

A About your school

1. Type of school (please tick):

city/urban	☐	suburban	☐	town/rural	☐
coeducational	☐	boys only	☐	girls only	☐

2. Number of pupils in school ☐

3. Number of pupils in S3 ☐

4. Number of pupils studying Biology in S3:

Standard Grade	☐
Acc 3/Int 1	☐
Int 2	☐

5. Number of pupils studying Chemistry in S3:

Standard Grade	☐
Acc 3/Int 1	☐
Int 2	☐

6. Number of pupils studying Physics in S3:

Standard Grade	☐
Acc 3/Int 1	☐
Int 2	☐

7. Number of pupils studying Science in S3: Standard Grade ☐

8. Number of pupils studying any other science courses in S3 (please specify)

_____ ☐

_____ ☐

9. In your school, is it possible to study three sciences in S3? Yes ☐ No ☐

10. Comments:

B About your class completing the ROSE questionnaire

1.Course of study

2.Number in class (if all present)

3.Number in class completing ROSE questionnaire

4. As an approximate estimate of the ability range of the pupils in this class please estimate the grades your pupils would be likely to obtain at the end of S4, assuming they were all sitting Standard Grade in your subject.

Grade	*Number of pupils*
1	
2	
3	
4	
5	
6	
7	

5. Comments:

C About the science curriculum and its delivery

To what extent do you agree with the following:
(Give your answer with a tick on each line)

		Disagree			*Agree*
1.	The curriculum followed by our associate primary schools prepares pupils well for our S1/2.....	☐	☐	☐	☐
2.	Pupils from at least one of our associate primary schools arrive well prepared for further study of science.....	☐	☐	☐	☐
3.	There is a great variation in what pupils from different associate primary schools achieve in science.....	☐	☐	☐	☐
4.	The S1/2 science curriculum prepares pupils well for S3/4.....	☐	☐	☐	☐
5.	The S1/2 science curriculum gives opportunities to build pupil interest in science	☐	☐	☐	☐
6.	Pupils generally find the science topics covered in the S1/2 science curriculum interesting	☐	☐	☐	☐
7.	Pupils generally find the science topics covered in the S3/4 science curriculum interesting	☐	☐	☐	☐
8.	Pupils generally find the science topics covered in the S5/6 science curriculum interesting	☐	☐	☐	☐
9.	There are adequate opportunities to cover topical science issues during school science courses	☐	☐	☐	☐
10.	The assessment used for science in S1/2 is fit for purpose	☐	☐	☐	☐
11.	The assessment used for science in S3/6 is fit for purpose	☐	☐	☐	☐
12.	I would like to see more practical work in school science.....	☐	☐	☐	☐
13.	The laboratories in my school are in good condition	☐	☐	☐	☐

		Disagree			*Agree*
14.	The science equipment in my school is in good condition.....	☐	☐	☐	☐
15.	The science equipment in my school is in plentiful supply.....	☐	☐	☐	☐
16.	The funds available in my school for science equipment and materials has increased in recent years	☐	☐	☐	☐
17.	The senior management in my school supports science at least as well as other subjects	☐	☐	☐	☐
18.	It is easy to find science supply staff for absence cover.....	☐	☐	☐	☐
19.	It has been easy to fill staff vacancies in science in recent years	☐	☐	☐	☐
20.	There are many opportunities for science CPD.....	☐	☐	☐	☐
21.	The science CPD available meets my needs	☐	☐	☐	☐

22. Comments:

Thank you for completing this questionnaire and arranging for your class to complete the ROSE pupil questionnaires.

Appendix 2 The ROSE Questionnaire

Draft

ROSE

The Relevance of Science Education

This booklet has questions about you and about your experiences and interests related to science in school and outside school.

There are no correct answers, only answers that are right for you.
Please think carefully and give answers that reflect your own thinking.

This questionnaire is being given to students in many different countries. That is why some questions may seem strange to you. If there is a question you do not understand, just leave it blank. If you are in doubt, you may ask a teacher, since this is not a test!

For most questions, you simply colour in the appropriate circle.

The purpose of this questionnaire is to find out what students in different parts of the world think about science at school as well as in their everyday life. This information may help us to make schools better.

Your answers are anonymous, so please, do not write your name on this questionnaire.

THANKYOU!
Your answers will be a big help.

START HERE :

Shade Circles Like This--> ●
Not Like This--> ⊗ ✓

I am a O girl O boy

I am ☐☐ **years old**

I live in _____
(write the name of your country)

I am studying Standard Grade / Intermediate
O Biology
O Chemistry
O Physics
O Science

Contact and copyright : Professor Svein Sjoberg, ILS, University of Oslo, PO Box 1099, Blindern, 0317 Oslo, Norway.
Tel. +47 2285 4155, Fax. +47 2285 4409, Email. svein.sjoberg@ils.uio.no

53651

R SE
The Relevance of Science Education

Shade Circles Like This--> ●
Not Like This--> ⊘ ✓ ✗

A. What I want to learn about

How interested are you in learning about the following?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	NOT INTERESTED → VERY INTERESTED
1. Stars, planets and the Universe	○ ○ ○ ○
2. Chemicals, their properties and how they react	○ ○ ○ ○
3. The inside of the earth	○ ○ ○ ○
4. How mountains, rivers and oceans develop and change	○ ○ ○ ○
5. Clouds, rain and the weather	○ ○ ○ ○
6. The origin and evolution of life on earth	○ ○ ○ ○
7. How the human body is built & functions	○ ○ ○ ○
8. Heredity and how genes influence how we develop	○ ○ ○ ○
9. Sex and reproduction	○ ○ ○ ○
10. Birth control and contraception	○ ○ ○ ○
11. How babies grow and mature	○ ○ ○ ○
12. Cloning of animals	○ ○ ○ ○
13. Animals in other parts of the world	○ ○ ○ ○
14. Dinosaurs, how they lived and why they died out	○ ○ ○ ○
15. How plants grow and reproduce	○ ○ ○ ○
16. How people, animals, plants and the environment depend on each other	○ ○ ○ ○
17. Atoms and molecules	○ ○ ○ ○
18. How radioactivity affects the human body	○ ○ ○ ○
19. Light around us that we cannot see (infrared, ultraviolet)	○ ○ ○ ○
20. How animals use colours to hide, attract or scare	○ ○ ○ ○
21. How different musical instruments produce different sounds	○ ○ ○ ○
22. Black holes, supernovas and other spectacular objects in outer space	○ ○ ○ ○
23. How meteors, comets or asteroids may cause disasters on earth	○ ○ ○ ○
24. Earthquakes and volcanoes	○ ○ ○ ○
25. Tornados, hurricanes and cyclones	○ ○ ○ ○
26. Epidemics and diseases causing large losses of life	○ ○ ○ ○
27. Brutal, dangerous and threatening animals	○ ○ ○ ○
28. Poisonous plants in my area	○ ○ ○ ○
29. Deadly poisons and what they do to the human body	○ ○ ○ ○
30. How the atom bomb functions	○ ○ ○ ○
31. Explosive chemicals	○ ○ ○ ○
32. Biological and chemical weapons and what they do to the human body	○ ○ ○ ○
33. The effect of strong electric shocks and lightning on the human body	○ ○ ○ ○
34. How it feels to be weightless in space	○ ○ ○ ○
35. How to find my way and navigate by the stars	○ ○ ○ ○
36. How the eye can see light and colours	○ ○ ○ ○
37. What to eat to keep healthy and fit	○ ○ ○ ○
38. Eating disorders like anorexia/ bulimia	○ ○ ○ ○
39. The ability of lotions and creams to keep the skin young	○ ○ ○ ○
40. How to exercise to keep the body fit and strong	○ ○ ○ ○
41. Plastic surgery and cosmetic surgery	○ ○ ○ ○
42. How radiation from solariums and the sun might affect the skin	○ ○ ○ ○
43. How the ear can hear different sounds	○ ○ ○ ○
44. Rockets, satellites and space travel	○ ○ ○ ○

	INTERESTED NOT → VERY
45. The use of satellites for communication and other purposes	O O O O
46. How X-rays, ultrasound, etc. are used in medicine	O O O O
47. How petrol and diesel engines work	O O O O
48. How a nuclear power plant functions	O O O O

B. My future job

How important are the following issues for your potential future occupation or job?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	IMPORTANT NOT → VERY
1. Working with people rather than things	O O O O
2. Helping other people	O O O O
3. Working with animals	O O O O
4. Working in the area of environmental protection	O O O O
5. Working with something easy and simple	O O O O
6. Building or repairing objects using my hands	O O O O
7. Working with machines or tools	O O O O
8. Working artistically and creatively in art	O O O O
9. Using my talents and abilities	O O O O
10. Making, designing or inventing something	O O O O
11. Coming up with new ideas	O O O O
12. Having lots of time for my friends	O O O O
13. Making my own decisions	O O O O
14. Working independently of other people	O O O O
15. Working with something I find important and meaningful	O O O O NOT → VERY IMPORTANT

	IMPORTANT NOT → VERY
16. Working with something that fits my attitudes and values	O O O O
17. Having lots of time for my family	O O O O
18. Working with something that involves a lot of travelling	O O O O
19. Working at a place where something new and exciting happens frequently	O O O O
20. Earning lots of money	O O O O
21. Controlling other people	O O O O
22. Becoming famous	O O O O
23. Having lots of time for my interests, hobbies and activities	O O O O
24. Becoming 'the boss' at my job	O O O O
25. Developing or improving my knowledge and abilities	O O O O
26. Working as part of a team with many people around me	O O O O

C. What I want to learn about

How interested are you in learning about the following?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	INTERESTED NOT → VERY
1. How crude oil is converted to other material like plastics and textiles	O O O O
2. Optical instruments and how they work (telescope, camera, microscope etc.)	O O O O
3. The use of lasers for technical purposes (CD players, bar-code readers etc.)	O O O O
4. How cassette tapes, CDs and DVDs store and play sound and music	O O O O
5. How things like radios and televisions work	O O O O
6. How mobile phones can send and receive mesages	O O O O
7. How computers work	O O O O
8. The possibility of life outside earth	O O O O NOT → VERY INTERESTED

	INTERESTED NOT			VERY
9. Astrology & horoscopes and whether the planets can influence human beings	O	O	O	O
10. Unsolved mysteries in outer space	O	O	O	O
11. Life and death and the human soul	O	O	O	O
12. Alternative therapies (acupuncture, yoga etc) and how effective they are	O	O	O	O
13. Why we dream while we are sleeping and what the dreams may mean	O	O	O	O
14. Ghosts and witches and whether they may exist	O	O	O	O
15. Thought transferance, mind reading, sixth sense, intuition etc	O	O	O	O
16. Why the stars twinkle & the sky is blue	O	O	O	O
17. Why we can see the rainbow	O	O	O	O
18. Properties of gems and crystals and how these are used for beauty	O	O	O	O

	AGREE Disagree			Agree
9. Environmental problems can be solved without big changes in our way of living	O	O	O	O
10. People should care more about protection of the environment	O	O	O	O
11. Rich countries should solve the world's environmental problems	O	O	O	O
12. Each of us can make a significant contribution to environmental protection	O	O	O	O
13. Environmental problems should be left to the experts	O	O	O	O
14. I am optimistic about the future	O	O	O	O
15. Animals should have the same right to life as people	O	O	O	O
16. It's right to use animals in medical experiments if this can save humans	O	O	O	O
17. Nearly all human activity is damaging for the environment	O	O	O	O
18. The natural world is sacred & should be left in peace	O	O	O	O

D. Me and the Environmental Challenges

To what extent do you agree with the following statements about problems with the environment (pollution of air & water, overuse of resources, global changes of the climate etc)?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	AGREE Disagree			Agree
1. Threats to the environment are not my business	O	O	O	O
2. Environmental problems make the future of the world look bleak & hopeless	O	O	O	O
3. Environmental problems are exaggerated	O	O	O	O
4. Science and technology can solve all environmental problems	O	O	O	O
5. I'm willing to have environm'l problems solved even by sacrificing many goods	O	O	O	O
6. I can personally influence what happens with the environment	O	O	O	O
7. We can still find solutions to our environmental problems	O	O	O	O
8. People worry too much about environmental problems	O	O	O	O

E. What I want to learn about

How interested are you in learning about the following?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	INTERESTED NOT			VERY
1. Symmetries and patterns in leaves and flowers	O	O	O	O
2. How the sunset colours the sky	O	O	O	O
3. The ozone layer and how it may be affected by humans	O	O	O	O
4. The greenhouse effect and how it may be changed by humans	O	O	O	O
5. What can be done to ensure clean air & safe drinking water	O	O	O	O
6. How technology helps us to handle waste, garbage and sewage	O	O	O	O
7. How to control epidemics and diseases	O	O	O	O
8. Cancer, what we know and how we can treat it	O	O	O	O
9. Sexually transmitted diseases and how to be protected against them	O	O	O	O

	INTERESTED NOT			VERY
10. How to perform first-aid and use basic medical equipment	○	○	○	○
11. What we know about HIV-AIDS and how to control it	○	○	○	○
12. How alcohol and tobacco might affect the body	○	○	○	○
13. How different narcotics might affect the body	○	○	○	○
14. The possible radiation dangers of mobile phones and computers	○	○	○	○
15. How loud sound and noise may damage my hearing	○	○	○	○
16. How to protect endangered species of animals	○	○	○	○
17. How to improve the harvest in gardens and farms	○	○	○	○
18. Medicinal use of plants	○	○	○	○
19. Organic and ecological farming without use of pesticides & artificial fertilisers	○	○	○	○
20. How energy can be saved or used in a more effective way	○	○	○	○
21. New sources of energy from the sun, wind, tides, waves etc	○	○	○	○
22. How different sorts of food are produced, conserved and stored	○	○	○	○
23. How my body grows and matures	○	○	○	○
24. Animals in my area	○	○	○	○
25. Plants in my area	○	○	○	○
26. Detergents, soaps and how they work	○	○	○	○
27. Electricity, how it is produced and used in the home	○	○	○	○
28. How to use and repair everyday electrical and mechanical equipment	○	○	○	○
29. The first landing on the moon and the history of space exploration	○	○	○	○
30. How electricity has affected the development of our society	○	○	○	○
31. Biological and human aspects of abortion	○	○	○	○
32. How gene technology can prevent diseases	○	○	○	○

NOT VERY INTERESTED

	INTERESTED NOT			VERY
33. Benefits and possible hazards of modern methods of farming	○	○	○	○
34. Why religion and science sometimes are in conflict	○	○	○	○
35. Risks and benefits of food additives	○	○	○	○
36. Why scientists sometimes disagree	○	○	○	○
37. Famous scientists and their lives	○	○	○	○
38. Big blunders and mistakes in research and inventions	○	○	○	○
39. How scientific ideas sometimes challenge religion, authority & tradition	○	○	○	○
40. Inventions and discoveries that have changed the world	○	○	○	○
41. Very recent inventions and discoveries in science and technology	○	○	○	○
42. Phenomena that scientists still cannot explain	○	○	○	○

F. My Science Classes

To what extent do you agree with the following statements about the science that you may have had at School?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	AGREE Disagree			Agree
1. School science is a difficult subject	○	○	○	○
2. School science is interesting	○	○	○	○
3. School science is rather easy for me	○	○	○	○
4. School science has opened my eyes to new and exciting jobs	○	○	○	○
5. I like school science better than most other subjects	○	○	○	○
6. I think everybody should learn science at school	○	○	○	○
7. The things I learn in science at school will be helpful in my everyday life	○	○	○	○
8. I think that the science I learn at school will improve my career chances	○	○	○	○
9. School science has made me more critical and sceptical	○	○	○	○

	AGREE: Disagree			Agree
10. School science has increased my curiosity about things we can't explain	O	O	O	O
11. School science has increased my appreciation of nature	O	O	O	O
12. School science has shown me the imp--ortance of science for our way of living	O	O	O	O
13. School science has taught me how to take better care of my health	O	O	O	O
14. I would like to become a scientist	O	O	O	O
15. I would like to have as much science as possible at school	O	O	O	O
16. I would like to get a job in technology	O	O	O	O

G. My opinions about Science & Technology

To what extent do you agree with the following statements?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	AGREE: Disagree			Agree
1. Science & technology (Sci & Tech) are important for society	O	O	O	O
2. Science & technology will find cures to diseases such as HIV/AIDS, cancer etc	O	O	O	O
3. Thanks to Sci &Tech, there'll be greater opportunities for future generations	O	O	O	O
4. Sci & Tech make our lives healthier, easier and more comfortable	O	O	O	O
5. New technologies will make work more interesting	O	O	O	O
6. The benefits of science are greater than the harmful effects it could have	O	O	O	O
7. Sci & Tech will help to eradicate poverty and famine in the world	O	O	O	O
8. Sci & Tech can solve nearly all problems	O	O	O	O
9. Sci & Tech are helping the poor	O	O	O	O
10. Sci & Tech are the cause of the environmental problems	O	O	O	O
11. A country needs Sci & Tech to become developed	O	O	O	O
12. Sci & Tech benefit mainly the developed countries	O	O	O	O
13. Scientists follow the scientific method that always leads to correct answers	O	O	O	O
	Disagree			Agree
	AGREE			

	AGREE: Disagree			Agree
14. We should always trust what scientists have to say	O	O	O	O
15. Scientists are neutral and objective	O	O	O	O
16. Scientific theories develop and change all the time	O	O	O	O

H. My out of School Experiences

How often have you done this outside School?
(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	No. of TIMES: Never			Often
1. Tried to find the star constellations in the sky	O	O	O	O
2. Read my horoscope (telling future from the stars)	O	O	O	O
3. Read a map to find my way	O	O	O	O
4. Used a compass to find direction	O	O	O	O
5. Collected different stones or shells	O	O	O	O
6. Watched (not on TV) an animal being born	O	O	O	O
7. Cared for animals on a farm	O	O	O	O
8. Visited a zoo	O	O	O	O
9. Visited a science centre or science museum	O	O	O	O
10. Milked animals like cows, sheep or goats	O	O	O	O
11. Made dairy products like yoghurt, butter, cheese or ghee	O	O	O	O
12. Read about nature or science in books or magazines	O	O	O	O
13. Watched nature programmes on TV or in cinema	O	O	O	O
14. Collected edible berries, fruits, mushrooms or plants	O	O	O	O
15. Participated in hunting	O	O	O	O
16. Participated in fishing	O	O	O	O
	Never			Often
	No. of TIMES			

	No. of TIMES: Never → Often
17. Planted seeds and watched them grow	○ ○ ○ ○
18. Made compost of grass, leaves or garbage	○ ○ ○ ○
19. Made an instrument (like a flute or drum) from natural materials	○ ○ ○ ○
20. Knitted, weaved etc	○ ○ ○ ○
21. Put up a tent or shelter	○ ○ ○ ○
22. Made a fire from charcoal or wood	○ ○ ○ ○
23. Prepared food over a campfire, open fire or stove burner	○ ○ ○ ○
24. Sorted garbage for recycling or for appropriate disposal	○ ○ ○ ○
25. Cleaned and bandaged a wound	○ ○ ○ ○
26. Seen an X-ray of a part of my body	○ ○ ○ ○
27. Taken medicines to prevent or cure illness or infection	○ ○ ○ ○
28. Taken herbal medicines or had alternative treatments eg. acupuncture	○ ○ ○ ○
29. Been to hospital as a patient	○ ○ ○ ○
30. Used binoculars	○ ○ ○ ○
31. Used a camera	○ ○ ○ ○
32. Made a bow and arrow, slingshot, catapult or boomerang	○ ○ ○ ○
33. Used an air gun or rifle	○ ○ ○ ○
34. Used a water pump or siphon	○ ○ ○ ○
35. Made a model such as a toy plane or boat etc	○ ○ ○ ○
36. Used a science kit (like for chemistry, optics or electricity)	○ ○ ○ ○
37. Used a windmill, watermill, waterwheel etc	○ ○ ○ ○
38. Recorded on video, DVD or tape	○ ○ ○ ○
39. Changed or fixed electric bulbs or fuses	○ ○ ○ ○
	Never → Often: No. of TIMES

	No. of TIMES: Never → Often
40. Connected an electric lead to a plug etc	○ ○ ○ ○
41. Used a stopwatch	○ ○ ○ ○
42. Measured the temperature with a thermometer	○ ○ ○ ○
43. Used a measuring ruler, tape or stick	○ ○ ○ ○
44. Used a mobile phone	○ ○ ○ ○
45. Sent or received an SMS (text message on a mobile phone)	○ ○ ○ ○
46. Searched the internet for information	○ ○ ○ ○
47. Played computer games	○ ○ ○ ○
48. Used a dictionary, encyclopaedia etc on a computer	○ ○ ○ ○
49. Downloaded music from the internet	○ ○ ○ ○
50. Sent or received e-mail	○ ○ ○ ○
51. Used a word processor on the computer	○ ○ ○ ○
52. Opened a device (e.g. radio, watch, computer etc) to find out how it works	○ ○ ○ ○
53. Baked bread, pastry, cake etc	○ ○ ○ ○
54. Cooked a meal	○ ○ ○ ○
55. Walked while balancing an object on my head	○ ○ ○ ○
56. Used a wheelbarrow	○ ○ ○ ○
57. Used a crowbar (jemmy)	○ ○ ○ ○
58. Used a rope and pulley for lifting heavy things	○ ○ ○ ○
59. Mended a bicycle tube	○ ○ ○ ○
60. Used tools like a saw, screwdriver or hammer	○ ○ ○ ○
61. Charged a car battery	○ ○ ○ ○
	Never → Often: No. of TIMES

I. Myself as a Scientist

Assume that you are grown up and work as a Scientist. You are free to do research that you find important and interesting. Write down some sentences about what you would like to do as a researcher and why.

I would like to...

Because...

J. How many books are in your home?

There are usually about 40 books per metre of shelving. Do not include magazines. (Please tick only one box.)

- ○ None
- ○ 1-10 books
- ○ 11-50 books
- ○ 51-100 books
- ○ 101-250 books
- ○ 251-500 books
- ○ More than 500 books

K. How I feel about Science in School

To what extent do you agree with the following :

(Give your answer by shading the appropriate circle on each line.
If you do not understand the question, leave the line blank.)

	Disagree → AGREE ← Agree			
1. In Science, I would rather learn a lot about fewer topics than a little about a lot of different topics	○	○	○	○
2. Doing practical and experimental work helps me to understand science topics	○	○	○	○
3. Doing practical and experimental work with good, modern apparatus makes me want to study Science	○	○	○	○
4. My School Science rooms are exciting places in which to work	○	○	○	○
5. If the practical content of the course were increased, it would give me a greater enjoyment of Science	○	○	○	○
6. I found Science at Primary School interesting	○	○	○	○
7. Science at Primary School prepared me well for Science classes in Secondary School	○	○	○	○
8. I find Science in Secondary School more interesting than Science in Primary School	○	○	○	○
9. What I learned in S1 and S2 Science, helped me with the Science course I now take	○	○	○	○

Disagree → AGREE ← Agree

Your Questionnaire is now complete.

Please return it now.

THANKYOU

Appendix 3: Ranking of all questions in Sections A, C & E by level, and for Glasgow, Highland & Independent Schools

Level		ALL		STUDY AT UPPER LEVEL						STUDY AT LOWER LEVEL				ALL		What I want to learn about
AREA		ALL SCHOOLS		ALL SCHOOLS		GLASGOW		HIGHLAND		INDEPENDENT		ALL SCHOOLS		GLASGOW		HIGHLAND		ALL SCHOOLS		
sample		2760		1803		150		101		221		957		119		51		2760		
meanACE		2.40		2.47		2.46		2.59		2.56		2.26		2.32		2.28		2.40		
Qu no		mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	
C	13	3.11	1	3.22	3	3.31	1	3.38	3	3.11	7	2.90	2	2.97	4	2.88	7	3.11	1	Why we dream while we are sleeping, and what dreams mean
E	8	3.10	2	3.23	2	3.29	2	3.45	2	3.27	1	2.86	4	2.85	6	3.10	1	3.10	2	Cancer, what we know and how we can treat it
A	34	3.09	3	3.24	1	3.26	3	3.48	1	3.26	2	2.81	5	2.97	3	2.81	12	3.09	3	How it feels to be weightless in space
A	31	2.99	4	3.07	4	3.03	7	3.31	4	2.98	14	2.86	3	2.99	2	2.98	4	2.99	4	Explosive chemicals
A	40	2.99	5	3.03	6	3.22	4	2.94	19	3.20	3	2.92	1	3.09	1	3.09	2	2.99	5	How to exercise to keep the body fit and strong
E	10	2.93	6	3.07	5	3.14	5	3.16	5	3.20	4	2.66	11	2.56	18	2.88	8	2.93	6	How to perform first-aid and use basic medical equipment
E	12	2.87	7	2.91	10	3.00	9	3.03	11	3.01	13	2.78	6	2.81	7	2.98	6	2.87	7	How alcohol and tobacco might affect the body
A	27	2.84	8	2.97	7	2.81	19	3.04	10	3.06	10	2.61	12	2.41	38	2.84	10	2.84	8	Brutal, dangerous and threatening animals
A	29	2.82	9	2.93	9	2.94	12	3.07	7	3.12	6	2.60	13	2.57	17	2.76	14	2.82	9	Deadly poisons and what they do to the human body
A	33	2.82	10	2.90	11	3.01	8	3.08	6	2.98	15	2.66	10	2.76	8	2.83	11	2.82	10	The effect of electric shocks and lightning on the body
A	37	2.82	11	2.84	14	3.04	6	2.72	42	3.03	11	2.77	7	2.91	5	2.98	5	2.82	11	What to eat to keep healthy and fit
C	8	2.80	12	2.96	8	2.99	10	3.06	9	3.18	5	2.50	24	2.45	33	2.30	46	2.80	12	The possibility of life outside earth
E	9	2.79	13	2.84	16	2.85	17	2.98	16	2.93	20	2.70	9	2.65	13	2.86	9	2.79	13	Sexually transmitted diseases and how to be protected
A	9	2.76	14	2.76	22	2.67	25	2.81	30	2.90	24	2.76	8	2.64	15	3.08	3	2.76	14	Sex and reproduction
C	11	2.75	15	2.85	12	2.91	13	3.01	13	3.01	12	2.55	20	2.51	23	2.41	33	2.75	15	Life and death and the human soul
E	11	2.75	16	2.84	17	2.88	14	2.90	23	2.98	16	2.58	14	2.43	36	2.68	16	2.75	16	What we know about HIV/AIDS and how to control it
A	25	2.74	17	2.84	13	2.78	20	3.00	14	2.94	17	2.56	18	2.51	22	2.54	23	2.74	17	Tornados, hurricanes and cyclones
A	32	2.74	18	2.83	18	2.87	15	3.00	15	2.87	26	2.55	19	2.74	9	2.57	19	2.74	18	Biological and chemical weapons and what they do to the body
C	15	2.70	19	2.84	15	2.96	11	2.97	17	2.83	30	2.45	26	2.43	35	2.37	37	2.70	19	Thought transference, mind-reading, sixth sense, intuition, etc.
A	12	2.68	20	2.81	19	2.57	41	2.91	22	3.06	9	2.43	28	2.47	30	2.54	21	2.68	20	Cloning of animals
E	16	2.68	21	2.79	20	2.67	27	2.95	18	2.72	38	2.48	25	2.39	43	2.72	15	2.68	21	How to protect endangered species of animals
A	7	2.66	22	2.74	26	2.70	23	2.67	46	2.93	18	2.52	21	2.64	14	2.45	28	2.66	22	How the human body is built and functions
C	14	2.66	23	2.71	28	2.87	16	2.74	38	2.65	47	2.57	16	2.53	20	2.46	27	2.66	23	Ghosts and witches, and whether they may exist
E	23	2.66	24	2.71	29	2.78	21	2.74	39	2.81	32	2.57	17	2.66	11	2.64	17	2.66	24	How my body grows and matures
A	23	2.64	25	2.78	21	2.82	18	3.02	12	2.84	29	2.37	37	2.43	34	2.36	38	2.64	25	How meteors or asteroids may cause disasters on earth
E	7	2.62	26	2.75	25	2.61	37	2.93	21	2.85	28	2.38	36	2.35	49	2.29	49	2.62	26	How to control epidemics and diseases
C	7	2.61	27	2.66	35	2.76	22	2.53	63	2.65	46	2.52	22	2.66	10	2.22	58	2.61	27	How computers work

Appendix 3: contd (overall rank 28-54)

Level		ALL		STUDY AT UPPER LEVEL								STUDY AT LOWER LEVEL						ALL		What I want to learn about
AREA		ALL SCHOOLS		ALL SCHOOLS		GLASGOW		HIGHLAND		INDEPENDENT		ALL SCHOOLS		GLASGOW		HIGHLAND		ALL SCHOOLS		
sample		2760		1803		150		101		221		957		119		51		2760		
meanACE		2.40		2.47		2.46		2.59		2.56		2.26		2.32		2.28		2.40		
Qu no		mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	
A	13	2.6	28	2.69	30	2.52	47	2.93	20	2.79	35	2.42	30	2.45	32	2.54	22	2.60	28	Animals in other parts of the world
A	24	2.6	29	2.69	31	2.66	29	2.85	27	2.82	31	2.42	31	2.34	50	2.28	50	2.60	29	Earthquakes and volcanoes
A	20	2.59	30	2.63	37	2.61	36	2.73	40	2.74	37	2.50	23	2.49	27	2.57	18	2.59	30	How animals use colours to hide, attract or scare
C	6	2.58	31	2.59	40	2.62	34	2.65	49	2.64	48	2.57	15	2.65	12	2.42	32	2.58	31	How mobile phones can send and receive messages
E	32	2.58	32	2.72	27	2.63	32	2.88	24	2.92	21	2.32	44	2.43	37	2.30	47	2.58	32	How gene technology can prevent diseases
A	30	2.57	33	2.66	34	2.45	58	2.86	26	2.71	39	2.40	32	2.38	44	2.29	48	2.57	33	How the atom bomb functions
E	42	2.57	34	2.76	23	2.56	44	3.07	8	3.08	8	2.21	62	2.18	76	2.10	77	2.57	34	Phenomena that scientists still cannot explain
A	22	2.56	35	2.75	24	2.67	26	2.86	25	2.91	22	2.20	63	2.19	74	1.90	96	2.56	35	Black holes, supernovas and other objects in space
A	26	2.55	36	2.69	32	2.59	39	2.82	28	2.93	19	2.30	48	2.21	68	2.20	59	2.55	36	Epidemics and diseases causing large losses of life
C	10	2.52	37	2.67	33	2.70	24	2.82	29	2.78	36	2.23	59	2.22	66	2.04	83	2.52	37	Unsolved mysteries in outer space
E	13	2.52	38	2.62	38	2.56	43	2.77	33	2.88	25	2.34	40	2.39	42	2.48	25	2.52	38	How different narcotics might affect the body
A	6	2.5	39	2.64	36	2.64	30	2.72	41	2.90	23	2.23	58	2.32	54	2.24	55	2.50	39	The origin and evolution of life on earth
E	5	2.5	40	2.56	44	2.45	60	2.69	45	2.60	54	2.39	34	2.54	19	2.25	54	2.50	40	What can be done to ensure clean air and safe drinking water
A	11	2.49	41	2.53	46	2.50	49	2.49	65	2.62	51	2.43	27	2.50	24	2.38	36	2.49	41	How babies grow and mature
A	18	2.48	42	2.56	42	2.45	57	2.67	47	2.68	42	2.31	46	2.37	45	2.40	34	2.48	42	How radioactivity affects the human body
A	46	2.48	43	2.56	43	2.54	46	2.80	32	2.67	44	2.31	47	2.39	41	2.22	57	2.48	43	How X-rays, ultrasound, etc. are used in medicine
C	4	2.48	44	2.51	49	2.55	45	2.72	43	2.55	59	2.43	29	2.34	51	2.47	26	2.48	44	How cassette tapes, CDs and DVDs store and play sound and music
E	14	2.48	45	2.53	47	2.64	31	2.63	52	2.60	55	2.39	35	2.47	31	2.14	69	2.48	45	The possible radiation dangers of mobile phones and computers
A	14	2.47	46	2.55	45	2.56	42	2.75	36	2.61	52	2.32	42	2.14	81	2.32	44	2.47	46	Dinosaurs, how they lived and why they died out
A	8	2.45	47	2.61	39	2.62	33	2.66	48	2.86	27	2.14	75	2.15	79	2.10	73	2.45	47	Heredity, and how genes influence how we develop
E	40	2.43	48	2.57	41	2.62	35	2.77	34	2.81	33	2.16	71	2.22	67	2.24	56	2.43	48	Inventions and discoveries that have changed the world
A	41	2.41	49	2.48	54	2.52	48	2.48	67	2.69	41	2.28	54	2.32	55	2.42	31	2.41	49	Plastic surgery and cosmetic surgery
E	24	2.41	50	2.43	59	2.27	77	2.61	57	2.39	73	2.35	38	2.34	53	2.45	29	2.41	50	Animals in my area
A	2	2.4	51	2.41	62	2.45	56	2.69	44	2.42	69	2.39	33	2.62	16	2.80	13	2.40	51	Chemicals, their properties and how they react
A	38	2.4	52	2.50	52	2.47	53	2.54	61	2.69	40	2.22	60	2.17	77	2.12	71	2.40	52	Eating disorders like anorexia or bulimia
A	19	2.39	53	2.45	55	2.66	28	2.62	54	2.38	74	2.28	52	2.50	25	2.49	24	2.39	53	Light around us that we cannot see (infrared, ultraviolet)
C	18	2.39	54	2.44	57	2.60	38	2.54	62	2.42	70	2.30	51	2.48	29	2.10	75	2.39	54	Properties of gems and crystals and how these are used for beauty

Appendix 3: contd (overall rank 55-81)

Level		ALL		STUDY AT UPPER LEVEL								STUDY AT LOWER LEVEL						ALL		What I want to learn about
AREA		ALL SCHOOLS		ALL SCHOOLS		GLASGOW		HIGHLAND		INDEPENDENT		ALL SCHOOLS		GLASGOW		HIGHLAND		ALL SCHOOLS		
sample		2760		1803		150		101		221		957		119		51		2760		
meanACE		2.40		2.47		2.46		2.59		2.56		2.26		2.32		2.28		2.40		
Qu no		mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	
E	21	2.39	55	2.52	48	2.43	64	2.76	35	2.60	56	2.15	73	2.23	64	2.20	62	2.39	55	New sources of energy from the sun, wind, tides, waves, etc.
E	31	2.39	56	2.49	53	2.58	40	2.57	58	2.68	43	2.21	61	2.30	56	2.27	52	2.39	56	Biological and human aspects of abortion
A	10	2.38	57	2.41	63	2.34	72	2.36	79	2.63	49	2.31	45	2.24	61	2.34	40	2.38	57	Birth control and contraception
E	41	2.37	58	2.51	50	2.44	62	2.63	53	2.81	34	2.10	77	2.11	85	2.06	82	2.37	58	Very recent inventions and discoveries in science and technology
A	1	2.36	59	2.50	51	2.47	52	2.74	37	2.56	58	2.08	79	2.12	84	2.18	63	2.36	59	Stars, planets and the universe
C	3	2.36	60	2.42	60	2.46	55	2.61	55	2.38	76	2.25	55	2.20	70	2.35	39	2.36	60	The use of lasers for technical purposes (CD Players etc)
A	36	2.35	61	2.36	69	2.48	50	2.52	64	2.36	78	2.32	43	2.52	21	2.30	45	2.35	61	How the eye can see light and colours
A	44	2.35	62	2.44	56	2.48	51	2.80	31	2.48	63	2.18	66	2.26	60	2.11	72	2.35	62	Rockets, satellites and space travel
C	16	2.35	63	2.38	67	2.41	66	2.48	68	2.44	66	2.30	49	2.41	39	2.27	51	2.35	63	Why the stars twinkle and the sky is blue
E	15	2.33	64	2.33	73	2.45	61	2.43	72	2.32	81	2.34	41	2.49	28	2.43	30	2.33	64	How loud sound and noise may damage my hearing
E	20	2.33	65	2.42	61	2.33	74	2.55	60	2.61	53	2.16	70	2.23	63	2.20	61	2.33	65	How energy can be saved or used in a more effective way
A	35	2.32	66	2.39	65	2.43	63	2.64	51	2.38	75	2.18	65	2.28	57	2.17	66	2.32	66	How to find my way and navigate by the stars
A	39	2.32	67	2.34	71	2.46	54	2.24	90	2.43	68	2.28	53	2.37	46	2.18	64	2.32	67	The ability of lotions and creams to keep the skin young
A	42	2.31	68	2.39	66	2.41	65	2.34	82	2.58	57	2.16	69	2.28	58	2.10	74	2.31	68	How radiation from solariums and the sun might affect the skin
C	5	2.31	69	2.35	70	2.40	67	2.46	69	2.41	72	2.25	56	2.34	52	2.20	60	2.31	69	How things like radios and televisions work
E	18	2.31	70	2.44	58	2.29	75	2.61	56	2.63	50	2.07	81	2.13	82	2.10	76	2.31	70	Medicinal use of plants
E	28	2.3	71	2.32	74	2.35	71	2.42	74	2.36	79	2.25	57	2.27	59	2.39	35	2.30	71	How to use and repair everyday electrical and mechanical equipment
C	17	2.28	72	2.27	79	2.39	69	2.36	81	2.24	87	2.30	50	2.50	26	2.33	43	2.28	72	Why we can see the rainbow
E	38	2.28	73	2.41	64	2.40	68	2.56	59	2.66	45	2.04	82	2.15	80	2.06	81	2.28	73	Big blunders and mistakes in research and inventions
A	28	2.27	74	2.37	68	2.34	73	2.43	70	2.44	65	2.09	78	2.10	86	2.16	67	2.27	74	Poisonous plants in my area
A	16	2.23	75	2.27	78	2.20	81	2.26	89	2.36	77	2.16	68	2.19	73	2.33	42	2.23	75	How people, animals, plants and the environment depend
A	43	2.22	76	2.24	81	2.27	76	2.36	80	2.24	85	2.20	64	2.24	62	2.26	53	2.22	76	How the ear can hear different sounds
A	47	2.22	77	2.16	89	2.18	85	2.43	71	2.08	97	2.34	39	2.35	48	2.56	20	2.22	77	How petrol and diesel engines work
C	9	2.22	78	2.33	72	2.45	59	2.65	50	2.24	86	2.02	84	1.97	94	1.96	89	2.22	78	Astrology and horoscopes, and whether planets can influence humans
E	29	2.22	79	2.29	77	2.27	78	2.42	75	2.46	64	2.10	76	2.10	87	1.94	93	2.22	79	The first landing on the moon and the history of space exploration
E	3	2.21	80	2.31	75	2.19	84	2.38	78	2.44	67	2.01	86	2.20	71	2.00	87	2.21	80	The ozone layer and how it may be affected by humans
C	12	2.2	81	2.30	76	2.36	70	2.41	76	2.49	62	2.00	87	1.97	95	1.82	100	2.20	81	Alternative therapies (acupuncture, homeopathy, yoga, healing etc)

Appendix 3: contd (overall rank 82-108)

Level		ALL		STUDY AT UPPER LEVEL								STUDY AT LOWER LEVEL						ALL		What I want to learn about
AREA		ALL SCHOOLS		ALL SCHOOLS		GLASGOW		HIGHLAND		INDEPENDENT		ALL SCHOOLS		GLASGOW		HIGHLAND		ALL SCHOOLS		
sample		2760		1803		150		101		221		957		119		51		2760		
meanACE		2.40		2.47		2.46		2.59		2.56		2.26		2.32		2.28		2.40		
Qu no		mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	mLS	rank	
E	2	2.18	82	2.20	83	2.24	79	2.30	88	2.26	84	2.15	72	2.37	47	2.06	79	2.18	82	How the sunset colours the sky
E	27	2.18	83	2.18	87	2.21	80	2.32	83	2.11	95	2.17	67	2.40	40	2.16	68	2.18	83	Electricity, how it is produced and used in the home
E	35	2.17	84	2.21	82	2.08	94	2.18	95	2.42	71	2.08	80	2.20	72	2.06	80	2.17	84	Risks and benefits of food additives
E	4	2.16	85	2.25	80	2.00	97	2.40	77	2.35	80	1.98	91	2.00	91	1.90	97	2.16	85	The greenhouse effect and how it may be changed by humans
A	48	2.13	86	2.18	86	2.20	82	2.24	91	2.16	93	2.03	83	2.17	78	1.86	99	2.13	86	How a nuclear power plant functions
E	22	2.12	87	2.11	94	2.17	87	2.16	96	2.18	92	2.15	74	2.23	65	2.34	41	2.12	87	How different sorts of food are produced, conserved and stored
E	34	2.1	88	2.19	84	2.16	89	2.32	84	2.50	61	1.92	94	2.13	83	1.65	106	2.10	88	Why religion and science sometimes are in conflict
A	45	2.08	89	2.16	88	2.17	86	2.31	86	2.18	91	1.91	95	1.97	93	1.94	92	2.08	89	The use of satellites for communication and other purposes
E	30	2.08	90	2.12	93	2.17	88	2.24	93	2.22	88	1.99	89	2.00	92	2.08	78	2.08	90	How electricity has affected the development of our society
A	3	2.07	91	2.12	92	2.12	91	2.21	94	2.18	89	1.96	92	1.92	97	2.00	86	2.07	91	The inside of the earth
A	17	2.06	92	2.18	85	2.14	90	2.31	85	2.31	82	1.84	103	1.91	101	2.02	85	2.06	92	Atoms and molecules
E	39	2.06	93	2.15	90	2.12	92	2.49	66	2.53	60	1.89	97	2.03	89	1.68	105	2.06	93	How scientific ideas sometimes challenge religion and authority
A	4	2.05	94	2.10	95	2.01	96	2.12	98	2.18	90	1.96	93	2.01	90	2.12	70	2.05	94	How mountains, rivers and oceans develop and change
A	21	2.04	95	2.14	91	2.19	83	2.42	73	2.08	96	1.87	100	1.92	98	1.94	91	2.04	95	How different musical instruments produce different sounds
E	36	2.04	96	2.07	97	1.98	98	2.04	101	2.30	83	1.99	90	2.21	69	1.92	95	2.04	96	Why scientists sometimes disagree
E	6	2.03	97	2.03	98	1.95	99	2.04	100	2.07	98	2.02	85	2.06	88	2.00	88	2.03	97	How technology helps us to handle waste, garbage and sewage
C	2	2.02	98	2.08	96	2.11	93	2.30	87	2.03	100	1.90	96	1.91	102	2.18	65	2.02	98	Optical instruments and how they work
A	5	1.97	99	2.02	99	2.03	95	1.96	103	2.14	94	1.87	99	1.95	96	1.92	94	1.97	99	Clouds, rain and the weather
E	26	1.94	100	1.91	102	1.93	100	1.96	104	1.86	103	2.00	88	2.19	75	1.96	90	1.94	100	Detergents, soaps and how they work
E	19	1.92	101	1.95	100	1.80	101	2.24	92	2.05	99	1.86	101	1.88	103	1.82	101	1.92	101	Organic farming without use of pesticides and fertilisers
E	17	1.91	102	1.92	101	1.76	104	2.09	99	1.93	101	1.88	98	1.92	99	2.04	84	1.91	102	How to improve the harvest in gardens and farms
E	25	1.83	103	1.84	103	1.75	105	1.94	106	1.85	104	1.82	104	1.92	100	1.73	104	1.83	103	Plants in my area
E	37	1.8	104	1.77	107	1.78	102	1.92	107	1.74	106	1.86	102	1.86	104	1.88	98	1.80	104	Famous scientists and their lives
A	15	1.77	105	1.80	104	1.72	106	1.94	105	1.80	105	1.71	107	1.69	107	1.62	107	1.77	105	How plants grow and reproduce
E	33	1.77	106	1.78	106	1.64	107	1.98	102	1.93	102	1.74	105	1.78	105	1.80	103	1.77	106	Benefits and possible hazards of modern methods of farming
C	1	1.76	107	1.78	105	1.76	103	2.13	97	1.69	107	1.73	106	1.75	106	1.80	102	1.76	107	How crude oil is converted to other materials, like plastics & textiles
E	1	1.5	108	1.47	108	1.44	108	1.68	108	1.46	108	1.55	108	1.64	108	1.46	108	1.50	108	Symmetries and patterns in leaves and flowers