The Relevance of Science Education Project (ROSE) in England: a summary of findings

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PREFACE

The first three chapters of this report set out the origins, nature and aims of the Relevance of Science Education Project (ROSE) and describe how the ROSE questionnaire was deployed in a sample of schools in England. Each of chapters 4-10 presents a summary of the responses of the students in England to the various sections of the questionnaire, the title of each chapter indicating the nature of the appropriate individual section. The statistical mean scores of the students to the fixed response items discussed in chapters 4 to 9 are presented in Appendix 1. Chapter 10 is concerned with the only free response item in the ROSE questionnaire.

ROSE is an international project but no attempt is made in this report to present a major international comparative study. The data in Appendix 2 are offered as an illustration of how some of the responses in England appear when set alongside those from some of the other countries participating in the ROSE project.

Given the overall volume of data generated by the responses of over 1,200 students to 250 questions, this report is necessarily a summary. More detailed statistical analyses form the basis of conference presentations or papers published in science education research journals.

EXECUTIVE SUMMARY

In considering this summary, it is important to remember that students express a variety of views and that drawing attention to gender differences runs the risk of ignoring important differences among boys and among girls themselves.

1. Most students agree that science and technology are important for society and are optimistic about the contribution that these disciplines can make to curing diseases such as HIV/AIDS and cancer. Science and technology are also seen as creating greater opportunities for future generations and as making everyday life healthier, easier and more comfortable.

2. There is a lower level of agreement that the benefits of science are greater than its possible harmful effects, although a majority of both boys and girls hold this view. Only a minority of boys and girls agree that science and technology will help to eradicate poverty and famine in the world.

3. Students' positive views about science, technology and society are not reflected in their opinions about their school science education. While this is regarded as 'relevant' and 'important' by most students, most boys (and rather more girls) don't like it as much as other subjects.

4. There is a group of students who like science better than other school subjects but do not find school science interesting.

5. There is a minority of students who are strongly supportive of science, like their school science, want as much science as possible at school and envisage themselves working in the future as a scientist or technologist. For these students, the commitment to science is, at best, only weakly associated with notions such as utility and relevance.

6. Most students do not agree that school science (GCSE) is a difficult subject.

7. Most boys and girls disagree that school science has made them more critical and sceptical, opened their eyes to new and exciting jobs or increased their appreciation of nature.

8. When asked what they wished to learn about, there are marked differences in the responses of boys and girls. For girls, the priorities lie with topics related to the self and, more particularly, to health, mind and well-being. The responses of the boys reflect strong interests in destructive technologies and events. Topics such as 'Famous scientists and their lives' and 'How crude oil is converted into other materials' are among the least popular with both boys and girls.

9. There are major differences in the out-of-school experiences of boys and girls. Those of girls are associated with activities involving the natural world, such as planting seeds or crafts such as knitting or weaving. In the case of boys, activities that might be described as mechanical are to the fore, although the engagement of girls with the use of simple tools should not be overlooked.

10. When asked about a future job, both boys and girls attach importance to having time for a family and to using their talents and abilities. However, helping other people is more important for girls than boys and they attach less importance than boys to becoming famous.

11. Both boys and girls disagree strongly that threats to the environment are not their business. However, such disagreement is not reflected in a corresponding general willingness to sacrifice many goods to solve or alleviate environmental problems. There is also, at best, only a moderate level of interest in learning about a range of environmental issues, save for the possible radiation dangers associated with mobile telephones and the protection of endangered species of animals.

12. Students are optimistic that solutions can still be found to environmental problems but girls are less confident than boys in the ability of science and technology to do so.

13. Some students see environmental problems as exaggerated, the cause of too much anxiety and as best left to experts to resolve. Others attach more importance to the role of individuals in addressing environmental problems and are willing to make personal sacrifices to this end.

14. When asked to choose a field of research they would pursue as a scientist, most students chose the treatment and cure of disease or aspects of space science. The former was much more popular with girls than boys but the difference was much narrower in the case of the latter. The two most common reasons for the choice of field of research involved references to curiosity/interest/excitement and to helping people or animals.

15. The responses of the students from schools in England fall within the broad pattern of responses from the industrialised countries within the ROSE project, although there are some important differences in means and gender differences. Given the differences in the cultural norms, education systems, school curricula, assessment regimes and pedagogy among these countries, it seems likely that students' views about science and technology are strongly coloured, if not determined, by elements that characterise the industrialised world but which are absent, or much less in evidence, in countries within the developing world.

16. The data raise a number of important research questions that need to be answered if attempts to encourage more students to choose the physical science as subjects of advanced study are to be successful. For example, at what age and in response

to what influences do students choose, or rule out, careers for which scientific qualifications are important? How important is the role played by parents, careers' advisers, students' peer groups, teachers and others? To what extent, if at all, can the reluctance of students to study the physical sciences beyond compulsory schooling be attributed to school-based factors? Any attempt to answer questions of this kind will require sophisticated, complex and longitudinal studies that will allow the relevant issues to be identified and explored over time.

1. The ROSE project in context

The Relevance of Science Education project (ROSE) is an international comparative programme of research based at the University of Oslo and directed by Professor Svein Sjøberg. It is a questionnaire-based study that explores the relevance of school science education from the perspective of the students themselves. The project rests on the assumption that knowledge of the views and perceptions of the students as learners is a necessary condition for effective science teaching. It uses the word relevance to embrace a range of factors in terms that can be described as affective. Its broad aim is to generate perspectives and empirical findings that can inform discussions about how best to improve science curricula and enhance students' interest in science and technology in ways that

- respect cultural diversity and gender equity
- promote personal and social relevance, and
- empower the learner for democratic participation and citizenship.

The immediate antecedents of the ROSE project lie in another project, also based at Oslo, entitled *Science and Scientists* (SAS). Findings from this earlier international project have been presented in Sjøberg (2000, 2003) and at several international conferences and they have formed the basis of a number of research theses (Henanger 2004; Myrland 1997; Sinnes 2001). The students involved with the SAS study were aged 13 whereas those associated with the ROSE project were aged 15 and thus likely to bring a somewhat more mature degree of reflection to bear upon the science education they were receiving at school.

The ROSE study may also be seen in the wider context of large-scale international comparisons of school science which have been such a prominent feature of the research and policy endeavour in science education during the past decade or so. The best known examples are arguably the Third International Mathematics and Science Study[1] (TIMSS) and the OECD Programme for International Student Assessment (PISA). The results of these international comparisons have been widely used by policy-makers (see, for example, Hussein 1992; Han 1995), despite the methodological and other difficulties associated with international comparative research and the criticism to which such work is vulnerable (Atkin and Black 1997; Keitel and Kilpatrick 1999). There are, of course, significant methodological and other differences between TIMSS and PISA, including the ages of some of the students involved. The former, the most recent in a series of studies associated with the International Association for the Evaluation of Educational Achievement (IEA), focused attention on the 'curriculum as a broad explanatory factor underlying student achievement' (Martin and Mullis 2000: 30). In PISA, the emphasis is

[1] Now referred to as *Trends in Science and Mathematics Education*

upon the extent to which education systems in the countries participating in the study prepare students to become lifelong learners able to play constructive roles as citizens in society (Schleicher 2000). In contrast to both TIMSS and PISA, the focus of the more modestly funded ROSE project is on students' attitudes, interests and out of school experiences that seem relevant to school science and technology.[2]

The ROSE study, like its predecessor, SAS, can also be seen as a contribution to the research that has sought to identify and promote the 'student voice' within education more generally. Such research has been a notable feature of much of the educational literature in recent years (e.g., Branscombe, Goswami and Schwartz 1992; Lloyd-Smith and Tarr 2000; Schultz and Cook-Sather 2001; Burke and Grosvenor 2003; Fielding 2004a; Flutter and Rudduck 2004), although it needs to be noted that different researchers have often used the term in different ways and directed their findings towards different ends. For some, the student voice refers to identifying, encouraging and expressing the unique self in an act of creative writing. For others, the focus of attention has been students' views about the form, content and purpose of their schooling with a view to promoting dialogue and participation. The purpose of such dialogue and participation has ranged from radical reform of the school, curriculum or pedagogy on the one hand, to more efficient school management and governance, improved standards, increased student motivation, enhanced school effectiveness and the renewal of civic society on the other (Lensmire 1998; Fielding 2004b). The Economic and Social Research Council (ESRC) has funded a major project entitled *Consulting Pupils about Teaching and Learning* (ESRC 2004). This initiative supports a range of more specific projects. Examples include 'How teachers respond to pupils' ideas on improving teaching and learning' and 'Pupils' perspectives on participation'. Another project has a methodological slant, 'Ways of consulting pupils about teaching and learning', although science does not feature prominently in the overall programme of work (http://www.consultingpupils.co.uk).

Among researchers in science education, there are several strands of work that might legitimately be encompassed by the term student voice. There is, for example, an established corpus of research that has explored students' views about science and scientists, e.g., Mead and Métraux 1962; Chambers 1983. The work of Chambers, based on a 'Draw-a-Scientist-Test', has been subsequently developed and deployed by several other researchers, e.g., Mason, Kahle and Gardner 1991; Symington and Spurling 1990, and more recent studies have revealed some shifts, including a greater degree of gender equity, in students' images of scientists over time (Matthews 1996). Inevitably, data generated by studies of this kind present problems of interpretation (Symington and Spurling 1990) and, perhaps at least partly for this reason, few of the findings seem to have been turned to significant pedagogical advantage.

There is also a substantial literature concerned with students' interests in science (e.g., Tamir and Gardner 1989), their views about the nature of science (Lederman1992; Kang *et al.* 2004; Ryder *et al.* 1999) and with their attitudes (Schibeci 1984; Simpson *et al.* 1994). Attitudes and interest seem likely to have a bearing on the teaching and learning of

[2] There is also a greater emphasis on gathering data from developing countries.

science as well as being important among the outcomes of science education. Nonetheless, as with the views about science and scientists, research into students' interests and attitudes seems to have had little general impact on pedagogy or science curriculum reform, perhaps because the implications of the findings for the science curriculum and for the way in which science is taught are by no means straightforward. It seems significant that the word student does not appear in the index of the two-volume *International Handbook of Science Education*, published in 1998 (Fraser and Tobin 1998).

More recent work has complemented these earlier studies of the 'student voice' in science education by redirecting research attention to focus more directly on what students think about the form, content and purpose of their school science education and exploring the curriculum and pedagogical implications of the findings. Attention has also been given to student attitudes towards a variety of science-related issues and whether or not they wish to pursue careers in science or technology. This more recent work is characterized by substantial methodological diversity. A student review of the science curriculum in England, undertaken at the end of 2001, used a web-based questionnaire designed by the students themselves who also took responsibility for writing (with professional support) the final report (Planet Science *et al.* 2003). In contrast, Osborne and Collins collected data about students' and parents' views of the English school science curriculum by means of focus groups in a project that began in 1997 (Osborne and Collins 2000, 2001). A later study, conducted on behalf of the Nestlé Social Research Programme, used a mixture of interviews, supervised self-completion questionnaires and an online 'panel' to obtain data from 11 to 21 year olds about their 'values and beliefs in relation to science and technology' (Haste 2004). In June 2005, the Examining Authority, OCR, reported the results of a survey carried out between November 2004 and February 2005 of 'pupils' perceptions of science and science education'(OCR 2005). Data were gathered by means of an on-line questionnaire from 950 students aged 14, 15 and 16 across a 'range of schools …and abilities'. A study carried out as part of the Siemens Generation21 initiative during 2005 involved 245 males and 258 females aged between 16 and 18 and explored the factors that influenced students' choice of subject to pursue beyond GCSE level. It concluded that one important factor for a majority (70%) of students in the sample was their belief that it was harder to gain an A-grade at A-level in science-based subjects than in non-science–based subjects (Siemens plc: 2006). These and other studies have been reviewed by Jenkins (2006).

The present level of interest in the student voice in science education almost certainly owes much to the relative unpopularity of the physical sciences as subjects of advanced study in most industrialised countries and the associated gender differentials which have proved so resistant to significant change. Politicians, like educational researchers, want to know why these issues arise and want to do something about them. Within the European Union, for example, attention has recently been focused on them as a result of a commitment by the Member States to increasing the number of science, mathematics and engineering graduates in accordance with the so-called Lisbon Declaration of 2000 and the subsequent call in 2002 by Heads of State to increase the proportion of European GDP invested in research from 1.9% to 3% (European Commission 2004). The untested assumption is that the more that is known about students' interests, enthusiasm, dislikes, beliefs and attitudes, the more feasible it will be to develop school science curricula that will engage their attention and help to reduce long-standing gender and other differentials.

At a more formal level, the wider context of education has been influenced by the European Convention on Human Rights and the UN Convention on Children's Rights. Article 12 of the latter asserts the right of a child to express an opinion and to have that opinion taken into account in any matter or procedure affecting that child. In recent years, many societies have accorded a heightened role to the views of young people about many of the activities in which they are required, or choose, to engage. Witness, for example, the 'Children's summit' (C8) held in advance of the G8 gathering of the world's richest nations in Gleneagles in Scotland in July 2005.

However, other factors can also be detected, especially in those education systems that have espoused a market philosophy. The consequences of this espousal are most evident in the language that has become commonplace in educational discussions in England and in some other countries that have adopted such a philosophy in the last fifteen or so years. That language characterises a science curriculum as something to be 'delivered', prioritises, sometimes even defines, education in terms of outcomes that can be measured, and places students and their parents in the position of customers. Customers have rights in an educational market and one way of exercising those rights is to express views about what science should be taught in school science courses and about how it should be 'delivered'. Although such views are likely to be far from homogeneous, differing both among parents and students and between them, they are increasingly seen as important elements of any curriculum debate. Traditionally, however, students have generally been regarded as consumers who are not worth consulting, a neglect that now sits increasingly uncomfortably alongside a market oriented approach to schooling (Rudduck and Flutter 2004).

From a historical, rather than a sociological perspective, seeking the views of students about their school science education can be seen as a reassertion of the student-centred curriculum initiatives of the 1960s, although these were much more marked in other, non-scientific, areas of schooling. They may, also, amount to something of a reaction to the narrow instrumentality that characterises much of the contemporary debate about school science education.

More pragmatic considerations may also be in play. Identifying and responding to the student voice is a means of reducing the alienation that some students feel from their schooling and thus of helping to overcome the associated problems. As with the earlier student centred movements within education, referred to above, involving students in decisions about their education can be regarded as a means of introducing them to the complexities and limitations of the democratic process and thus as something of a preparation for their future role as citizens. From this perspective, accommodating the student voice becomes a means of transforming schooling (Kushman 1997; Fletcher 2003) and of making the curriculum more relevant to students' needs and interests.

> Science is in the curriculum because it *is* relevant and, it should be added, relevant to *people*. Relevance is the very reason for its existence, and it should be the very backbone of science teaching (Newton 1988: 7)

Translating relevance into curriculum terms is, of course, both contentious and problematic, although it is undoubtedly the case that it has usually been defined with the interests of adults, rather than young people, in mind. The ROSE project is an attempt to redress the balance by identifying and articulating the voice of the learner in school science.

2. The ROSE questionnaire and its development

The objectives of the ROSE study are as follows.

1. The development of theoretical perspectives which are sensitive to the diversity of backgrounds (cultural, social, gender etc.) of students in order to facilitate the discussion of priorities relating to scientific and technological education.
2. The development of an instrument to collect data on students' experiences, interests, priorities, images and perceptions that are relevant to the learning of science and technology and their attitudes towards these subjects.
3. The collection, analysis and discussion of data from a wide range of countries and cultural contexts, using the instrument referred to above.
4. The development of policy recommendations for the improvement of curricula, textbooks and classroom activities based on the findings of the project.
5. The identification and discussion of issues relating to the relevance and importance of science in public debate and in scientific and educational contexts.

The students involved in the ROSE study are aged 15/16 and the project began formally in September 2001. As indicated earlier, funding was obtained from a variety of sources and the development of the test instrument took place with advice from an international ROSE Advisory Group that met in Oslo in October 2001[3]. The wide international scope of the project, the limited funds available and the fact that the intention was exploratory rather than the testing of one or more precisely specified hypotheses pointed towards a questionnaire based study. The decision to use closed, rather than open-ended, questions[4] reflected the need to collect data relatively easily and inexpensively and in a form that could be readily coded for analysis. Students completing the questionnaire were invited to respond using a four-point Likert scale. The limitations and problems of such an approach to data collection are well-known and are fully described in the methodological literature (see, for example, Cohen *et al.* 2000). Most obviously, the answers obtained from respondents are determined by the questions presented to them and it is by no means always valid to assume that respondents interpret a question in the way intended by its author. Beyond this, there is much debate among researchers about the number of choices to be included in a Likert scale (see, for example,Weng 2004).While the use of five options allows two choices to be placed on either side of a 'neutral' mid-point (such as 'Don't know'), the significance to be attributed to that mid-point is contentious. There

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[3] The Group that met in October 2001 consisted of Dir. Vivien M Talisayon (The Philippines), Dr. Jane Mulemwa (Uganda), Dr. Debbie Corrigan (Australia), Dir. Jayshree Mehta (India), Professor Edgar Jenkins (England), Dir. Vasilis Kouladis (Greece), Dr. Ved Goel (The Commonwealth Institute), PISA Project leader Marit Kǽrnsli (Norway), Professor and TIMSS-coordinator Svein Lie (Norway), Dr. Marianne Ǿdegaard (Norway) and Dr Astrid Sinnes (Norway). Professor Glen Aikenhead (Canada) and Professor Masakata Ogawa (Japan) were also members of the Advisory Group but were unable to attend the initial meeting.

[4] The ROSE questionnaire contains one open-ended question. See Appendix 2.

are also issues associated with the numerical values commonly used to quantify responses to a Likert scale. The use of a 1-4 scale, as in the ROSE questionnaire, opens the data to a range of statistical manipulation[5], although it is acknowledged that the scale cannot be assumed to be one of equal intervals and that there is much debate among researchers about how best to analyze Likert responses. The naming of the various intervals is also of some significance. In the case of the ROSE instrument, the decision was taken to attach a heading only to each of the extreme ends of the scale, i.e. to points 1 and 4. In this study, we have used the Wilcoxon test for two related samples, the Kolmogorov-Smirnov test for two unrelated samples and Kruskal-Wallis k test for unrelated samples. In order to investigate more complex relationships which may exist within domains, factor analysis has been used. Since this is a parametric technique, care is needed when drawing statistical inferences from data near to the critical value.

Inevitably, there is some tension between the use of a fixed-response questionnaire and the attempt to explore and capture diversity. While this tension is perhaps ultimately incapable of complete resolution, the ROSE study attempted an accommodation by maximising the range of topics covered by the questionnaire and doing so with the aid of the international Advisory Group. While the outcome has been a lengthy questionnaire, there is no evidence from the responses that a significant number of students found it overlong, e.g., by failing to complete all the sections.

A further difficulty arises simply from the fact the ROSE study is international in scope. Questions that make sense in one culture may lack meaning, or have a significantly different meaning, in another. It is also the case that questions that may be asked in one country cannot, for various reasons, be asked in another (e.g., items relating to abortion, homosexuality or even evolution). Cross-cultural collaboration in developing the ROSE questionnaire has therefore been of seminal importance. A related issue is that of language. Since even the word ‘science’ carries different meanings in Anglophone contexts from, for example, Germany, France or the Scandinavian countries, the issues of meaning and translation are highly significant, although they are not, of course, confined to the ROSE study. The original ROSE questionnaire was developed in English and, in an attempt to minimize these cross-cultural and linguistic difficulties, the text was kept as simple and direct as possible. ‘Back-translation’ and piloting (see below) also helped to reduce what are fundamental problems with any international comparative research project in science education.

Identifying the topics to be included in the final version of the questionnaire involved several stages. These included a short test survey, discussion groups with students, and conversations with science teachers, all conducted, for practical reasons, within Norway. This was followed by an international trial of an extensive questionnaire. This led to the anticipated deletion of many items while serving as a check on the range of cultural diversity among the participating countries. At the same time as this international trial, the questionnaire was also translated into Norwegian and piloted in five Norwegian schools. This produced explicit and occasionally lengthy criticism of a number of aspects

[5] There are similarities in the use of a 4-point scale and in the system of coding between the ROSE study and the student questionnaire deployed in the PISA project.

of the questionnaire. Following discussions with members of the GRASSMATE group[6] in Norway in June 2002, a second international trial took place, using a revised version of the questionnaire. Following further revision, a third and final international trial took place in September 2002 and the research instrument was finalized at the beginning of November of the same year.

The lengthy international process of developing the ROSE questionnaire was directed not simply at generating a research instrument that could be deployed in very diverse cultural and educational contexts. It was also centrally concerned with the issues of validity, reliability and credibility. These issues are discussed in Schreiner and Sjøberg (2004) and are therefore not rehearsed here.

The final questionnaire

There are many extra-curricular and out-of school factors that influence the nature and extent of students' engagement with their school science and technology education. These include sex, nationality, age, parents' level of education and occupation, peer culture and language of instruction.

The front page of the ROSE questionnaire asks respondents to identify three such factors, although it is emphasized that each questionnaire is completed anonymously. The three factors are age, sex and nationality and these are the only variables used in making *international* comparisons. The questionnaire allowed individual participating countries to add a country specific question should they wish to do so. The socio-economic background of the students was investigated by a question, placed at the end of the questionnaire, about the number of books in their homes. This question mirrors that used in the PISA 2000 study and serves as a reasonably reliable proxy indicator of socio-economic status. The final ROSE questionnaire consisted of ten sections (A-J) and is reproduced as Appendix 3.

Sections A, C and E consist of a total of 108 items, reduced from 450 in the earliest stage of development of the questionnaire. Each section is headed '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 these sections of the questionnaire reflects both content and context. The content is drawn from the following list, although not all elements are equally represented or addressed in equal detail.

Astrophysics and the universe
Earth/geological science
Human biology
Zoology, animals
Botany, plants
Chemicals
Light, colours and radiation

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[6] GRASSMATE (Graduate Program in Science, Mathematics and Technology Education) is a Norwegian project aimed at developing research capability in sub-Saharan Africa.

Sounds
Energy and electricity
Technology

The list of contexts below is influenced by several factors that include insights from the sociological literature relating to youth culture, research in science education and the views of students and teachers expressed during earlier stages of developing the questionnaire.

Environmental protection
Practical use, everyday relevance
Spectacular phenomena, horror
Human biology (health, fitness, issues of particular relevance to young people)
Mystery, philosophy, wonder, quasi-science, beliefs
Beauty, aesthetic aspects
Science, technology and society, nature of science, etc.

There is, of course, no attempt to associate any one item in the questionnaire uniquely with one context or element of content.

Section B consists of 26 items in which students are invited to indicate the importance they attach to a number of issues for their potential future occupation or job. The scale ranged from 'Not very important' to 'Very important'.

Section D consists of 18 items relating to the environment. Respondents are invited to indicate the extent to which they agree/disagree with a series of statements about the environment.

The 16 items in **Section F** are concerned with students' views about their school science education. Given the linguistic and cultural sensitivity of the word science, each country was requested to substitute the term 'school science/science at school' with the appropriate name of the corresponding school subject in the country concerned.

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

Section H explores students' out-of-school experiences/activities and consists of 61 items. As might be anticipated from an international study, the range of activities/experiences that may have a bearing on students' interests in science and technology is very wide.

Section I begins with an invitation to students to imagine that they are grown up and working as a scientist and to write a little about what they would do and why. This is followed by two statements that the student is asked to complete (*I would like to… Because….)*. This is the only open-ended question in the ROSE study. The responses therefore needed to be analysed with the aid of a coding system that was developed for this purpose. The coding reflected the topic chosen by the student (e.g., gene technology, psychology, space) and the reasons given for the choice (e.g., help people, get rich, become famous).

3. Deploying the ROSE questionnaire

Guidance on organising and conducting the ROSE study was provided in a *Handbook* for participants. The text below is based on the relevant sections of Schreiner and Sjøberg (2004) which sets out more fully the procedures summarised here.

Where appropriate, the ROSE questionnaire was translated into the language of instruction while preserving, as far as possible, the original A4 format and style. 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.

The target population of the ROSE study is the cohort of 15 year old students within an education system, or, more precisely, the grade level where most 15 year olds are likely to be found. In a number of countries, this coincides with the final year of compulsory schooling. In others, it marks the point at which various forms of selection, streaming or curriculum choices are made. Some of the countries involved in the ROSE study might be described as 'mono-cultural'. In such cases, it would make sense to refer to national averages. In other cases, however, where there are large variations in geography, culture, ethnicity, or education systems, calculating such averages would be uninformative, if not actually misleading. The project thus allowed the identification of one or more smaller target populations for investigation.

In each participating country, the ROSE sample was drawn from a defined target population and the sampling unit was a school class, rather than individuals. To avoid reducing the effective size of the sample, the desired norm was one class from each school. The list of schools was selected at random, with proportional sampling being used when schools differed significantly in the number of pupils on roll. The sample was also drawn to accommodate schools of different types, e.g., single sex, co-educational, fee-paying, maintained, selective/ non-selective. The target was a minimum of 25 participating schools. Assuming a class size of 25 per school, this offered the possibility of a minimum of 625 respondents.

Pilot testing of the ROSE questionnaire 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 students any question that they found difficult to understand. It was emphasised to students that the ROSE questionnaire was not a test and that all returns were completely anonymous.

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 student'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. Each page shift in the questionnaire was coded with an 'x'. The following examples illustrate what this meant in practice.

Questions A01 to A48. Question A. What I want to learn about
Measurement level: Ordinal
Missing value: 9

Value	Label
1	not interested
2	low not interested
3	low very interested
4	very interested

Questions G01-G16 Question G. My opinions about science and technology
Measurement level: Ordinal
Missing value: 9

Value	Label
1	disagree
2	low disagree
3	low agree
4	high agree

The open ended question (Myself as a scientist) required the reading of many responses before a coding system could be constructed (see Section 10). Empty data files in SPSS and Excel formats were provided by the project organisers in Oslo and all questionnaires were given a unique identification number to allow for ease of retrieval when this proved necessary. All coded files were returned to the project organisers, together with details of the target population and sample.

In the case of England, the sample of schools was drawn to reflect as far as possible the geographical distribution and type of secondary schools within the English education system. Each participating school was asked to say whether it wished to be sent enough questionnaires for one class or some other number. Almost all schools chose the former, presumably to minimise the disruption to the normal teaching routine. A total of 1,284 questionnaires were eventually received from 34 schools (a 60% return), although not all students answered all the questions presented to them. While it is not now possible to identify the individual schools that participated in the ROSE study in England, the completed returns suggest that about 7% of the students came from independent, i.e. fee-paying, schools, a proportion that accords surprisingly well, if somewhat fortuitously, with the wider national picture. For a variety of reasons, including the severe shortage of, and rapid turnover among, science teachers in parts of London, schools from the capital are almost certainly under-represented among the completed questionnaires. The pupils' responses were coded and the data cleaned at the University of Oslo, where all the data from the participating countries were merged into a single SPSS file.

Of the students who completed questionnaires, almost all were 14 or 15 years old, and 86 were aged 16. The few pupils aged 13 and one aged 17 were excluded from the dataset. Although the study focused on Year 10 in the English school system, the range of ages represented could have been a factor in the pupils' responses, particularly those relating to their career aspirations (Section B of the ROSE questionnaire).Accordingly, where appropriate, the age of the pupils was treated as a co-variate in the analyses.

The International Dimension

ROSE is an international project that has collected data from a large number of countries, many of them in the developing world. Although this report is concerned with the results of the ROSE project in England, Appendix 2 includes a small number of graphs intended to give some indication of how some of the responses from students in England compare with those given by their counterparts in other countries involved in the ROSE project at the time the analysis was made.

4. What I want to learn about

The basic statistics relating to the 108 items of this element of the ROSE questionnaire (Sections A, C and E) are presented in Appendix 1 along with comparable data for the remaining Sections. Attention here is confined to a number of salient features of the responses to Sections A, C and E.

By assigning a score from 1 (Not interested) to 4 (Very interested) to the students' responses, it is possible to calculate a mean score for each of the items in this element of the questionnaire. At the risk of some over-simplification, it is possible to regard a mean score of 2.5 as representing a 'neutral' position where there is neither interest nor a high level of interest in a given topic. Such an approach also facilitates the comparison of the responses from boys and girls.

It also permits the calculation of an overall mean score for both sexes. This revealed that there was essentially no difference between boys and girls in overall measure of interest (girls = 2.47, boys = 2.50). However, of the 108 items, no less than 80 generated responses from boys and girls where the differences were statistically significant. Broadly speaking, it is reasonable to conclude that boys and girls are equally interested in science as represented in this element of the ROSE questionnaire but that their interests in particular aspects of science are very different.

Further insight into this gender difference in response is provided by the data in Tables 4.1 and 4.2. For girls, the priorities lie with topics related to the self, and more particularly, to health, mind and well-being. For boys, the 'top ten' are very different and reflect strong interests in destructive technologies and events. Gender differences are also evident in the topics that are least popular with the students who responded to the questionnaire, although they are somewhat less marked since some topics are particularly unappealing to both boys and girls, e.g., 'The conversion of crude oil into other materials' and 'Plants in my area'.

Although the distribution of interests among boys and girls is very different, it is important to acknowledge that a high level of interest in a given topic by one sex does not necessarily mean that the same topic is of no interest to the other. For example, although 'Black holes, supernovae and other spectacular objects in outer space' is a topic that most boys indicate strongly they would wish to learn about, the topic is also of interest to girls but at a lower level (mean score 2.72). Likewise, boys would also like to learn about 'Why we dream when we are sleeping and what the dreams may mean' but the topic does not command such a high level of interest (mean score 2.89) as among the girls. In contrast, many boys are not interested in learning about 'Eating disorders' (mean score 2.03) and girls relatively show little enthusiasm for understanding 'How the atom bomb functions' (mean score 2.27).

Table 4.1: The ten most popular topics for boys and girls (Mean score ≥ 3.0*)

BOYS	GIRLS
Explosive chemicals (3.38)	Why we dream when we sleeping and what the dreams may mean (3.47)
How it feels to be weightless in space (3.29)	Cancer, what we know and how we can treat it (3.35)
How the atom bomb functions (3.24)	How to perform first-aid and use basic medical equipment (3.33)
Biological and chemical weapons and what they do to the human body (3.22)	How to exercise to keep the body fit and strong (3.20)
Black holes, supernovae and other spectacular objects in outer space (3.17	Sexually transmitted diseases and how to be protected against them (3.11)
How meteors, comets or asteroids may cause disasters on earth (3.14)	What we know about HIV/AIDS and how to control it (3.10)
The possibility of life outside earth (3.12)	Life and death and the human soul (3.05)
How computers work (3.08)	Biological and human aspects of abortion (3.04)
The effect of strong electric shocks and lightning on the human body (3.07)	Eating disorders like anorexia or bulimia (3.03)
Brutal, dangerous and threatening animals (3.04)	How alcohol and tobacco might affect the body (3.03)

* 1 = Not interested, 4 = Very interested

Factor analysis of all the responses to sections A, C and E from the whole sample, i.e., boys and girls, identified three factors accounting for 23%, 8% and 5% of the total variance respectively. The first of the clusters involved A7, A8, A 26, A38, E7, E8, E9, E10, E11, E12, E13, E 23, E 31 and E32. These items are concerned with health, genetics, the treatment of disease and first aid. The second cluster relates to items A27, A28, A29, A30, A31, A32, A33 and A48. The common feature of these items is a reference to actual or potentially harmful technologies, substances or events. In contrast, the third cluster centres upon environmental concerns (C1, E3, E4, E5, E6, E17, E18, E19, E20, E21, E22, E25, E 26 and E33). Table 4.3 gives the details.

Factor analysis of the responses to sections A, C and E by gender presents a somewhat different picture. Three factors are identifiable in the case of girls accounting for 26%, 7% and 5% of the total variance respectively (See Table 4.4). The first cluster

Table 4.2: The ten least popular topics for boys and girls (Mean score ≤ 2*)

BOYS	GIRLS
Alternative therapies (1.95)	Benefits and possible hazards of modern farming (1.89)
Benefits and possible hazards of modern farming (1.93)	Plants in my area (1.86)
Famous scientist and their lives (1.93)	Organic and ecological farming (1.86)
Organic and ecological farming (1.86)	How technology helps us handle waste, garbage and sewage (1.84)
How plants grow and reproduce (1.83)	Atoms and molecules (1.83)
Plants in my area (1.82)	How petrol and diesel engines work (1.73)
How crude oil is converted to other materials (1.79)	How a nuclear power plant functions (1.72)
Detergents and soaps (1.74)	Famous scientists and their lives (1.71)
Lotions, creams and the skin (1.70)	Symmetries and patterns in leaves (1.67)
Symmetries and patterns in leaves (1.42)	How crude oil is converted into other materials (1.51)

* 1 = Not interested, 4 = Very interested

consists of items E29, E30, E34, E36, E37, E38, E39, E40, E41 and E42. These items relate to social and historical aspects of science and technology, including the interaction of science and religion, and to as yet unexplained phenomena. The second cluster consists of items A7, A8, E7, E8, E9, E10, E11, E12, E13, E31 and E32. The link between these items is clearly health and well-being. The third cluster consist of items that relate to the environment, the use of natural resources and to a number of everyday practical matters (E4, E17, E18,E19, E20, E21, E22, E25, E27, E28 and E33).

In the case of boys, principal component analysis identified only two factors, accounting for 23% and 5% of the total variance respectively (see Table 4.5). An interest in the technological is manifest in the responses to items that relate to ‘how things work’ but an emphasis on health-related issues is less clear cut than in the case of the girls. The three items of the second component are all concerned with aspects of space science.

Table 4.3: Principal Component Analysis, Sections A, C and E, Boys and Girls*

Component 1	Component 2	Component 3
How the human body is built and functions (0.458)	Brutal, dangerous and threatening animals (0.530)	How crude oil is converted to other materials, like plastics and textiles (0.427)
Heredity and how genes influence how we develop (0.433)	Poisonous plants in my area (0.530)	The ozone layer and how it may be affected by humans (0.545)
Epidemics and diseases causing large losses of life (0.427)	Deadly poisons and what they do to the human body (0.667)	The greenhouse effect and how it may changed by humans (0.656)
Eating disorders like anorexia and bulimia (0.446)	How the atom bomb functions (0.734)	What can be done to ensure clean air and safe drinking water (0.562)
How to control epidemics and diseases (0.668)	Explosive chemicals (0.757)	How technology helps us handle waste, garbage and sewage (0.501)
Cancer, what we know and how we can treat it (0.764)	Biological and chemical weapons and what they do to the human body (0.731)	How to improve the harvest in gardens and farms (0.647)
Sexually transmitted diseases and how to be protected against them (0.716)	The effect of strong electric shocks and lightning on the human body (0.675)	Medicinal uses of plants (0.477)
How to perform first-aid aid and use basic medical equipment (0.694)	How a nuclear power plant functions (0.504)	Organic and ecological farming without use of pesticides and artificial fertilizers (0.689)
What we know about HIV/AIDS and how to control it (0.737)		How energy can be saved or use din a more effective way (0.663)
How alcohol and tobacco might affect the body (0.640)		New sources of energy from the sun, wind, tides, waves, etc. (0.570)
How different narcotics might affect the body (0.601)		How different sorts of food are produced, conserved and stored (0.554)
How my body grows and matures (0.470)		Plants in my area (0.544)
Biological and human aspects of abortion (0.586)		Detergents, soaps and how they work (0.429)
How gene technology can prevent diseases (0.596)		Benefits and possible hazards of modern methods of farming (0.615)

*Principal component analysis, Varimax rotation with Kaiser normalization

Table 4.4: Principal Component Analysis, Sections A, C and E, Girls*

Component 1	Component 2	Component 3
The first landing on the moon and the history of space exploration (0.511)	How the human body is built and functions (0.410)	The greenhouse effect and how it may be changed by humans (0.478)
How electricity has affected the development of society (0.476)	Heredity and how genes influence how we develop (0.407)	How to improve the harvest in gardens and farms (0.586)
Why religion and science sometimes are in conflict (0.603)	How to control epidemics and diseases (0.583)	Medicinal uses of plants (0.473)
Why scientists sometimes disagree (0.709)	Cancer, what we know and how we can treat it (0.731)	Organic and ecological farming without use of pesticides and artificial fertilizers (0.690)
Famous scientists and their lives (0.657)	Sexually transmitted diseases and how to be protected against them (0.677)	How energy can be saved or used in a more efficient way (0.767)
Big blunders and mistakes in research and inventions (0.717)	How to perform first-aid aid and use basic medical equipment (0.635)	New sources of energy from the sun, wind, tides, waves etc. (0.626)
How scientific ideas sometimes challenge religion, authority and tradition (0.704)	What we know about HIV/AIDS and how to control it (0.714)	How different sorts of food are produced, conserved and stored (0.616)
Inventions and discoveries that have changed the world (0.709)	How alcohol and tobacco might affect the body (0.579)	Plants in my area (0.452)
Very recent inventions and discoveries in science and technology (0.604)	How different narcotics might affect the body (0.579)	Electricity, how it is produced and used in the home (0.410)
Phenomena that scientists still cannot explain (0.603)	Biological and human aspects of abortion (0.485)	How to use and repair everyday electrical equipment (0.426)
	How gene technology can prevent diseases (0.529)	Benefits and possible hazards of modern farming (0.512)

* Principal component analysis, Varimax rotation with Kaiser normalization.

Table 4.5: Principal Component Analysis, Sections A, C and E, Boys*

Component 1	Component 1(cont.)	Component 1 (cont.)	Component 2
How people, animals, plants and the environment depend on each other (0.509)	The ozone layer and how it may be affected by humans (0.623)	The possible radiation dangers of mobile phones and computers (0.544)	Black holes, supernovas and other spectacular objects in outer space (0.556)
Atoms and molecules (0.510)	The greenhouse effect and how it may be changed by humans (0.623)	How loud sound and noise may damage my hearing (0.555)	How meteors, comets or asteroids may cause disasters on earth (0.541)
How radioactivity affects the human body (0.507)	What can be done to ensure clean air and safe drinking water (0.637)	How to protect endangered species of animals (0.530)	How the atom bomb functions (0.569)
How the eye can see light and colours (0.563)	How technology helps us handle waste, garbage and sewage (0.626)	How to improve the harvest in gardens and farms 0.531)	
How radiation from solariums and the sun might affect the skin (0.568)	How to control epidemics and diseases (0.605)	Medicinal use of plants (0.540)	
How the ear can hear different sounds (0.608)	Cancer, what we know and how we can treat it (0.565)	Organic and ecological farming without use of pesticides and artificial fertilizers (0.0.576)	
Rockets, satellites and space travel (0.507)	How energy can be saved or used in a more effective way (0.645)	Electricity, how it is produced and used in the home (0.603)	
The use of satellites for communication and other purposes (0.566)	New sources of energy from the sun, wind, tides, waves, etc. (0.602)	The first landing on the moon and the history of space exploration (0.525)	
How X-rays, ultrasound etc. are used in medicine (0.637)	How different sorts of food are produced, conserved and stored (0.590)	How electricity has affected the development of our society (0.576)	
How a nuclear power plant functions (0.502)	How my body grows and matures (0.534)	Biological and human aspects of abortion (0.557)	
How crude oil is converted to other materials like plastics and textiles (0.571)	Plants in my area (0.536)	How gene technology can prevent diseases (0.620)	
Optical instruments and how they work (0.627)	Detergents, soaps and how they work (0.586)	Benefits and possible hazards of modern methods of farming (0.612)	
How to perform first-aid aid and use basic medical equipment (0.525)	What we know about HIV/AIDS and how to control it (0.551)	Phenomena that scientists still cannot explain (0.517)	
How things like radio and televisions work (0.501)	How alcohol and tobacco might affect the body (0.513)		
How the sunset colours the sky (0.527)	How different narcotics might affect the body (0.574)		

- Principal Component Analysis, unrotated

5. My future job

This section (B) consists of 26 items. The basic statistics are given in Appendix 1.

A principal component analysis (Varimax rotation with Kaiser normalization) of the responses from girls identified four components that account respectively for 18.7%, 10.1%, 8.2% and 6.7% of the total variance. The first cluster in Table 5.1 relates to items B9 (0.545), B13 (0.535), B15 (0.730), B16 (0.693), and B25 (0.638). These items refer to using my talents and abilities, making my own decisions, working with something personally important and meaningful and that fits with my attitudes and values, and developing my knowledge and abilities.

The second cluster relates to items B20 (0.736), B21 (0.793), B22 (0.630) and B24 (0.783). Here, the common elements are earning lots of money, controlling other people, becoming famous and becoming 'the boss' at my job. The third cluster, consisting of B3 (0.639), B4 (0.712), B6 (0.728) and B7 (0.734), has a more immediately practical component and encompasses working with animals, working in the area of environmental protection, building or repairing objects using my hands, and working with machines or tools.

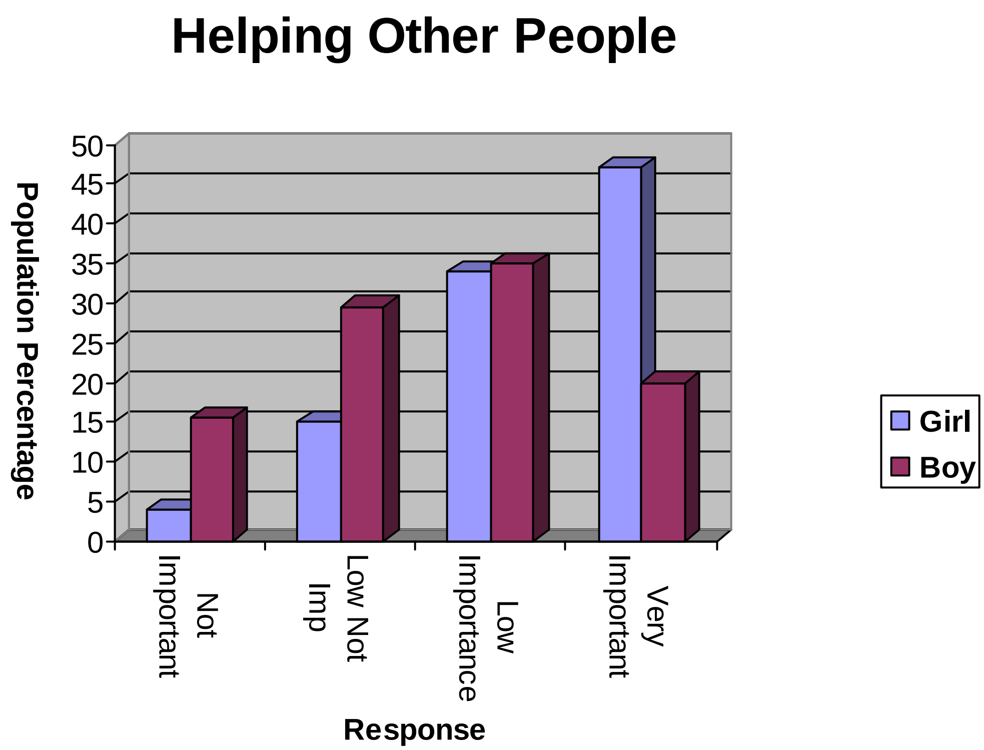
In the case of boys, four clusters jointly account for 43.0% of the total variance. The first cluster (17.2% of total variance) relates to items B20 (0.701), B21 (0.786), B22 (0.606) and B24 (0.777) and mirrors the second cluster identified in the case of the girls. The second cluster in the case of the boys (10.2% of total variance) consists of items B8 (0.667), B9 (0.493), B10 (0.794) and B11 (0.783). Here the emphasis is on creativity (working artistically and creatively in art, using my talents and abilities, making, designing or inventing something, and coming up with new ideas). Two items only account for the third cluster (8.6% of total variance):- B15 (0.775) and B16 (0.806). The commonality here might be described as personal satisfaction (working with something I find important and meaningful, working with something that fits my attitudes and values). The remaining cluster (7.0% of total variance) consists of items B3 (0.765), B4 (0.783) and B5 (0.514) and has some elements in common with the third cluster identified in the case of the girls (working with animals, working in the area of environmental protection) with the added wish to work with something easy and simple.

Calculation of the correlation of individual items in this section of the questionnaire shows that the boys and girls expressing an interest in working with people (B1) are also interested in helping other people (B2), in working in the area of environmental protection (B4) and in working as part of a team (B26). However, no dominant pattern emerges from the calculation.

Table 5.1: Principal component analysis, Section B, boys and (girls)

Statements/components	1	2	3	4
B1. Working with people rather than things	-0.007 (0.040)	0.005 (-0.008)	0.079 (-0.142)	0.040 (0.100)
B2. Helping other people	-0.091 (0.168)	-0.062 (-0.013)	0.087 (0.146)	0.266 (-0.028)
B3. Working with animals	-0.005 (0.100)	0.049 (-0.021)	-0.022 **(0.639)**	**0.765** (-0.054)
B4. Working in the area of environmental protection	0.000 (0.122)	0.158 (-0.078)	0.166 **(0.712)**	**0.783** (-0.009)
B5.Working with something easy and simple	0.134 (-0.374)	0.033 (0.247)	-0.028 (0.394)	**0.514** (-0.029)
B6 Building or repairing objects using my hands	0.118 (-0.024)	0.111 (0.047)	0.047 **(0.728)**	0.250 (0.302)
B7. working with machines or tools	0.057 (0.047)	0.133 (0.085)	-0.101 **(0.734)**	0.130 (0.193)
B8.Working artistically and creatively in art	-0.068 (-0.024)	**0.667** (0.014)	-0.127 (0.131)	0.268 **(0.798)**
B9. Using my talents and abilities	-0.063 **(0.545)**	**0.493** (0.018)	0.214 (0.054)	-0.201 (0.426)
B10. Making, designing or inventing something	0.116 (0.112)	**0.794** (0.060)	0.084 (0.160)	0.062 **(0.823)**
B11. Coming up with new ideas	0.082 (0.240)	**0.783** (0.059)	0.208 (0.009)	0.050 **(0.685)**
B12. Having lots of time for my friends	0.099 (-0-005)	0.087 (0.063)	0.089 (-0.035)	-0.011 (0.198)
B13. Making my own decisions	0.147 **(0.535)**	0.167 (0.036)	0.374 (-0.066)	-0.320 (0.151)
B14. Working independently of other people	0.048 (0.190)	0.148 (0,093)	0.425 (0.096)	-0.095 (0.030)
B15. Working with something I find important and meaningful	-0.047 **(0.730)**	0.120 (-0.109)	**0.775** (0.088)	0.029 -0.010)
B16. Working with something that fits my attitudes and values	0.003 **(0.693)**	0.037 (0.020)	**0.806** (0.058)	0.093 (0.002)
B17.Having lots of time for my family	0.059 (0.177)	0.044 (0.094)	0.126 (0.058)	0.125 (0.070)
B18. Working with something that involves a lot of traveling	0.104 (-0.058)	-0.008 (0.098)	0.002 (0.048)	0.091 (0.130)
B19. Working at a place where something new and exciting happens	0.347 (0.373)	0.121 (0.201)	0.411 (0.055)	0.033 (0.121)
B20. Earning lots of money	**0.701** (0.007)	0.020 **(0.736)**	0.093 (-0.040)	-0.107 (0.004)
B21.Controlling other people	**0.786** (-0,051)	-0.029 **(0.793)**	0.013 (0.033)	-0.011 (-0.038)
B22. Becoming famous	**0.606** (-0.114)	0.142 **(0.630)**	-0.142 (0.065)	0.240 (0.060)
B23. Having lots of time for my interests, hobbies and activities	0.199 (0.203)	0.102 (0.289)	0.093 (0.164)	0.098 (0.133)
B24. Becoming 'the boss' at my job	**0.777** (0.124)	0.016 **(0.783)**	0.013 (0.007)	0.026 (0.112)
B25 Developing or improving my knowledge and abilities	0.070 **(0.638)**	0.210 (0.047)	0.379 (0.092)	-0.026 (0.202)
B26 Working as part of a team with many people around me	0.062 (0.238)	-0.076 (0.088)	-0.007 (0.162)	0.038 (0.018)

Helping other people is more important for girls than boys and they attach less importance than boys to 'becoming famous'. The gender differences in the responses to items B6 and B7 resonate with findings from elsewhere in the questionnaire that highlight the relative unpopularity among girls of the technological and mechanical. Perhaps somewhat unexpectedly, there is little difference between the boys and the girls in the importance they attach to working with animals (B3). Both boys and girls respond in broadly similar ways when asked to rate the importance for their future job of having time for their family (B17) and of using their talents and abilities (B9). Girls, however, attach greater importance than boys to working with people rather than things (B1).



6. Me and the environmental challenges

Table 6.1 presents the descriptive statistics summarising the responses to the 18 statements in Section D of the questionnaire relating to ‘Me and the environmental challenges’. Gender differences in these responses, together with an indication of their statistical significance (Chi Square and Kolmogorov-Smirnov tests) are given in Table 6.2.

The data make clear that both boys and girls disagree strongly with the statement that ‘Threats to the environment are not my business’, although there is, of course, no indication of where such concern might lie among other possible priorities. However, such disagreement is not reflected in a corresponding willingness to ‘sacrifice many goods’ (Statement 5) in order to solve or alleviate environmental problems. Rather more boys than girls, although still a minority in each case, agree that they can personally influence what happens to the environment (D.6) whereas more girls than boys, in each case a substantial majority, agree that ‘each of us can make a significant contribution to environmental protection’ (D.12). Unlike most of the 18 statements, there is no statistically significant difference between boys and girls in the sense of optimism expressed about the consequences of environmental problems for the future reflected in their responses to statement 2. The relatively high proportions of those agreeing with this statement are noteworthy. However, the responses to statement to 2 need to be placed alongside those to statement 7 which reflect considerable confidence on the part of both boys and girls that solutions can still be found to environmental problems as well as alongside those to statement 14. The message seems to be that while environmental problems may make the future look bleak, the situation is not irremediable. It may also be the case that the responses reflect differences in personal and global views of the future, the former being much more optimistic than the latter. Equally noteworthy is the pattern of responses to statement 14 which lends no support to other studies reporting that girls generally hold more pessimistic images about the future than boys.

Statements 2, 3 4, 7, 8 and 9 relate to the scale of environmental challenges currently facing the world. Girls disagree more strongly than boys that environmental problems are exaggerated (D.3) and the pattern of their responses reflects a lower level of confidence in the ability of science and technology to solve environmental problems. It is important, however, that an acknowledgement of the limits of science and technology in solving environmental problems is distinguished from attitudes towards science and technology more generally. Despite the pattern of responses to statements 4, 7 and 14, the research evidence is that those who are optimistic about the future have generally positive attitudes towards scientific and technological development (Hicks and Holden 1995). Girls also disagree more strongly than boys with the assertion that ‘People worry too much about environmental problems’ (D. 8), although opinion is much more evenly divided over the question of whether such problems can be solved without major changes in life style (D.9).

Statements 10 to 13 explore where responsibility might lie for addressing environmental problems. A large majority of both boys and girls agrees that people should care more about environmental protection (D.10), but there is a particularly marked difference in their views about the responsibility to be attributed to the developed world in solving environmental problems (D.11). There is little general support for the view that environmental problems should be left to the experts (D.13), a finding that resonates with the contribution attributed to science and technology in solving environmental problems (D.4)

Responses to statement 17 indicate only minority agreement among both boys and girls with the assertion that all human activity is damaging to the environment. There is, however, a surprising level of support, especially among girls, for the notion of the natural world as something sacred that should be left in peace (D.18).

Table 6.3 shows the results of a principal component analysis of the responses, by gender. The four components identified account for approximately 50% of the total variance for both boys and girls. Among the girls, the responses clustering around statements 5, 6, 7, 10 and 12 are suggestive of a group of students who attach importance to the role of the individual in addressing environmental problems and who are willing to make personal sacrifices to this end. Evidence from other sources suggests that such views are likely to be related to early life experiences and to exposure to courses of environmental education, although research findings relating to the latter are equivocal. A different group, reflected in the responses to statements 1, 3, 7 and 13, regard environmental problems as exaggerated, the cause of too much anxiety and as best left to experts to resolve. This distinction between what might be called personal and vicarious responsibility towards the environment is also evident in the case of boys, although the factor analysis reveals some differences in the clusters. There is a resonance here with the notion of egocentric, anthropocentric and ecocentric attitudes towards the environment (Christensen 1991). As the name suggests, the first of these is self-centred:- it reflects a belief that what is good for the individual is also good for the wider society. An anthropocentric stance is essentially utilitarian and rests on the view that environment related decisions should seek to generate the greatest good for the largest number of people. An ecocentric view assigns intrinsic value to all aspects of the environment, animate and inanimate:- in the case of the ROSE respondents, it underpins such beliefs as animals should have the same right to life as people, nearly all human activity is damaging to the environment and the natural world is sacred and should be left in peace. Using these categories, the data suggest that girls are more ecocentric than boys, a finding replicated in most of the countries involved in the ROSE project (see, for example, Schreiner and Sjǿberg 2003).

It is interesting to examine the responses in Tables 6.1 and 6.2 in the light of the responses of the same sample of students to sections A, C and E of the ROSE questionnaire. The responses to the environment-related topics in these sections are summarised, for both boys and girls, in Table 6.4. They suggest, at best, a moderate level of interest in learning about the environmental topics presented in this element of the

ROSE questionnaire, with only two topics (the possible radiation dangers associated with mobile telephones and computers and the protection of endangered species of animals) securing a mean score ≥ 2.5 on the four point scale.

Table 6.1: Me and the environmental challenges: descriptive statistics

Statement	Disagree %	Low Disagree %	Low Agree %	Agree %	Nil Response %	*Agreement Index %	Median
1.Threats to the environment are not my business	44.8	31.2	15.9	6.0	2.1	-54.1	L. Dis
2.Environmental problems make the future of the world look bleak	16.4	33.4	28.6	19.2	2.4	-2.0	L. Dis
3.Environmental problems are exaggerated	22.0	36.5	24.1	13.4	4.0	-21.0	L. Dis
4. Science and technology can solve all environmental problems	30.6	35.8	20.9	9.5	3.2	-36.0	L. Dis
5. I am willing to have environmental problems solved even if this means sacrificing many goods	21.1	36.3	28.5	10.8	3.3	-18.1	L. Dis
6. I can personally influence what happens with the environment	23.2	30.0	28.2	15.3	3.3	-9.7	L. Dis
7. We can still find solutions to our environmental problems	6.2	13.6	37.5	40.0	2.7	+57.7	L. Agr
8. People worry too much about environmental problems	24.0	33.4	26.4	15.3	2.6	-15.7	L. Dis
9.Environmental problems can be solved without big changes in our way of living	15.7	33.6	29.8	17.8	3.0	-1.7	L. Dis
10. People should care more about protection of the environment	5.8	14.7	36.8	39.7	3.2	+57.8	L. Agr
11. It is the responsibility of the rich countries to solve the environmental problems of the world	28.9	28.1	25.3	15.0	2.6	-16.7	L. Dis
12. I think each of us can make a significant contribution to environmental protection	6.9	20.0	35.7	34.6	2.8	+43.4	L. Agr
13. Environmental problems should be left to the experts	30.3	36.7	19.2	10.8	3.0	-37.0	L. Dis
14. I am optimistic about the future	9.3	19.2	38.9	29.1	3.5	+39.5	L. Agr
15. Animals should have the same right to life as people	10.7	19.4	30.5	36.0	3.3	+36.4	L. Agr
16. It is right to use animals in medical experiments if this can save human lives	27.7	27.6	22.7	18.5	3.5	-14.1	L. Dis
17. Nearly all human activity is damaging to the environment	25.1	42.0	21.3	8.2	3.5	-37.6	L. Dist
18.The natural world is sacred and should be left in peace	14.0	27.3	35.7	19.7	3.3	+14.1	L. Agr

N = 1284 (all pupils in sample)
* %age agreeing minus the % disagreeing.

The level of concern about the environment indicated by some of data in Tables 6.1 and 6.2 is thus not reflected in the level of interest in learning at school about the environmental topics presented in Table 6.4.

Table 6.2: Me and the environmental challenges: gender differences in responses (%)

Statement No.	Girls		Boys		Chi Square	*K-S
	Agree	Disagree	Agree	Disagree		
1	20.2	79.8	24.6	75.4	0.062	NS
2	48.1	51.9	50.0	50.0	NS	NS
3	32.8	67.2	45.7	54.3	0.000	0.000
4	24.0	76.0	39.2	60.8	0.000	0.000
5	41.3	58.7	40.1	59.9	NS	NS
6	41.4	58.6	48.6	51.4	0.011	0.085
7	79.3	20.7	80.2	19.8	NS	NS
8	36.1	63.9	46.1	53.9	0.000	0.04
9	48.8	51.3	49.5	50.5	NS	NS
10	81.0	19.0	77.0	23.0	0.084	0.011
11	34.0	66.0	49.5	50.5	0.000	0.000
12	74.3	25.7	70.0	30.0	0.087	0.005
13	27.1	72.9	35.0	65.0	0.003	0.009
14	72.9	27.1	67.9	32.1	0.056	NS
15	75.1	24.9	62.1	37.9	0.000	0.000
16	35.4	54.6	50.2	49.8	0.000	0.000
17	29.2	70.8	31.8	68.2	NS	NS
18	62.2	37.8	52.2	47.8	0.000	0.004

N Boys = 618, Girls 660, Missing = 6 (data based on pupils who have expressed an opinion)

* Kolmogorov-Smirnov

Table 6.3: Principal component analysis of responses by gender (girls in brackets)*

Statement	Component			
	1	2	3	4
Threats to the environment are not my business	**0.587** (-0.234)	-0.207 (**0.594)**	0.212 (-0.072)	-0.061 (-0.018)
Environmental problems make the future of the world look bleak and hopeless	0.028 (0.279)	0.0154 (0.111)	**0.541** (0.163)	0.217 (0.131)
Environmental problems are exaggerated	**0.660** (-0.051)	0.161 (**0.723)**	- 0.144 (-0.431)	0.0351 (-0.023)
Science and technology can solve all environmental problems	0.290 (-0.069)	0.0760 (0.325)	-0.099 (-0.176)	**0.576** (0.400)
I am willing to have environmental problems solved even if this means sacrificing many goods	0.188 (**0.610)**	0.300 (-0.336)	0.134 (-0.009)	**0.619** (0.072)
I can personally influence what happens with the environment	0.141 (**0.603)**	0.362 (-0.162)	-0.235 (-0.183)	0.395 (0.145)
We can still find solutions to our environmental problems	0.0285 (**0.764)**	**0.725** (0.087)	0.007 (0.040)	0.159 (-0.075)
People worry too much about environmental problems	**0.725** (-0.186)	.0079 (**0.725)**	-0.097 (0.042)	-0.141 (0.057)
Environmental problems can be solved without big changes in our way of living	0.326 (0.293)	**0.502** (**0.533**)	0.161 (0.144)	-0.269 (-0.122)
People should care more about protection of the environment	-0.269 (**0.701)**	**0.523** (-0.155)	0.306 (0.163)	0.261 (0.167)
It is the responsibility of the rich countries to solve the environmental problems of the world	-0.074 (0.214)	-0.131 (0.017)	0.311 (-0.344)	**0.597** (**0.513**)
I think each of us can make a significant contribution to environmental protection	-0.277 (**0.742)**	**0.607** (-0.124)	0.380 (0.174)	0.075 (0.043)
Environmental problems should be left to the experts	**0.676** (-0.032)	-0.206 (**0.615**)	0.094 (-0.029)	0.113 (0.310)
I am optimistic about the future	0.127 (0.423)	**0.544** (0.210)	-0.116 (0.092)	0.072 (-0.16)
Animals should have the same right to life as people	-0.094 (0.273)	0.194 (0.084)	**0.671** (**0.694)**	-0.092 (0.205)
It is right to use animals in medical experiments if this can save human lives	0.389 (0.141)	0.228 (0.076)	- 0.333 (**-0.772)**	0.268 (0.146)
Nearly all human activity is damaging for the environment	0.112 (0.004)	-0.191 (0.008)	**0.427** (0.142)	0.350 (**0.770**)
The natural world is sacred and should be left in peace	0.038 (0.349)	0.096 (-0.064)	**0.707** (0.398)	0.125 (0.469)

* Principal component analysis, Varimax rotation with Kaiser normalization

Table 6.4: Students' views on 'What I want to learn about', by gender*

Topic	Mean score**(boys, n = 517)	S.D. (boys)	Mean score** (girls, n = 571)	S.D. (girls)
The ozone layer and how it may be affected by humans.	2.55	1.047	2.30	0.981
The greenhouse effect and how it may be changed by humans	2.25	0.994	2.14	0.948
What can be done to ensure clean air and safe drinking water	2.37	0.993	2.50	0.969
How technology helps us handle waste, garbage and sewage	2.04	0.994	1.85	0.912
The possible radiation dangers of mobile phones and computers	2.61	1.058	2.58	0.990
How loud sound and noise may damage my hearing	2.32	1.007	2.27	0.943
How to protect endangered species of animals	2.55	1.040	2.78	1.001
How to improve harvest in gardens and farms	2.00	0.982	1.87	0.875

* All the differences are significant except those relating to the possible dangers of mobile phones and the damage that may be caused by loud sounds

** 1 = not interested, 4 = very interested

7. My science classes

This section (F) of the questionnaire invited students to indicate the extent to which they agreed with a series of sixteen statements 'about they science they may have had at school'. The sixteen statements and students' responses to them are given in Table 7.1.

Table 7.1: **Students' responses (percentage in each category) to statements about the science they may have had in school.**

	disagree	low disagree	low agree	agree
	%	%	%	%
1. School science is a difficult subject	24.1	33.7	27.5	13.6
2. School science is interesting	15.9	23.0	38.1	23.1
3. School science is rather easy for me to learn	20.3	37.1	31.1	11.4
4. School science has opened my eyes to new and exciting jobs	33.7	31.3	22.0	13.0
5. I like school science better than most other subjects	42.3	24.8	19.9	10.7
6. I think everybody should learn science at school	17.0	15.1	28.0	39.9
7. The things that I learn in science at school will be helpful in my everyday life	15.6	24.0	35.8	24.6
8. I think that the science I learn at school will improve my career chances	14.3	18.8	34.2	32.6
9. School science has made me more critical and skeptical	25.8	35.4	28.1	10.7
10. School science has increased my curiosity about things we cannot yet explain	17.6	23.2	30.8	28.5
11. School science has increased my appreciation of nature	26.5	31.8	27.0	14.7
12. School science has shown me the importance of science for our way of living	21.4	30.5	33.6	14.5
13. School science has taught me how to take better care of my health	16.3	24.6	34.9	22.0
14. I would like to become a scientist	58.1	21.0	13.2	7.7
15.I would like to have as much science as possible at school	44.7	28.2	17.6	9.5
16. I would like to get a job in technology	41.4	25.5	20.6	12.6

Overall, the students' responses suggest that while few of them aspire to become scientists (statement 14) or like school science better than other subjects (statement 5), there is evidence that science is regarded as interesting (statement 2), relevant (statements 7,8, 10 and 13) and important (statements 6 and 12). Interestingly, there is no strong evidence to support the frequently expressed view that students find school science particularly difficult.

The results of a principal component analysis for boys and girls are given in Table 7.2. In the case of boys, the three factors account for 40.5%, 9.1% and 7.1% of the total variance respectively. The corresponding percentages for girls are 42.0, 10.6 and 6.8. The first component represents the same cluster of responses for both boys and girls, although there are some differences in the individual data. In addition, the cluster of responses that constitutes component 2 suggests that those students who like school science better than most other subjects and, in the case of girls, agree that it has opened their eyes to new exciting jobs (statements 4 and 5), also want to become a scientist, have as much science as possible in schools and would like a job in technology Statements 14, 15 and 16). Gender differences are much more marked in the case of the third component identified in Table 7.2, with the boys' responses clustering around statements 3, 6 and 8.

Three other noteworthy issues begin to emerge from the students' responses to this section of the ROSE questionnaire. First, the data relating to statements 14, 15 and 16 and components 2 and 3 do not support the notion that a perception of relative subject difficulty at GCSE level is a major element in the decision whether or not to study science beyond this level. Secondly, those students strongly attracted towards a career in science or technology (Statements 14, 15 and 16), do not seem to attach much importance to such issues such as interest, relevance or enhanced career opportunities. It is as if, for these students, science is something they simply wish to study while agreeing that it is not something that 'everybody should learn at school'. Finally, these students might perhaps be contrasted with those among their peers who attach some importance to the personal benefits arising from studying science at school (e.g., statements 7, 8, 11, 12 and 13) but have no inclination to 'become a scientist' or 'get a job in technology'.

Some of the statements in Tables 7.1 and 7.2 relate to potential outcomes of school science education. Students' responses to these statements might be judged disappointing in the light of the claims made for science in the national curriculum in force in England at the relevant time. Among much else, science is said to stimulate and excite pupils' 'curiosity about phenomena', link 'direct practical experience with ideas' and act as a 'spur to critical and creative thought'. The data suggest that most boys and girls disagree that school science has made them 'more critical and sceptical', opened their 'eyes to new and exciting jobs' or increased 'their appreciation of nature'. It would also be difficult to sustain a claim that school science has shown most students 'the importance of science for our way of living', especially in the case of girls. In contrast, both boys and girls agree that school science has taught them 'how to take better care' of their health and made them more curious about 'things we cannot yet explain'. Both boys and girls

Table 7.2: Principal component analysis of the responses to the sixteen statements, boys and (girls)*

	Component		
Statement	1	2	3
F1. School science is a difficult subject	-.164 (-.042)	-.170 (-.170)	**-.734 (-.824)**
F2. School science is interesting	**.523 (.526)**	.333 (.387)	.463 (.400)
F3. School science is rather easy for me to learn	.122 (.040)	.246 (.289)	**.615 (.723)**
F4. School science has opened my eyes to new and exciting jobs	.484 (.385)	.489 (.637)	.302 (.203)
F5. I like school science better than most other subjects	.279 (.265)	**.609 (.738)**	.459 (.298)
F6. I think everybody should learn science at school	**.534 (.622)**	-.002 (.085)	**.564** (.411)
F7. The things that I learn in science at school will be helpful in my everyday life	**.603 (.709)**	.124 (.100)	.401 (.330)
F8. I think that the science I learn at school will improve my career chances	**.509 (.604)**	.118 (.267)	**.512** (.320)
F9. School science has made me more critical and skeptical	**.560 (.534)**	.296 (.401)	.120 (.089)
F10. School science has increased my curiosity about things we cannot yet explain	**.677 (.701)**	.212 (.283)	.251 (.079)
F11. School science has increased my appreciation of nature	**.678 (.670)**	.334 (.280)	-.109 (-.116)
F12. School science has shown me the importance of science for our way of living	**.759 (.743)**	.259 (.261)	.067 (-.013)
F13. School science has taught me how to take better care of my health	**.700 (.709)**	.111 (.087)	-.023 (-.066)
F14. I would like to become a scientist	.124 (.143)	**.834 (.817)**	.152 (.213)
F15. I would like to have as much science as possible at school	.312 (.304)	**.715 (.747)**	.260 (.236)
F16. I would like to get a job in technology	.190 (.136)	**.616 (.653)**	.062 (.034)

*Principal Component Analysis, Varimax rotation with Kaiser normalization.

also judge that their school science education will be helpful in their everyday lives and improve their ‘career chances’, although in the case of the latter there is a statistically significant gender difference, with boys more in agreement than girls.

For those concerned about the future well-being of science itself, perhaps the most disappointing data in Table 7.1 relate to the final three statements. Some of the mean scores here, for both boys and girls, are among the lowest registered in response to this section of the questionnaire. A career in science has little appeal for either boys or girls and the prospect of having ‘as much science as possible at school’ is not attractive to either. A ‘job in technology’ has more appeal for boys than girls but, even here, the mean score falls below the ‘neutral’ position of 2.5.

The findings from this section of the ROSE questionnaire convey a number of messages for those with a professional interest in school science education. The data suggest, for example, that many young people have already made up their minds whether or not they wish to pursue a career in science or technology by the time they embark on their GCSE courses at the age of 14 or 15. If this is indeed the case, it implies that good teaching of science to younger pupils is of particular importance. The data also make clear that students' interests in science depend both upon the science and upon gender, and that these two factors are closely linked.

It is possible to use this section of the questionnaire to classify the students in terms of their school science preference by cross-tabulating the responses to items F2 and F5. This is done in Table 7.3 for boys, girls and the whole sample. Using an aggregate score of 6 (out of the possible 8 for the two items), students can be placed in one of four groups, according to how far they agree that they like school science better than most other subjects and how far they agree that school science is interesting.

Table 7.3: Cross-tabulations between items F2 and F5 for English students

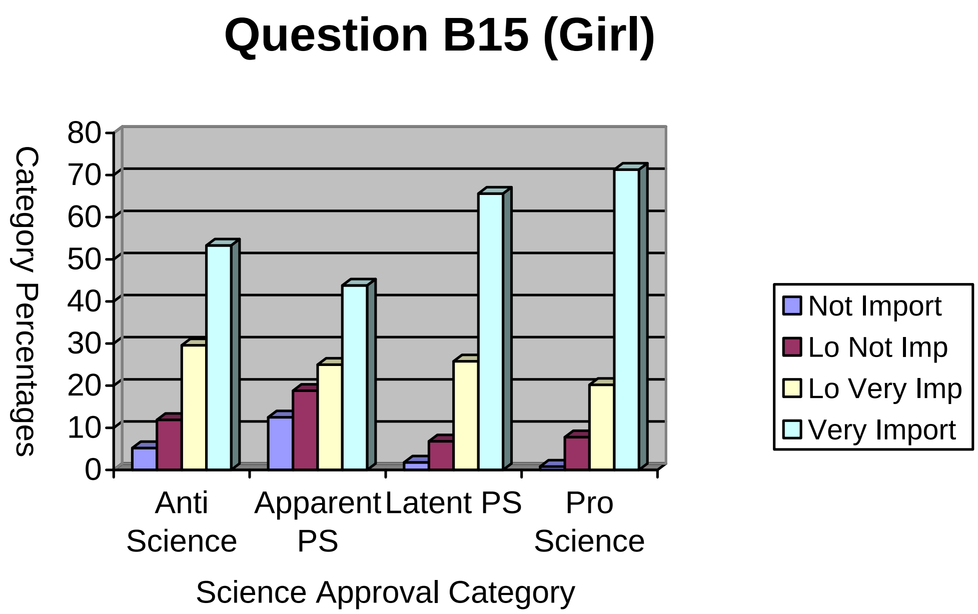
Gender			F5 I like school science better than most other subjects				Total
			Disagree	Low Disagree	Low Agree	Agree	
Mixed	F2 School science is interesting	Disagree	168	197	136	41	**542**
		Low Dis	20	64	186	47	**317**
		Low Agr	4	24	121	102	**251**
		Agree	7	1	29	99	**136**
		Totals	**199**	**287**	**472**	**289**	**1246**
Girl	F2 School science is interesting	Disagree	104	133	87	19	**343**
		Low Dis	7	27	96	21	**151**
		Low Agr	0	10	46	33	**89**
		Agree	5	1	10	43	**59**
		Totals	**116**	**171**	**239**	**116**	**642**
Boy	F2 School science is interesting	Disagree	64	64	49	22	**199**
		Low Dis	13	37	90	26	**166**
		Low Agr	4	14	75	69	**162**
		Agree	2	0	19	56	**77**
		Totals	**83**	**115**	**233**	**173**	**604**

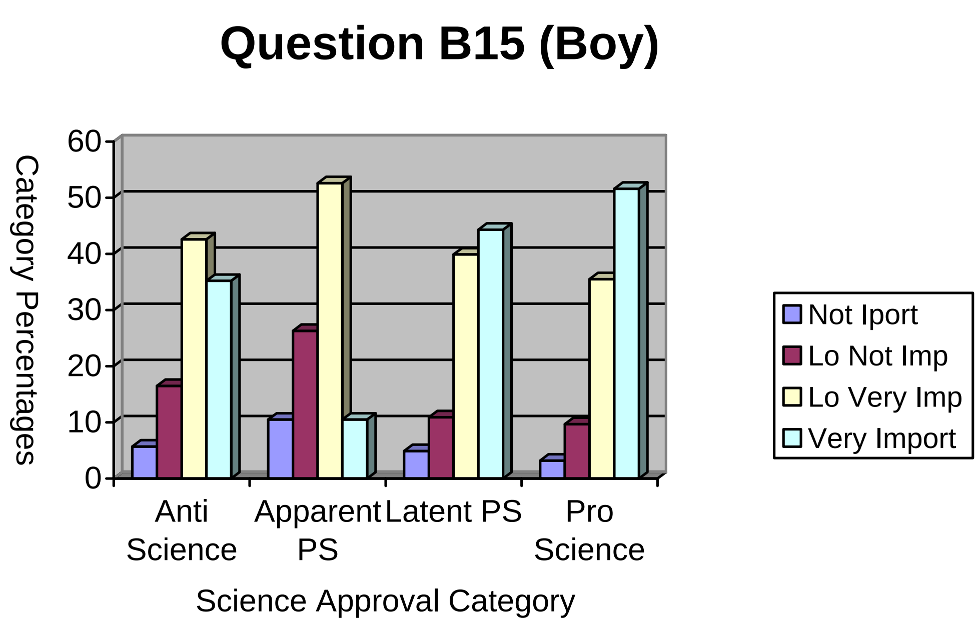
The cross-tabulation suggests groups that might be described respectively as pro-science , apparent pro-science (apparent PS), latent pro-science (latent PS) and anti-science. The first of these groups, the pro-science group, consists of students who agree/low agree that school science is interesting and agree/low agree that they like it better than most other subjects. Those in the apparent science group agree/low agree that they like science better than most other subjects but disagree/low disagree that school science is interesting. The small group of latent pro-science students agree/low agrees that school science is interesting but disagree/low disagree that they like it better than most other subjects. The final group, anti-science, disagree/low disagree that they like science better than most other subjects and also disagree/low disagree that school science is interesting.

Table 7.4: Classification of English Students in terms of School Science Preference

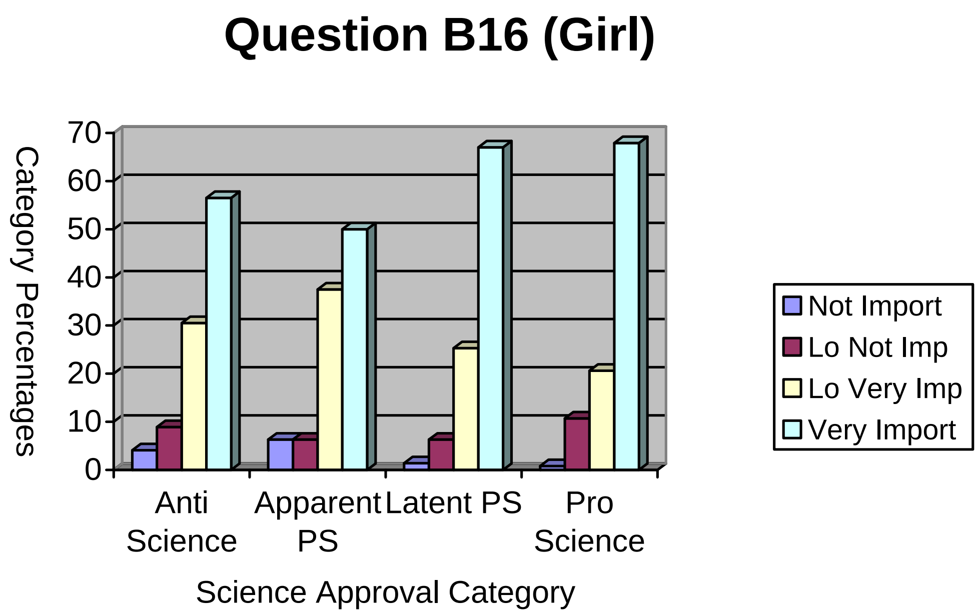
Gender	Pro-science (%)	Latent pro-science	Anti-science (%)	Apparent pro-science	Total
Girls	132 (20.6)	16 (2.5)	271 (42.2)	223 (34.7)	642
Boys	219 (36.3)	20 (3.3)	178 (29.5)	187 (31.0)	604
Mixed	351 (28.2)	36 (2.9)	449 (36.0)	410 (32.9)	1246

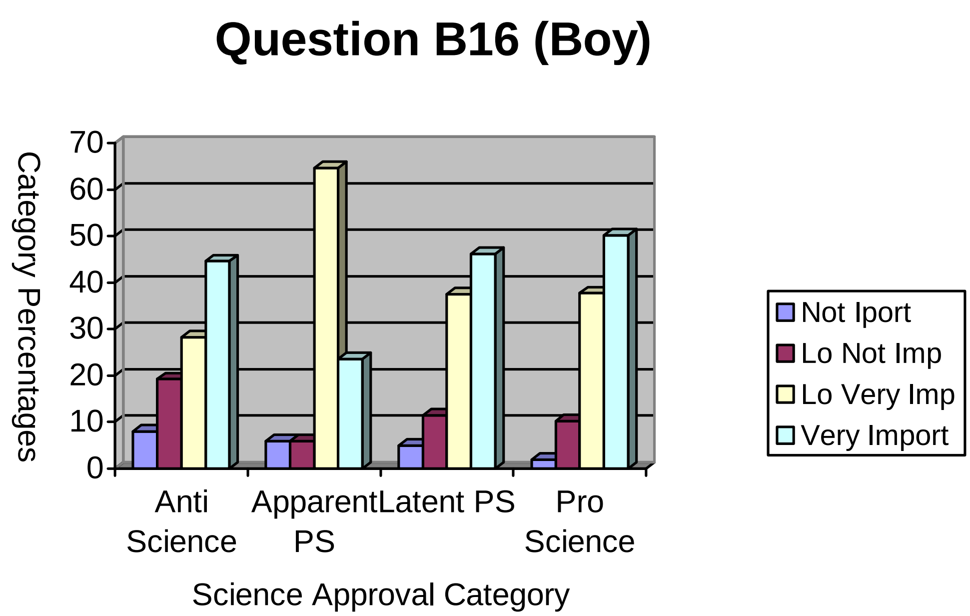
The outcome of this cross-tabulation suggests an analytical framework with which to investigate other responses to the ROSE questionnaire and raises a number of questions that deserve exploration. For example, what are the underlying characteristics of students in the pro-science group that distinguish them from those in the apparent group? Is it possible through appropriate pedagogy and/or curriculum intervention to increase the numbers of students in the pro-science group? Further analysis of the ROSE data permits the identification of the specific characteristics of each group in terms of their interest in scientific topics, their attitudes towards of range of scientific and technological issues or the number of books in the home. See the examples below and Ogawa and Shimode 2004.



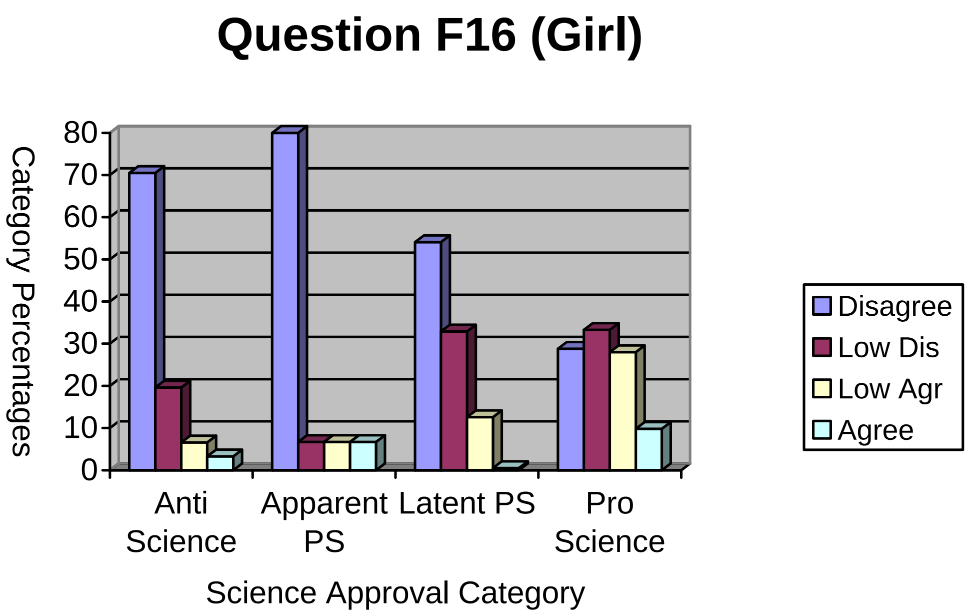


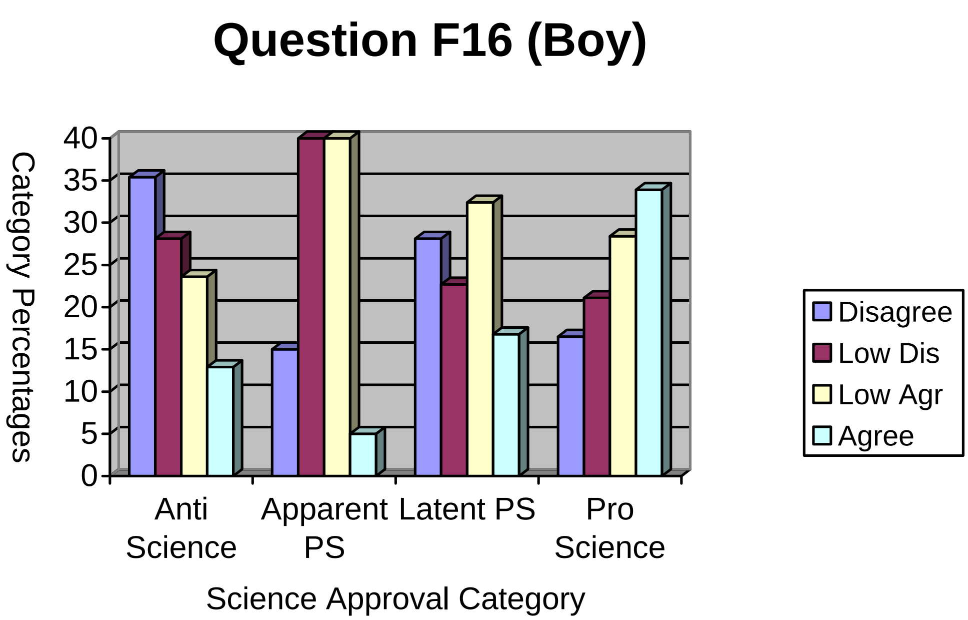
B15. Working with something I find important and meaningful



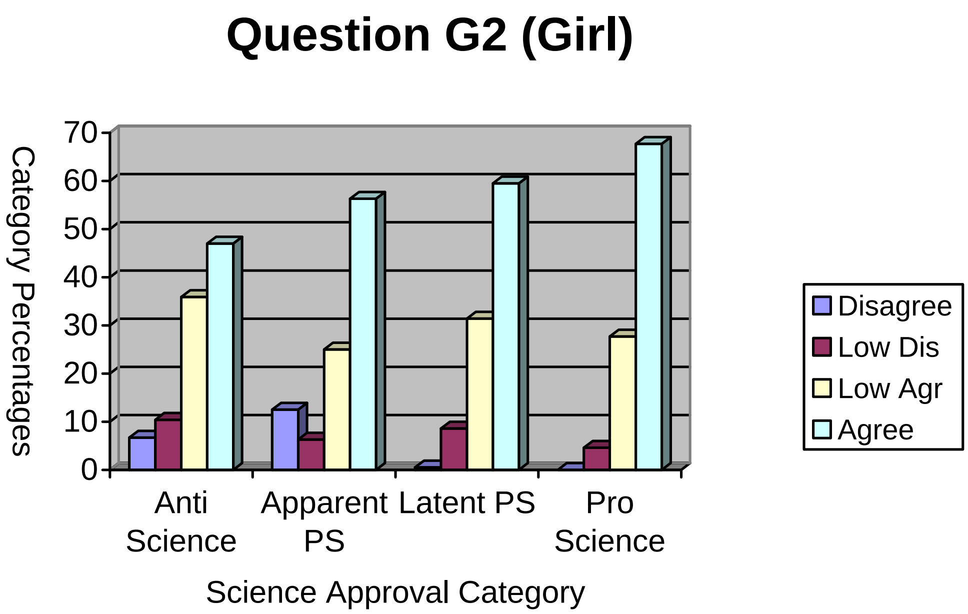


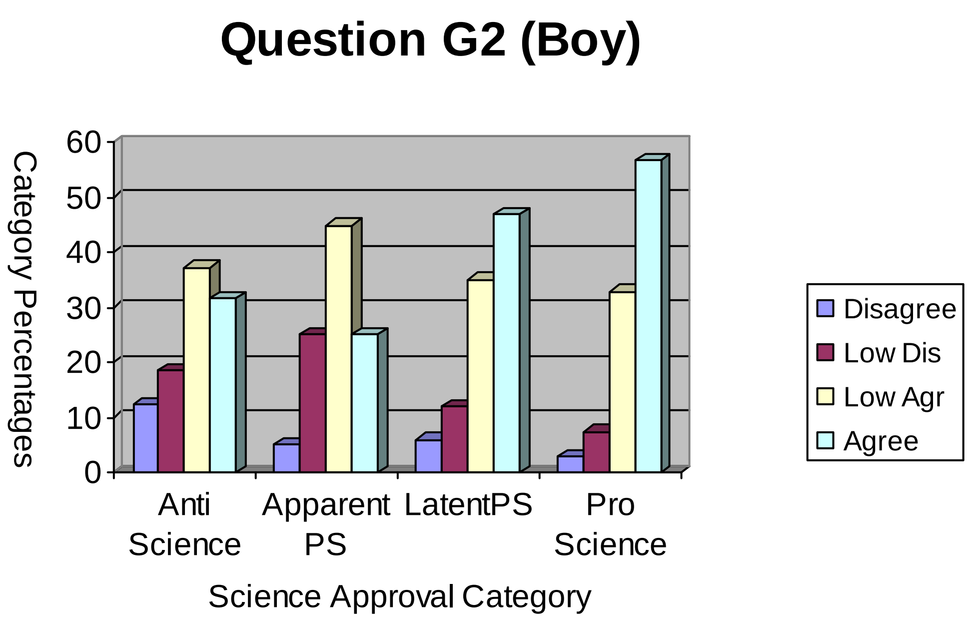
B16. Working with something that fits my attitudes and values



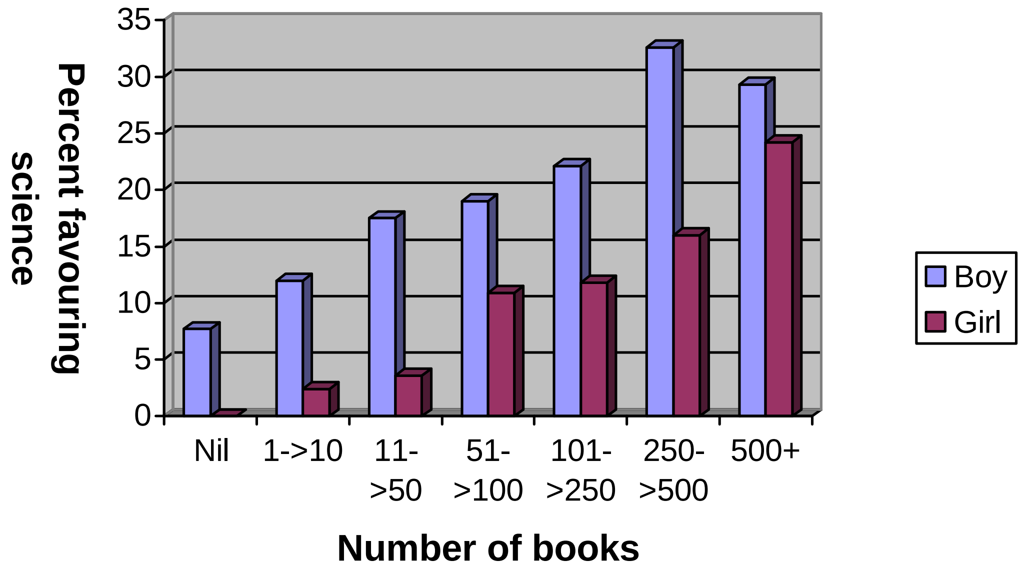


F16. I would like to get a job in technology





G2. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.



Favouring science = an aggregate score of 7 or above on items F2 and F5.

8. My Opinions about science and technology

This section (G) of the ROSE questionnaire invited students to indicate the degree of their agreement with each of 16 statements about science and technology and their role in society. The distribution of responses is given in Table 8.1. Gender differences in the responses are given in Table 8.2 (618 boys, 660 girls)

Table 8.1: Distribution of Responses to My Opinions about Science and Technology.

Item No.	Disagree %	Low disagree %	Low agree %	Agree %	Nil response	Agreement index	Median
G1	10.0	17.4	33.6	36.4	2.6	+42.6	L. agree
G2	4.8	10.4	32.9	49.2	2.6	+66.9	Agree
G3	6.3	11.8	33.8	45.3	2.8	+61.0	L. agree
G4	6.9	16.4	37.6	36.4	2.7	+51.0	L. agree
G5	10.0	19.2	35.0	31.8	4.0	+37.6	L. agree
G6	12.7	31.5	34.8	16.6	4.4	+7.2	L. agree
G7	21.0	34.6	29.9	10.5	4.0	-15.1	L. disagree
G8	32.2	36.8	19.5	8.3	3.3	-41.2	L. disagree
G9	26.2	37.4	23.1	8.5	4.8	-32.2	L. disagree
G10	17.7	37.6	29.2	11.9	3.6	-14.2	L. disagree
G11	9.3	20.2	40.0	26.3	4.2	+36.8	L. agree
G12	12.5	23.7	33.8	25.9	4.1	+23.5	L. agree
G13	25.8	37.8	25.2	6.9	4.3	-31.5	L. disagree
G14	47.2	33.4	12.7	3.2	3.5	-64.7	L. disagree
G15	29.2	38.9	20.6	5.9	5.0	-41.6	L. disagree
G16	9.2	15.0	38.9	33.9	3.0	+48.6	L. agree

The data in these two Tables suggest a number of positive messages about young people's views about science and technology, e.g., their role in society (G1) and optimism about the contribution they can make to curing diseases such as HIV/AIDS and cancer (G2). Science and technology are also seen as creating greater opportunities for future generations (G3) and as making everyday life healthier, easier and more comfortable (G4). There is a lower level of agreement with the assertion that the benefits of science are greater than its possible harmful effects (G6), although a majority of both boys and girls hold his view. Disagreement is most marked in items G7, G8, G9 and G10. Only a minority of boys (47.1%) and of girls (37.3%) agree that science and technology will help eradicate poverty and famine in the world or that science and technology can solve nearly all problems (boys: 35.3%; girls 22.4%). Most of the respondents do not see science and technology as the cause of environmental problems (G10) but there is no majority support among either boys or girls for the statement that science and technology are helping the poor (G9). The responses to items G13, G14 and G14 suggest a significant degree of disagreement with the three statements about the objectivity of science, the role of scientific method and the degree of trust that should be placed in what scientists have to say.

Table 8.2: Gender differences in responses to 'My opinions about science and technology'.

Item No.	Girls	Girls	Boys	Boys	Chi Square	K-S*
	Agree %	Disagree %	Agree %	Disagree %		
G1	68.3	31.7	75.9	24.1	0.003	0.002
G2	88.0	12.0	80.7	19.3	0.000	0.002
G3	80.4	19.6	82.5	17.5	NS	NS
G4	75.0	25.0	77.3	22.7	NS	NS
G5	67.3	32.7	72.0	28.0	0.074	0.053
G6	52.4	47.6	55.2	44.8	NS	NS
G7	37.3	62.7	47.1	52.9	0.001	0.006
G8	22.4	77.6	35.3	64.7	0.000	0.000
G9	27.4	72.6	39.2	60.8	0.000	0.000
G10	41.3	58.7	44.1	55.9	NS	NS
G11	65.3	34.7	73.2	26.8	0.003	0.041
G12	58.8	41.2	66,0	34.0	0.010	0.074
G13	27.7	72.3	39.6	60.4	0.000	0.000
G14	12.7	87.3	20.5	79.5	0.000	0.004
G15	24.0	76.0	32.0	68.0	0.002	0.043
G16	73.5	26.5	76.9	23.1	NS	NS

* This has been used to compare the entire distribution. Chi Square has been used to compare agree/disagree using a 2x2 tableau.

Many of the gender differences in Table 8.2 are statistically significant. In general, girls are less confident/less optimistic than boys in their responses to this section of the ROSE questionnaire, although the differences are not great. The results of a factor analysis of the responses by gender are given in Table 8.3 and they reveal some differences in the clusters. Positive views about the role and contribution of science and technology are evident in each case (see Component 1) but there are differences in the responses to items G7 and G11. In the case of the boys, the second component reflects a high degree of trust in scientists and scientific method, allied with confidence in the contribution that science and technology can make to the eradication of poverty and the solution of most problems. While girls also express this confidence, there is no corresponding association with trust in scientists and scientific method. That trust is reflected in the third cluster for girls, whereas the third cluster for the boys links science with advantaging the richer countries and with causing environmental problems.

Table 8.3: Principal Component Analysis of 'My opinions about science and technology for boys and (girls)*

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

* Principal component analysis, Varimax rotation with Kaiser normalization

Boys: Components 1, 2 and 3 account for 30.7%, 15.2% and 7.7% of total variance respectively.
Girls: Components 1, 2, and 3 account for 30.3%, 14.1% and 7.5% of total variance respectively.

9. My out-of-school experiences

Each of the 61 items in this section (H) of the ROSE questionnaire invites the respondents to indicate the extent of their experience (‘never’ to ‘often’) of an activity that might be judged relevant to their school science education, e.g., used a compass to find direction, planted seeds and watched them grow. As might be expected from an international study, the 61 statements cover a wide range of activities.

Factor analysis of the sample (boys and girls) identifies four components, the first of which accounts for 11% of the total variance, with the remaining three each accounting for a further 6%. The first cluster consists of items H15, H16, H32,H33,H34,H35, H39,H40,H52,H56,H57,H58,H59,H60 and H61. The majority of activities to which these items refer might be described as ‘hands-on’ practical/technological (e.g., changed an electric bulb or fuse, mended a bicycle), although H15, H16, H32 and H33 embrace practical activities of a different kind (e.g., hunting, fishing, using an air rifle). The second cluster (H44, H45, H46, H47, H48, H49, H50 and H51) are all related to modern electronic technologies, such as the internet and the mobile telephone. The third cluster (H1, H5, H12, H13, H14, H17, and H18) is underpinned by reference to the natural world, e.g., finding constellations in the sky, collecting edible berries and fruits. The remaining cluster (H30, H31, H38, H41, H42, and H43) brings together items related to measurement and/or observation (e.g., binoculars or a camera, used a measuring ruler, tape or stick).

It is frequently said that girls may be disadvantaged in studying science and technology at schools because their out-of-school experiences are less directly relevant than those of boys to success in these subjects at school. A factor analysis of the responses by gender to this section of the ROSE questionnaire is therefore of particular interest. The outcome is shown in Tables 9.1 and 9.2. Four factors are identified in the case of the boys, accounting for 9%, 8%, 5% and 5% of the total variance respectively. In the case of the girls, two factors account for 20% and 8% of the total variance. For both boys and girls, modern electronic technologies feature significantly among their out-of-school experiences. However, Tables 9.1 and 9.2 suggest that their other out-of-school experiences differ substantially, with girls being much more strongly associated with activities involving the natural world (e.g. planted seeds) or craft (e.g., knitting or weaving). In the case of the boys, activities that might be described as mechanical are to the fore, although the engagement of girls with the use of simple tools should not be overlooked.

Table 9.1: My out of school experiences (boys)*

Component 1	Component 2	Component 3	Component 4
Participated in hunting (0.493)	Used a mobile ‘phone (0.753)	Watched (not on TV) an animal being born (0.619)	Recorded on video, DVD or tape (0.501)
Changed or fixes electric bubs or fuses (0.470)	Sent or received an SMS (0.764)	Cared for animals on a farm (0.565)	Used a stopwatch (0.735)
Connected an electric lead to a plug (0.550)	Searched the internet for information (0.705)	Milked animals like cows, sheep or goats (0.770)	Measured the temperature with a thermometer (0.694)
Opened a device to find out how it works (0.486)	Played computer games (0.561)	Made dairy products like yoghurt, butter, cheese or ghee (0.609)	Used a measuring ruler, tape or stick (0.662)
Used a wheelbarrow ().655)	Used a dictionary, encyclopaedia, etc., on a computer (0.413)	Knitted, weaved, etc., (0.532)	
Used a crowbar (jemmy) (0.737)	Downloaded music from the internet (0.673)		
Used a rope and pulley for lifting (0.713)	Sent or received e-mail (0.769)		
Mended a bicycle tube (0.717)	Used a word processor on a computer (0.670)		
Used tools like a saw, screwdriver or hammer (0.652)			
Charged a car battery (0. 727)			

*Principal component analysis, Varimax rotation with Kaiser normalization.

Table 9.2: My out of school experiences (girls)*

Component 1	Component 1 (cont.)	Component 2
Used a compass to find direction (0.512)	Cleaned and bandaged a wound (0.591)	Used a mobile 'phone (0.656)
Read about nature or science in books or magazines (0.519)	Used binoculars (0.558)	Sent or received an SMS (0.590)
Watched nature programmes on TY or in a cinema (0.529)	Made a bow and arrow, slingshot, catapult or boomerang (0.577)	Searched the internet for information (0.614)
Collected edible berries, fruits, mushrooms or plants (0.531)	Made a model such as toy plane or boat etc. (0.623)	Played computer games (0.506)
Planted seeds and watched them grow (0.531)	Used a windmill, watermill, water wheel etc. (0.509)	Used a dictionary, encyclopaedia, etc., on a computer (0.515)
Made compost of grass, leaves or garbage (0.541)	Used a stopwatch (0.518)	Sent or received e-mail (0.516)
Made an instrument …from natural materials (0.504)	Measured the temperature with a thermometer (0.0.520)	Use a word processor on the computer (0.558)
Knitted, weaved etc., (0.526)	Walked while balancing an object on my head (0.530)	
Put up a tent or shelter (0.511)	Used a wheelbarrow (0.5370	
Made a fire from charcoal or wood (0.528)	Used a rope and pulley for lifting (0.555)	
Prepared food over a campfire, open fire or stove burner (0.551)	Used tools like a saw, screwdriver or hammer (0.595)	

* Principal component analysis, factors not rotated (unstable with Varimax rotation)

10. If I were a scientist

In Section I of the ROSE questionnaire, students were asked to assume that they were adults and working as a scientist. Given freedom to undertake research that they personally regarded as 'important and interesting', they were then invited to 'write some sentences' about what they would like to do as a researcher and why. Unlike the remainder of the ROSE questionnaire which consisted of fixed response items, it was necessary here to devise a scheme for analyzing and coding what the students had written. The two components of Section I (what and why) were separately coded (I1 and I2) and each of these subsequently divided to accommodate the topics chosen for research and the various reasons offered by students for their choice. Full details of the coding scheme are available in Schreiner and Sjøberg (2004).

Table 10.1 My field of research if I were a scientist (boys and girls)

FIELD OF RESEARCH	NUMBER BOYS	NUMBER GIRLS
Biology: human, body	33	61
Diseases, medicine, cures	112	240
Microbiology, gene technology	14	16
Animals, plants, nature	31	65
Other biology	0	1
Technology: computers, electronics etc.	29	10
Motor cars, buildings, road, transport etc.	26	3
Weapons	7	0
Other technology or not specified	3	1
Environment	14	21
Earth, weather, climate	14	12
Chemistry, atoms, reactions etc.	30	17
Physics, electricity, heat etc.	12	3
Space, stars, planets, black holes, space travel	120	92
Psychology, human behaviour	9	19
Invent things	14	4
Do experiments, work in laboratory	4	
Paranormal, philosophical, mysterious, wonder, etc.	12	17
Social and economic sciences	1	-
Do not want to do research	1	-

Table 10.1 summarises the areas in which students indicated they would wish to pursue on the assumption that they were adult research scientists.

Table 10.2 indicates the reasons for the choices made. In examining these Tables, it is important to remember that a minority of students indicated that they would be interested in more than one area of research.

Table 10.2: The reason(s) for my chosen field of research

REASON	**NUMBER (%)**
Curiosity, interests, seems fun, exciting, want to	532 (63.3)
Related to a profession I want to follow	16 (1.1)
Important in general or for society/humanity	131 (9.0)
Helping people, animals, etc.	287 (19.8)
Becoming rich, popular, famous	30 (2.1)
Other/non specified	157 (10.8)

It would be rash to draw major seminal conclusions from the data in these two Tables. Students' understanding of what might be involved in working as a research scientist in, for example, physics or earth science, is, at best, limited and, at worst, misleading or incorrect. Also, while such work is likely to involve at some stage work in a laboratory or conducting experiments, only a handful of students mentioned these aspects of scientific research in their written responses. Nonetheless, some comments are appropriate. As a number of other studies have shown, biological and space science dominate the fields of research that interest students, both boys and girls. Biology featured in 573 responses, with marked emphases on medicine/treatment of diseases and on animals, plants and the world of nature. Space science (stars, planets, black holes, space travel, etc.) accounts for the next largest group (212) of expressed interests among the fields of research. In contrast, working with different technologies, especially modern information technologies, features less prominently than might have been anticipated. Research as a chemist seems to hold more appeal to students than either psychology or the paranormal, although each of these is mentioned more frequently than physics as a field of research. There is also little reflection here of the interest of boys evident in Table 4.1 in learning about weapons and destructive technologies. This suggests that pupils are well able to distinguish what they might like to learn about in their school science courses from the broad field of inquiry that they would wish to pursue if they were research scientists. Gender differences are once again marked with girls prioritising medicine/disease and boys technology.

11. Overview

The responses of the students in England to the ROSE questionnaire offer a number of positive messages about their views on science and technology. There is a large measure of agreement that science and technology are important for society and there is optimism about the contribution that they can make to curing diseases such as HIV/AIDS and cancer. Science and technology are also seen as creating greater opportunities for future generations and as making everyday life healthier, easier and more comfortable. There is a lower level of agreement with the assertion that the benefits of science are greater than its possible harmful effects, although a majority of both boys and girls hold this view. Among the boys who are most optimistic about the social benefits of science and technology, there is also a high degree of confidence in science, scientists and scientific method. While girls also express a similar degree of optimism, such optimism in their case is not linked statistically with trust in science, scientists or scientific method. Interestingly, there is only a low level of agreement among the students in England that science and technology are helping the poor.

The responses of the students in England to the ROSE questionnaire may be compared with data from a number of other studies, notably the Eurobarometer survey conducted within the 25 member states of the European Union, the candidate countries and the members of the European Free Trade Association. The Eurobarometer data are derived from a total of 32,897 face to face interviews, based upon specific questions (European Commission, 2005, pp. 130-31). A few of the statements in the ROSE study are similar to, or identical with, those used in the Eurobarometer survey, although direct comparison of the findings from the two sources is not straightforward because of differences in sampling, methodology and of the way in which the findings are presented. The Eurobarometer survey shows that most Europeans (88%) are optimistic that scientific and technological progress will help to cure illnesses such as AIDS and cancer and that science and technology will make life healthier, easier and more comfortable (78%). 77% agree that, thanks to science and technology, there will be more opportunity for future generations but only a small majority, 52%, believes that the benefits of science are greater than any harmful effects it may have. These percentages can be compared with the responses to statements G2, G4, G3 and G6 respectively. The Eurobarometer survey (European Commission, *op.cit.*, 58-62) also shows that only 21% of Europeans agree that ‘science and technology can sort out any problem’ (compare the response to statement G8) and that only 39% agree that ‘Science and technology will help eliminate poverty and hunger around the world’ (compare the response to statement G7). The generally supportive attitude towards science and technology reported in the ROSE and Eurobarometer surveys is also evident in the data collected by the National Science Board in the USA, although, in general, such support is stronger than within Europe. For example, more Americans (72%) than Europeans (52%) agreed in 2001 that the benefits of scientific research outweighed any harmful results (National Science Board, 2004, ch.7, p.4).

In England, as in many other developed countries, the various positive messages about science, technology and society are not reflected in the students’ responses to a series of statements about their school science education. School science is judged 'interesting' by a small majority of students (more so by boys than girls), and rather more regard it as 'relevant' and 'important' and as a subject that 'everybody should learn at school'. However, most boys and (more so) girls don't like it as much as other subjects. In broad terms, the view of most students about school science might be summed up as 'important but not for me' (Jenkins and Nelson 2005), although it should be noted that there is a minority of students who are strongly supportive of science, like their school science, want as much science as possible at school and envisage themselves working as a scientist or technologist in due course. For the students in this minority group, the commitment to science and school science seems unrelated to issues such as utility or relevance (e.g., 'science will be helpful in my everyday life', 'will improve my career chances'). Interestingly, it does seem to be related to the notion of school science as a 'difficult' subject, a notion that is not shared more widely, although girls find it more difficult than boys. The cross tabulation presented in Tables 7.3 and 7.4. suggests that there is a group of students in the sample responding to the ROSE questionnaire (the 'apparent pro-science' students) who agree/low agree that they like science better than most other subjects but disagree/low disagree that school science is interesting. This would seem to open the possibility of curricular, pedagogic or other forms of intervention designed to encourage more students to study science beyond the stage when they are compelled to do so. However, such a possibility needs to be set alongside the finding that a career in science or technology has little appeal for most students, the latter being particularly the case for girls.

One particularly noteworthy feature of the students' views about their school science education concerns the outcomes frequently attributed to the learning of science. According to the national curriculum in force in England at the time the students completed the questionnaire science was said to 'stimulate and excite pupils' curiosity about phenomena', link 'direct practical experience with ideas' and act as a 'spur to critical and creative thought'. The data suggest that most boys and girls disagree that their school science has made them 'more critical and sceptical', 'opened their eyes to new and exciting jobs' or increased 'their appreciation of nature'. It would also be difficult to sustain a claim that school science has shown most students 'the importance of science for our way of living', especially in the case of girls.

When asked what they wished to learn about (Sections A, C and E), the pattern of overall responses suggests that boys and girls are equally interested in science but that their interest in particular aspects of science is different. While interest among both boys and girls in topics drawn from space or earth science (e.g. A22, 23, 24, 25, 34) is high and the gender differentials are modest, this is not the case for a number of other topics, especially those relating to the mechanical/technical (e.g., A47, 48) the destructive (e.g., A31, 32), eating disorders (e.g., A38), cosmetic surgery, and alternative therapies and beauty (e.g. A39, 40, C12).

Although it is important not to read too much into the differences in the ways in which boys and girls have responded to the ROSE questionnaire as a whole (see, for example, the note of caution by Brickhouse *et al.* 2000), such differences constitute one of the most consistent features of the data from the students in England. Given the administrative, legislative, curricular and pedagogic initiatives directed towards gender equity in England in the last thirty or so years, the persistence and nature of the gender differentials revealed by the ROSE data might be regarded as disappointing. Whether in terms of what they would like to learn, of their attitudes towards science and technology, of what they regard as important in their future employment, or of the kinds of research they would wish to pursue as a scientist, there are significant differences in the views of most boys and girls. The dangers of a school science curriculum formally differentiated by gender are obvious. However, when considered together with other findings relating to how girls prefer to be taught or assessed, the ROSE data suggest that it may be time to examine whether a commitment to gender equity might be better met by such an approach.

The factor analyses of the responses to the various components of the ROSE report have identified a number of clear clusters, value sets, among the views expressed by the students. For example, earning lots of money, controlling other people, becoming famous and 'boss' at a job represent one set of values that belong together in the case of both boys and girls. Another set of responses cluster around using one's talents and abilities, making one's own decisions, and working with something personally important, meaningful and consistent with personal attitudes and values. The relationships between these various value sets and the responses to other elements of the ROSE questionnaire constitute a rich field for further exploration.

The responses of the students in England to the various elements of the ROSE questionnaire fall within the broad pattern that characterises the participating countries of the developed world, although there are some important differences in means and gender differential. It is a pattern that stands in marked contrast to that associated with the developing countries (see, for example, Appendix 2). Given the differences in education systems, curricula, pedagogy, patterns of assessment and much else between the countries within the developed world, it is difficult not to conclude that some of the factors shaping, if not determining, the attitudes of young people in these countries towards scientific and technological careers may lie outside the school in the wider society. If, as sociologists like Bauman (1995, 1998) and Habermas (1981) have argued, industrialised western societies are characterised by, among much else, a prioritising of consumption over production and a colonisation of the cognitive and moral spheres of human life by the aesthetic realm, such features are unlikely to be without impact on the way in which young people perceive, and respond to, science and technology. As Lash (2001) has noted, any shift from cognition to perception highlights the importance of personal and social experience and diminishes the value to be attached to knowledge gained through the abstraction of judgement.

It is appropriate to end with a few more general notes of caution. Reference has already been made to the methodological limitations of a questionnaire-based study and of analysing Likert responses. Beyond these limitations, however, it is important to recognise that students do not 'speak' with a single voice and that that voice changes throughout compulsory schooling. Like the Eurobarometer and National Science Board surveys in the USA, the ROSE data are a snapshot in time, although both the

Eurobarometer and the National Science Board surveys collect data at successive points in time in ways that allow some shifts on opinion to be identified. However, if changes throughout schooling in the student voice and, more particularly, in their interests in and attitudes towards science, are to be more fully understood, research methodologies that are more complex, sensitive, qualitative and differently focused are required and these will need to allow the salient issues to be identified and tracked over time. To what extent, if at all, can the reluctance of students to study the physical sciences beyond compulsory schooling be attributed to school-based factors, such as the content of the science curriculum, the way science is taught and/or assessed and/or the alleged difficulty of the physical sciences as subjects of study? How are students' attitudes towards science and technology related to success at school and what influences that success? How important are other factors such as the influence exerted by parents, students' peer groups within and outside school, or careers' advisers, and what is the nature and extent of their interaction? Until more is known about the answers to questions of this kind, attempts to encourage more students to choose the physical sciences as subjects of advanced study seem likely to be at best hit and miss and, at worst, counterproductive.

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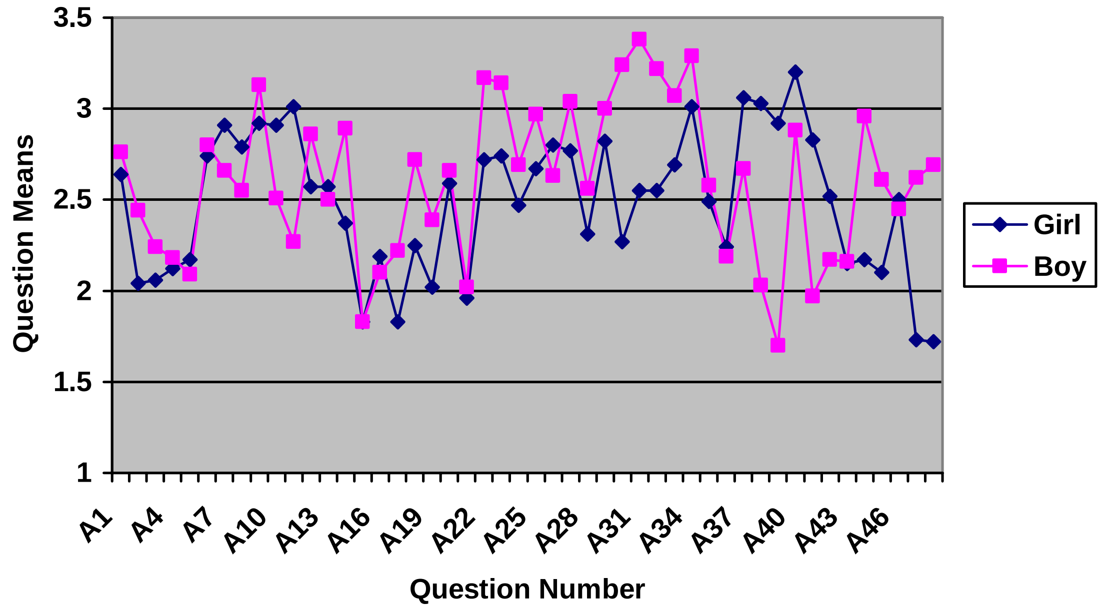
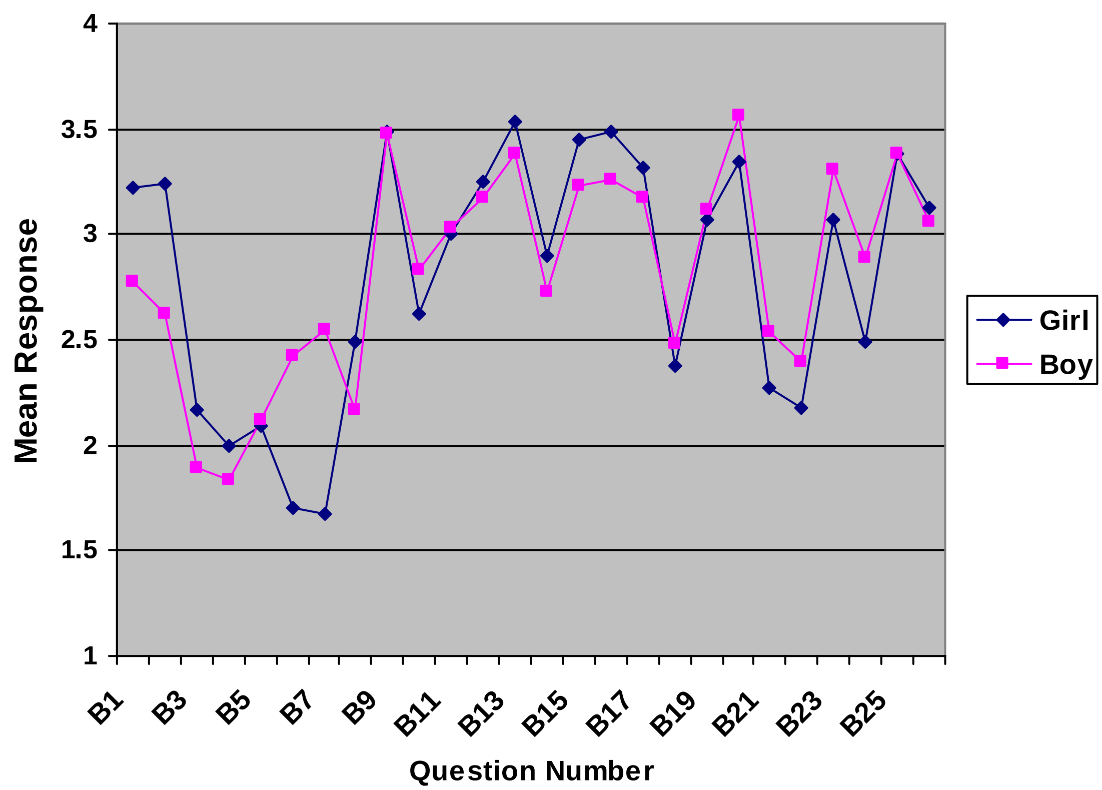
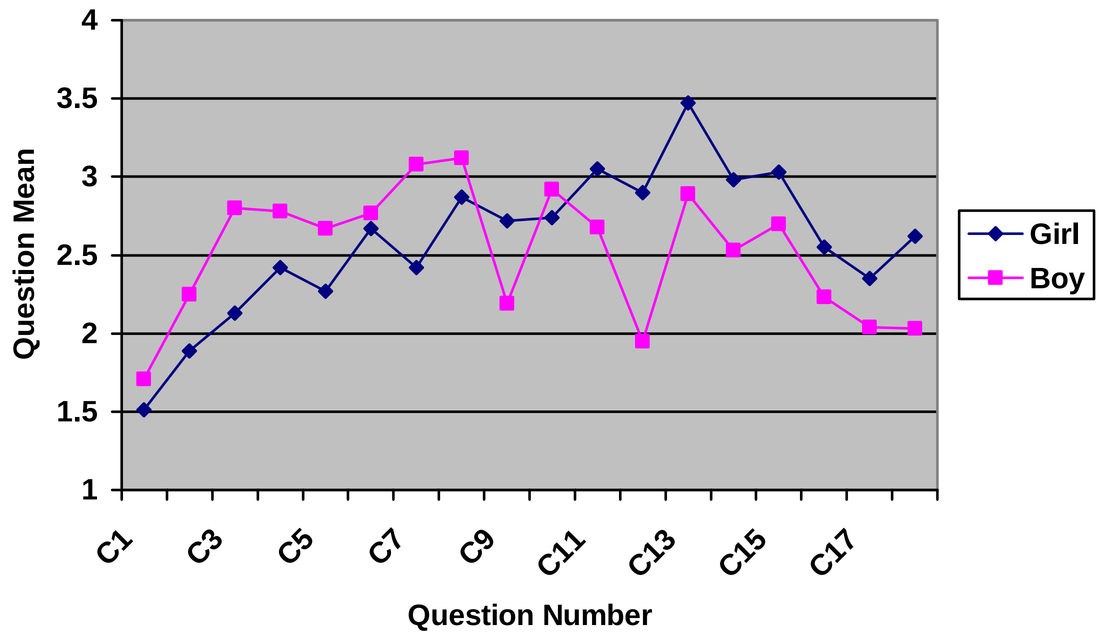
APPENDIX 1: Mean scores by gender (England)

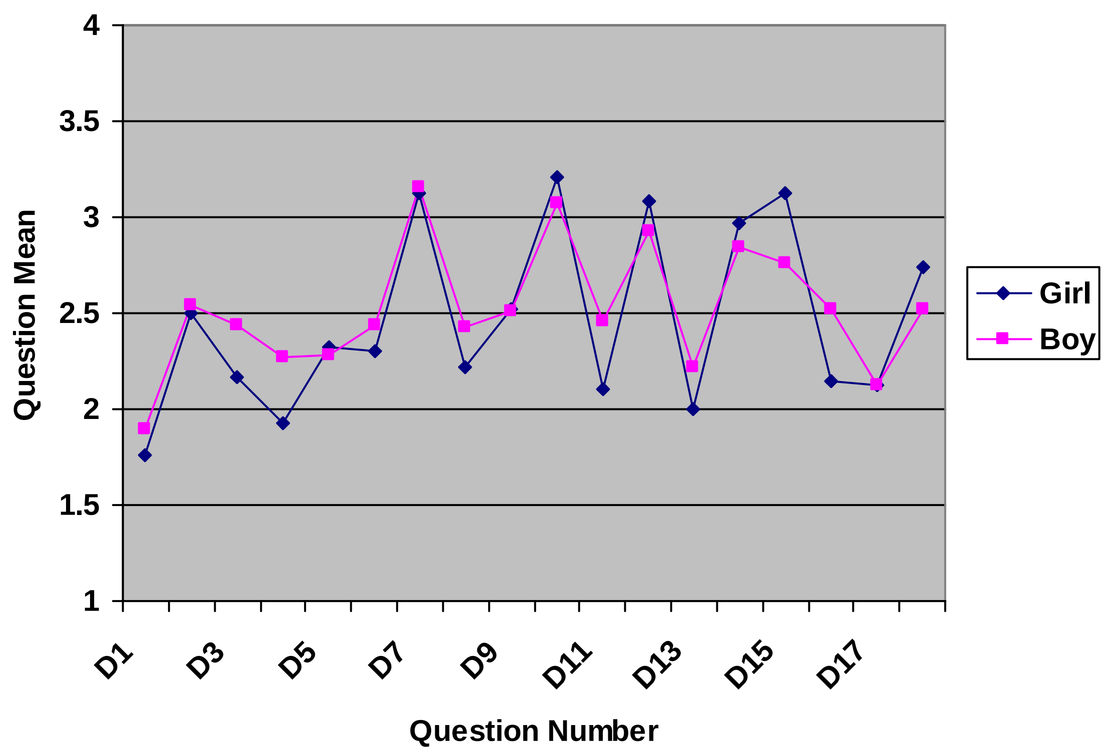


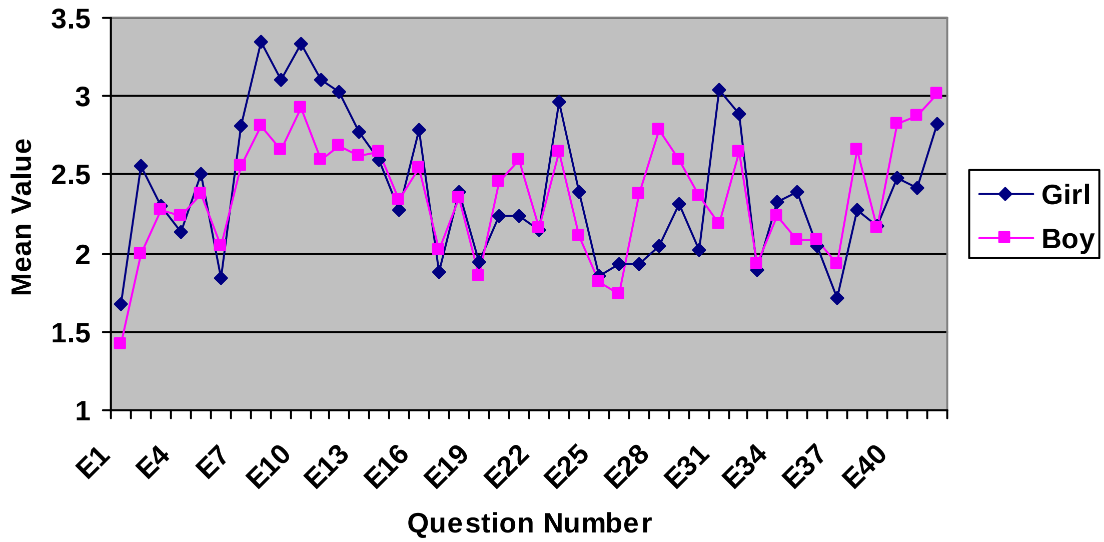
Question Means
3.5
3
2.5
2
1.5
1
A1
A4
A7
A10
A13
A16
A19
A22
A25
A28
A31
A34
A37
A40
A43
A46
Question Number
Girl
Boy



Mean Response
4
3.5
3
2.5
2
1.5
1
B1
B3
B5
B7
B9
B11
B13
B15
B17
B19
B21
B23
B25
Question Number
Girl
Boy


4
3.5
3
2.5
2
1.5
1
Question Mean
C1
C3
C5
C7
C9
C11
C13
C15
C17
Question Number
Girl
Boy


4
3.5
3
2.5
2
1.5
1
Question Mean
D1
D3
D5
D7
D9
D11
D13
D15
D17
Question Number
Girl
Boy


3.5
3
2.5
2
1.5
1
Mean Value
E1
E4
E7
E10
E13
E16
E19
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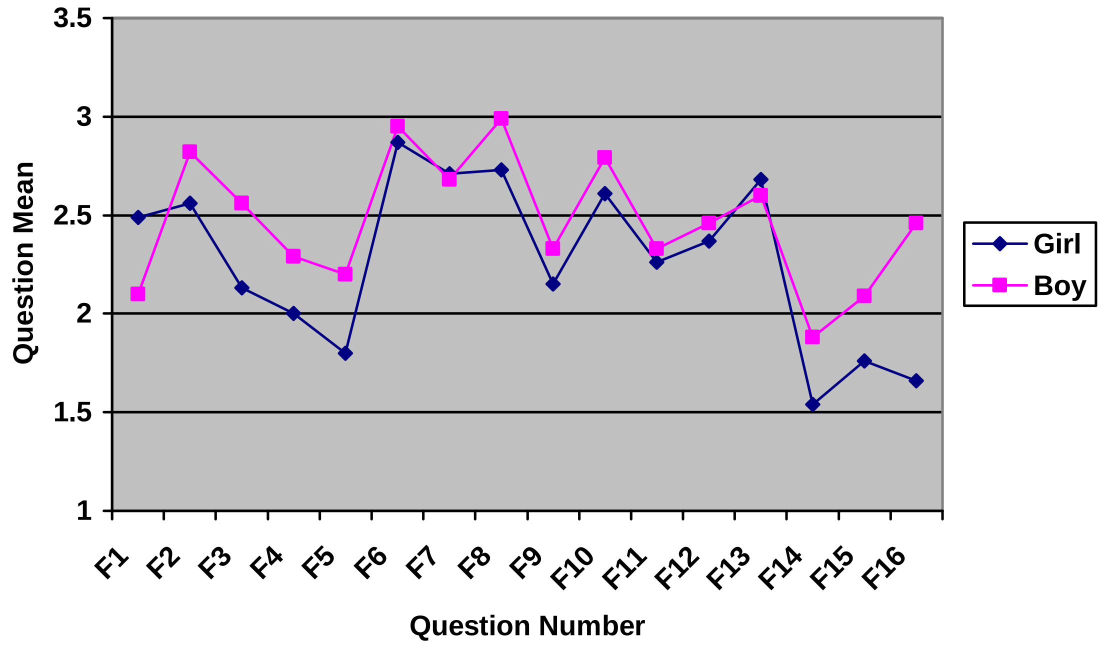
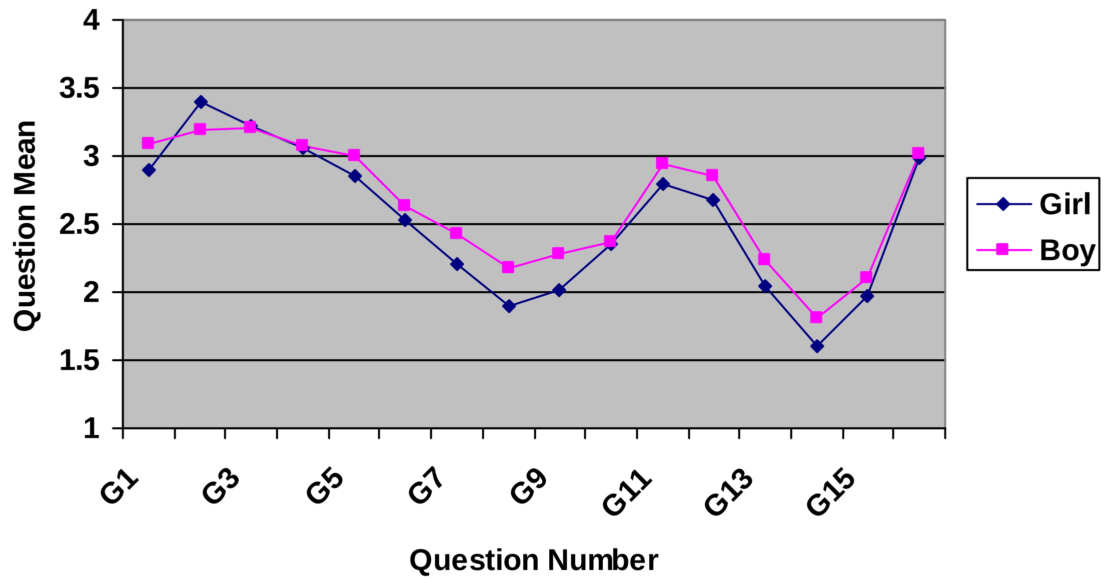
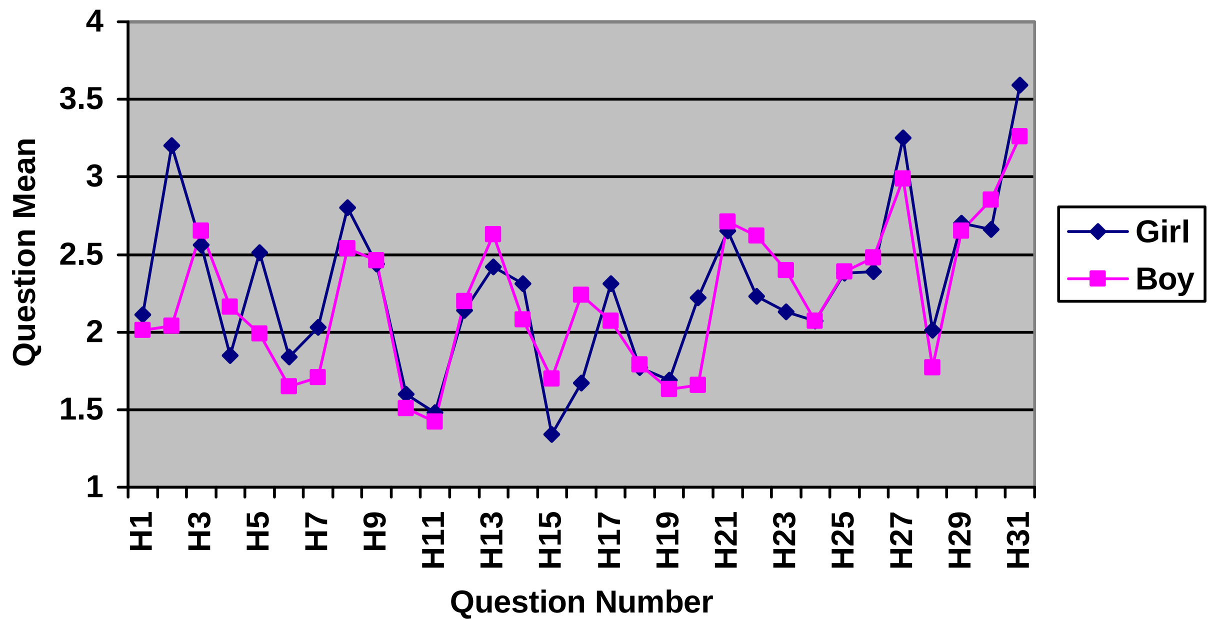
E25
E28
E31
E34
E37
E40
Question Number
Girl
Boy

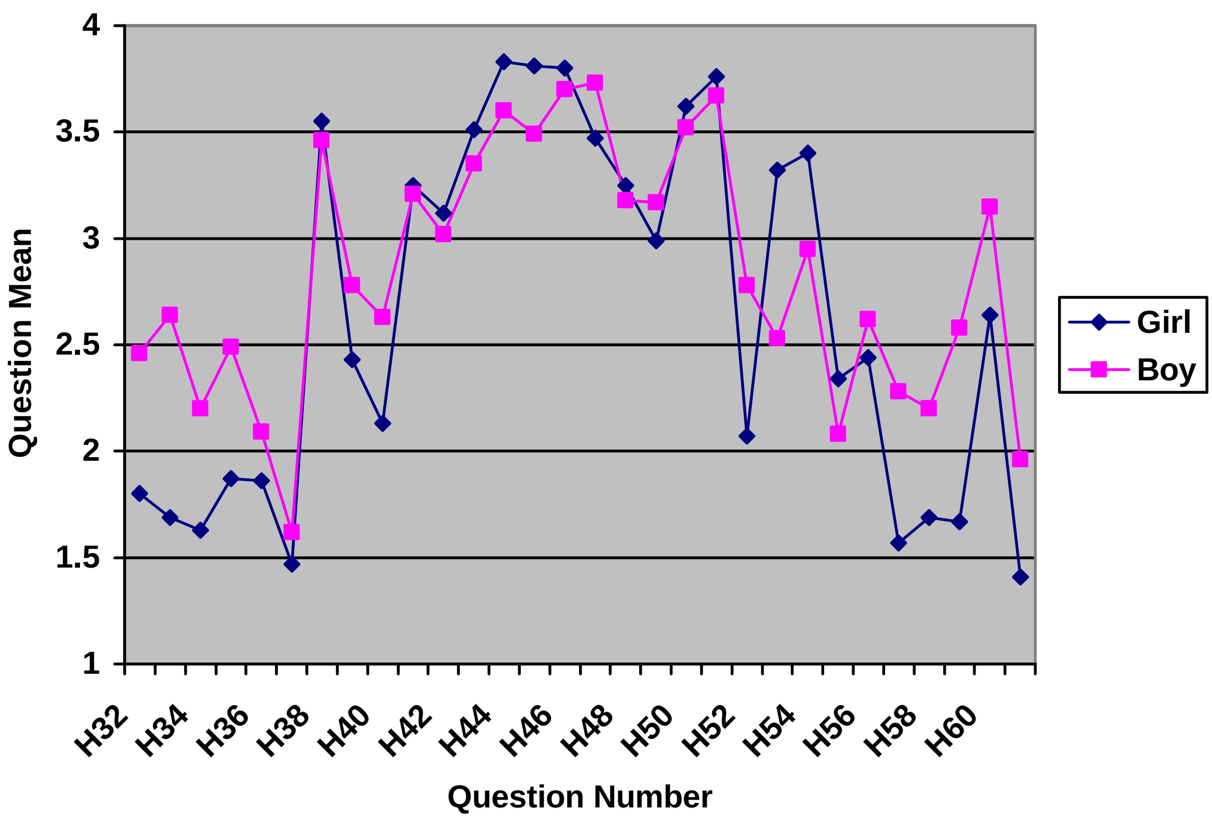

3.5
3
2.5
2
1.5
1
Question Mean
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
F11
F12
F13
F14
F15
F16
Question Number
Girl
Boy



Question Mean
4
3.5
3
2.5
2
1.5
1
G1
G3
G5
G7
G9
G11
G13
G15
Question Number
Girl
Boy

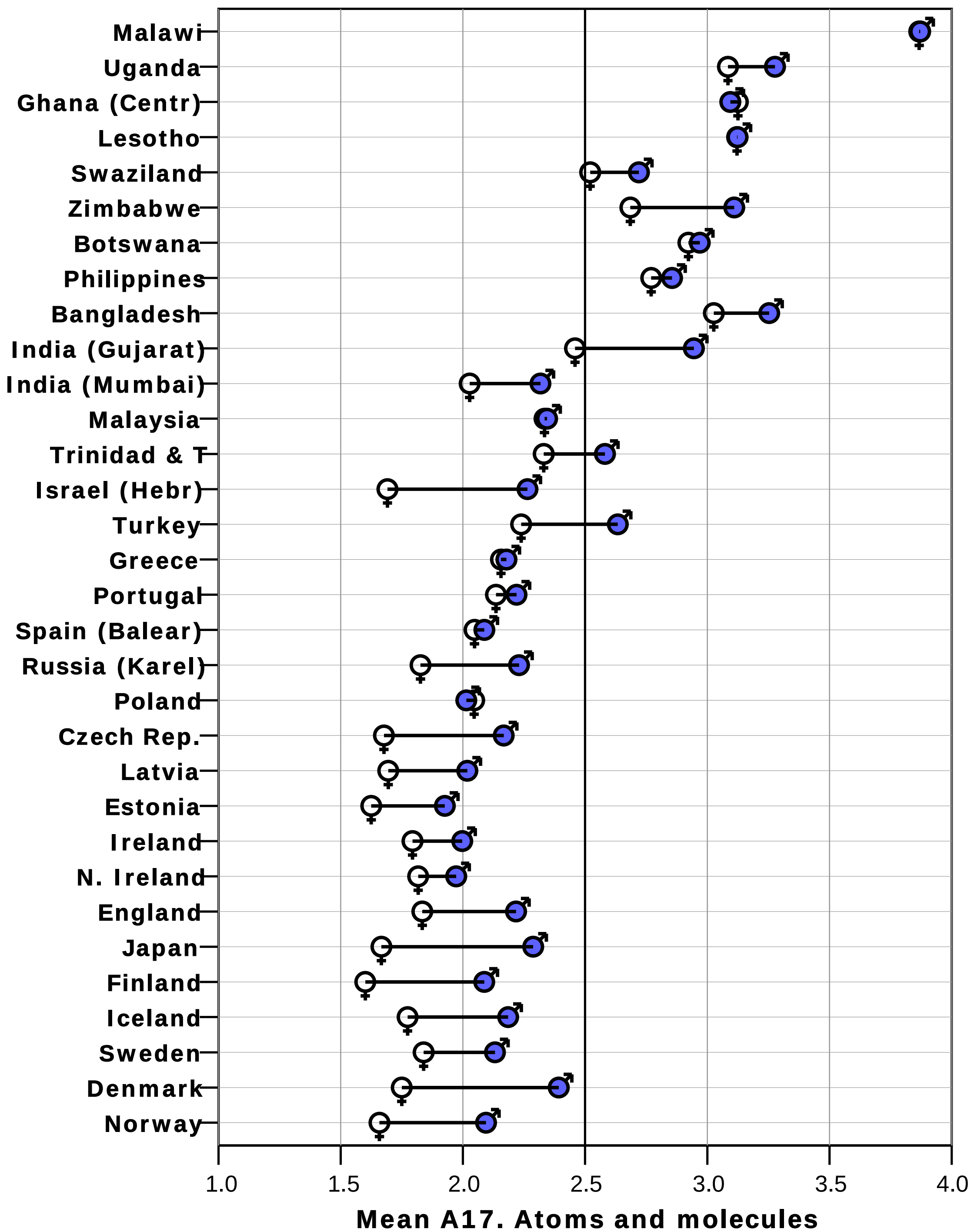


Question Mean
4
3.5
3
2.5
2
1.5
1
H1
H3
H5
H7
H9
H11
H13
H15
H17
H19
H21
H23
H25
H27
H29
H31
Question Number
Girl
Boy

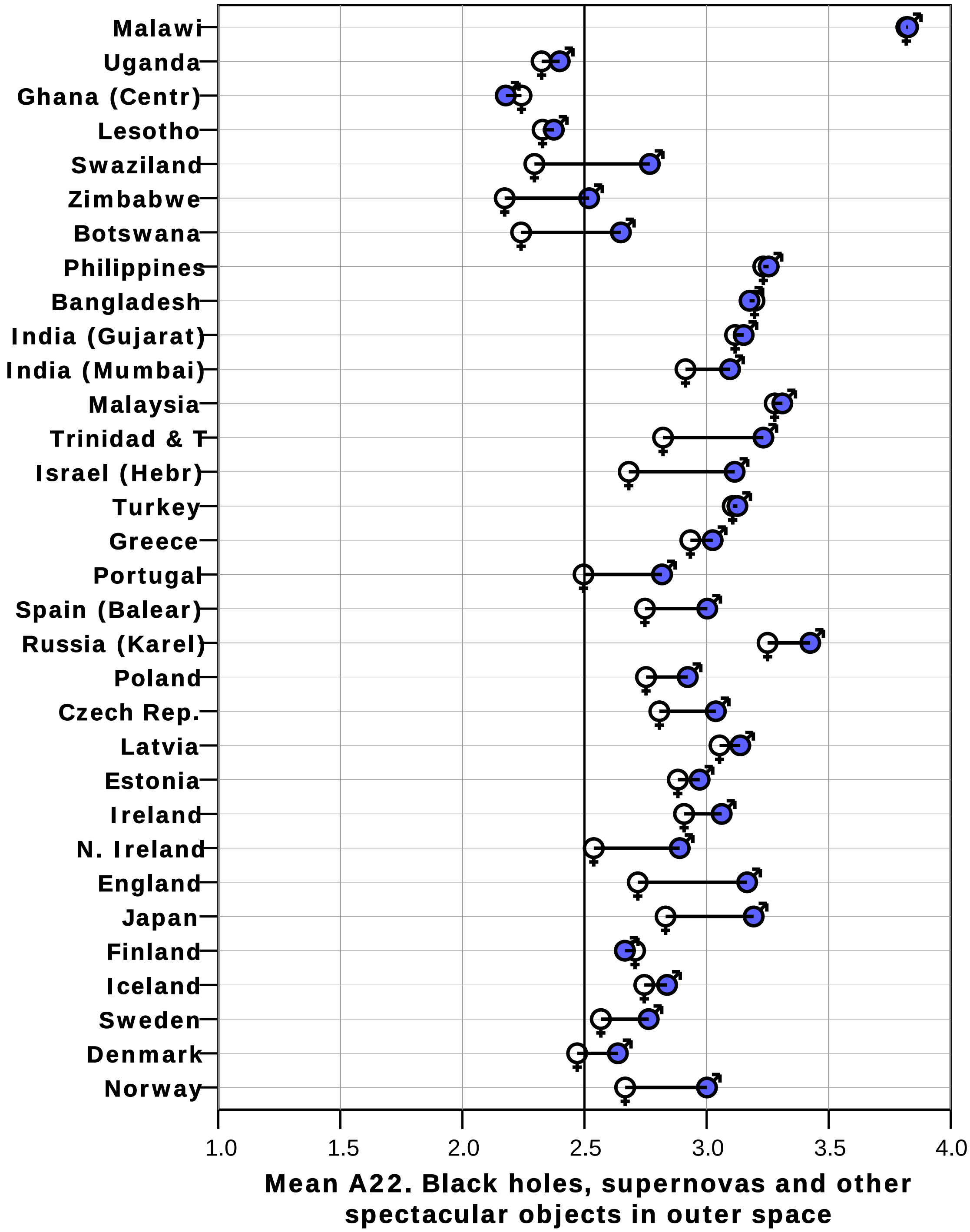


4
3.5
3
2.5
2
1.5
1
Question Mean
H32
H34
H36
H38
H40
H42
H44
H46
H48
H50
H52
H54
H56
H58
H60
Question Number
Girl
Boy

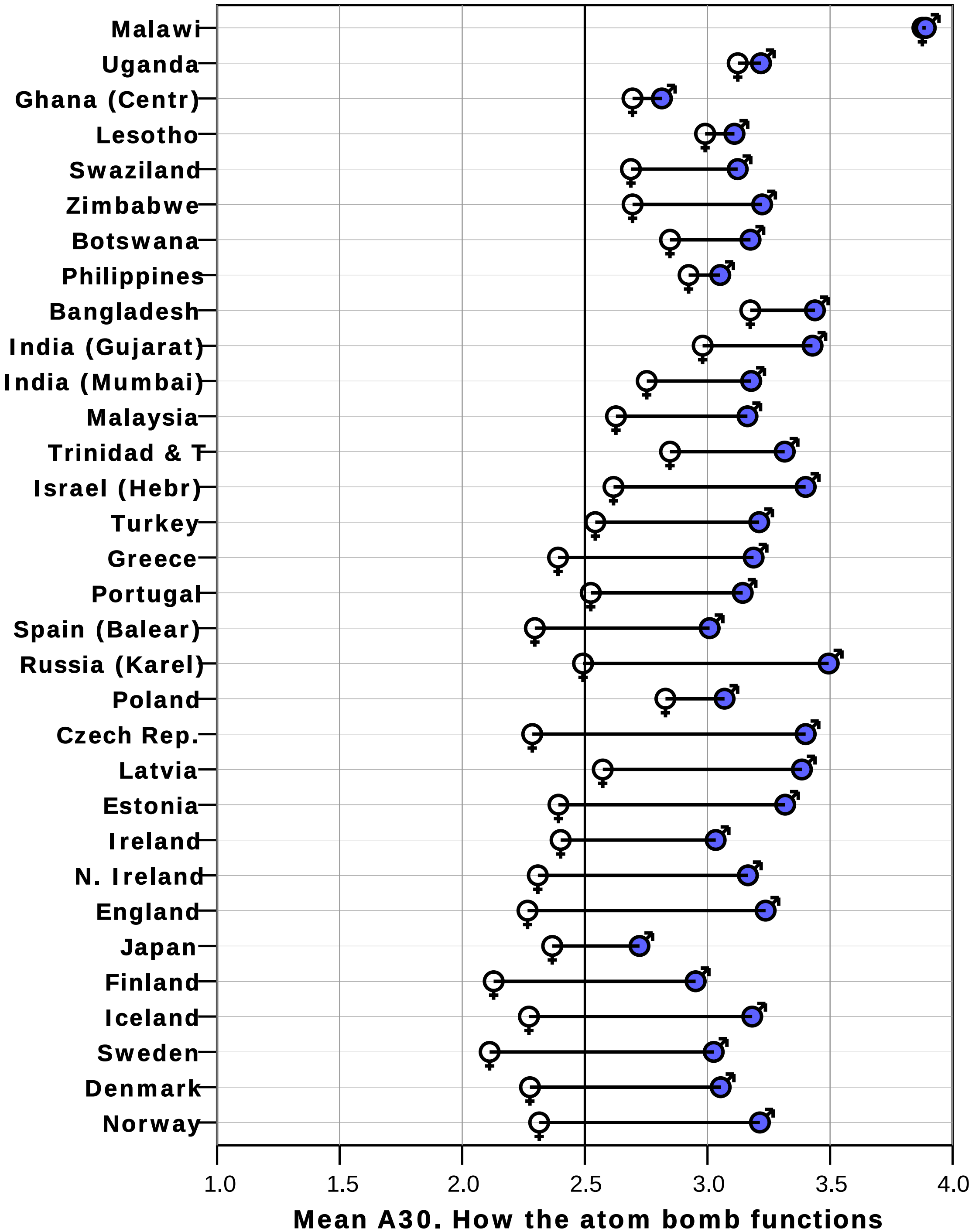
APPENDIX 2: Some international comparisons



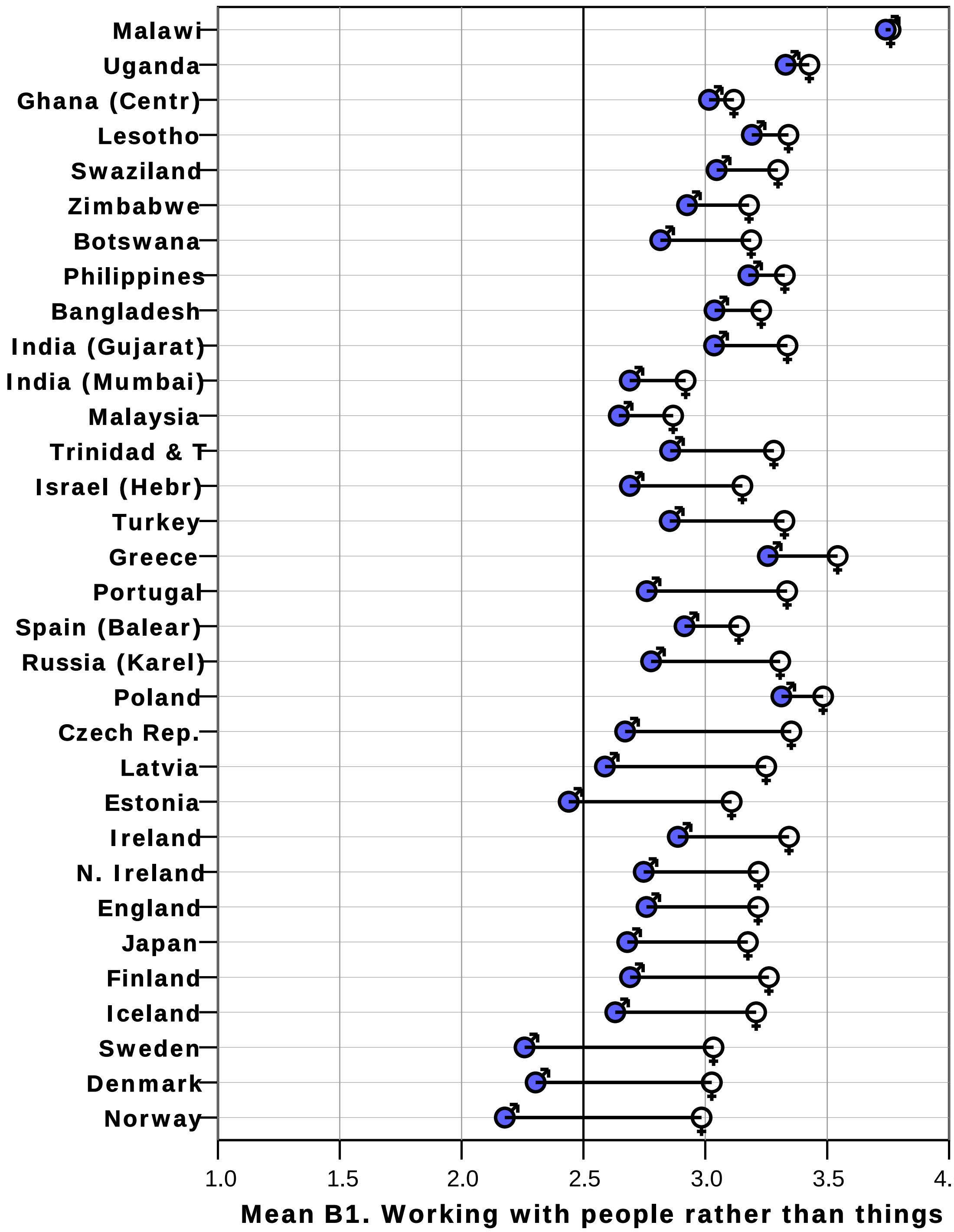
1 = not interested, 4 = very interested



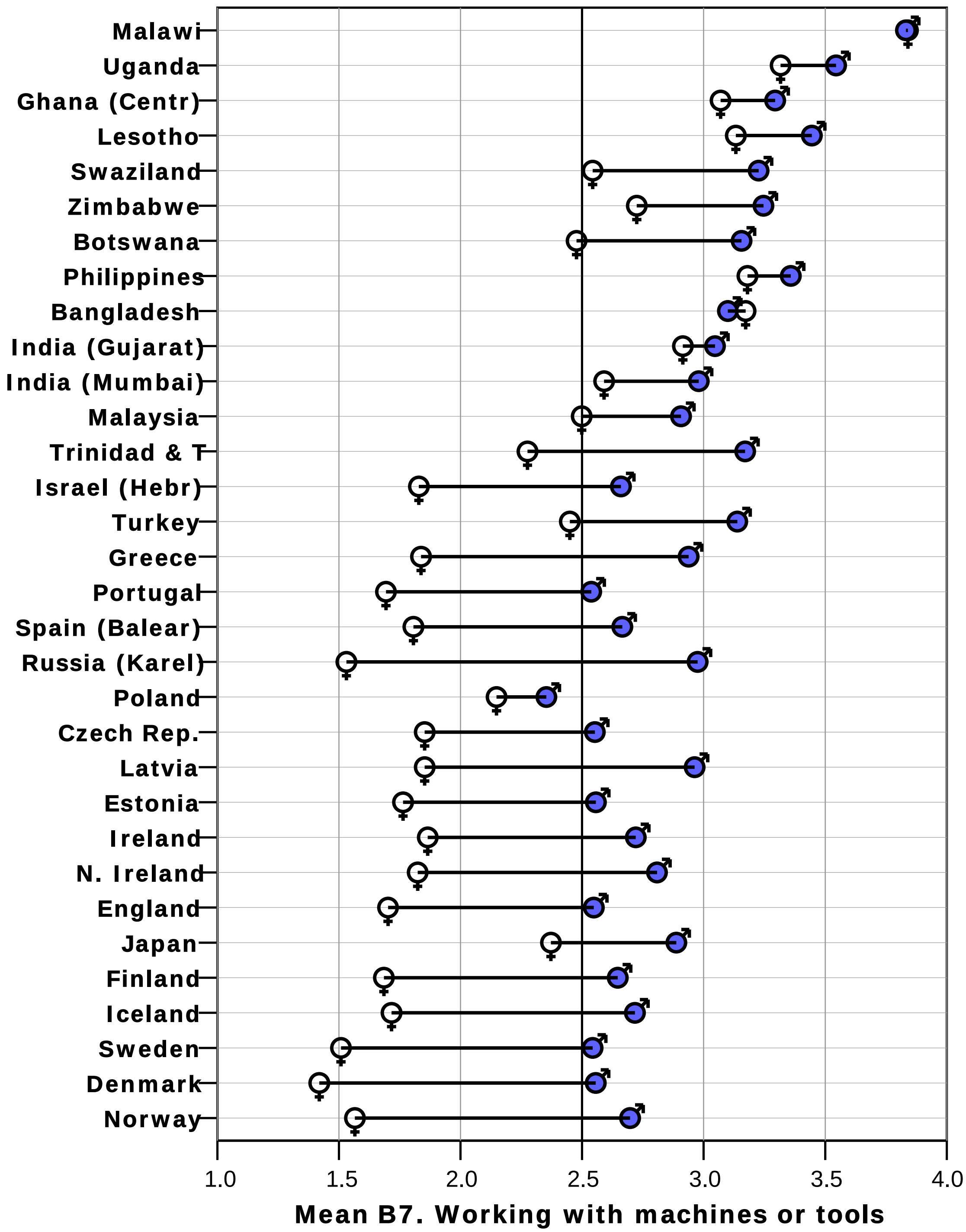
1 = not interested, 4 = very interested



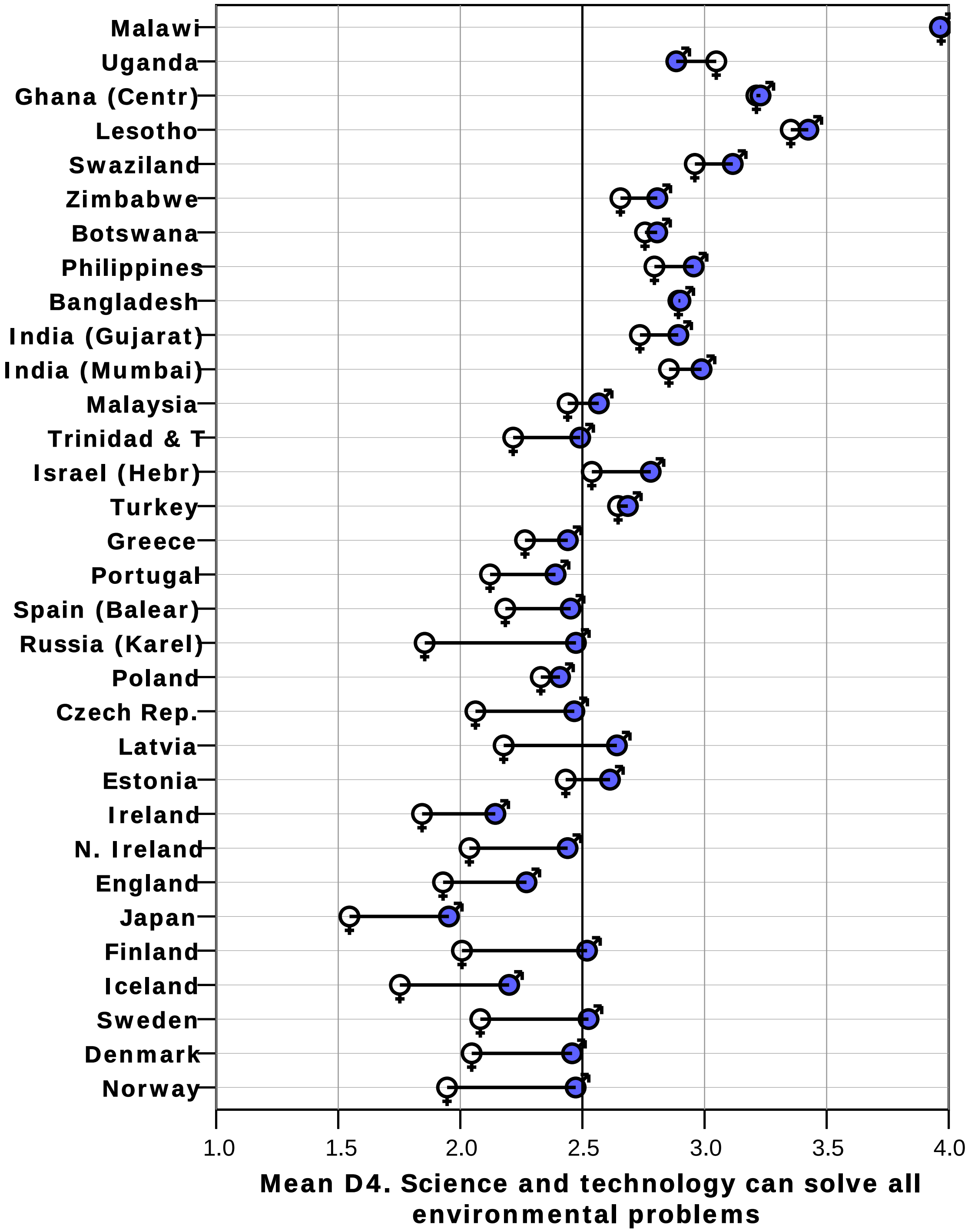
1 = not interested, 4 = very interested



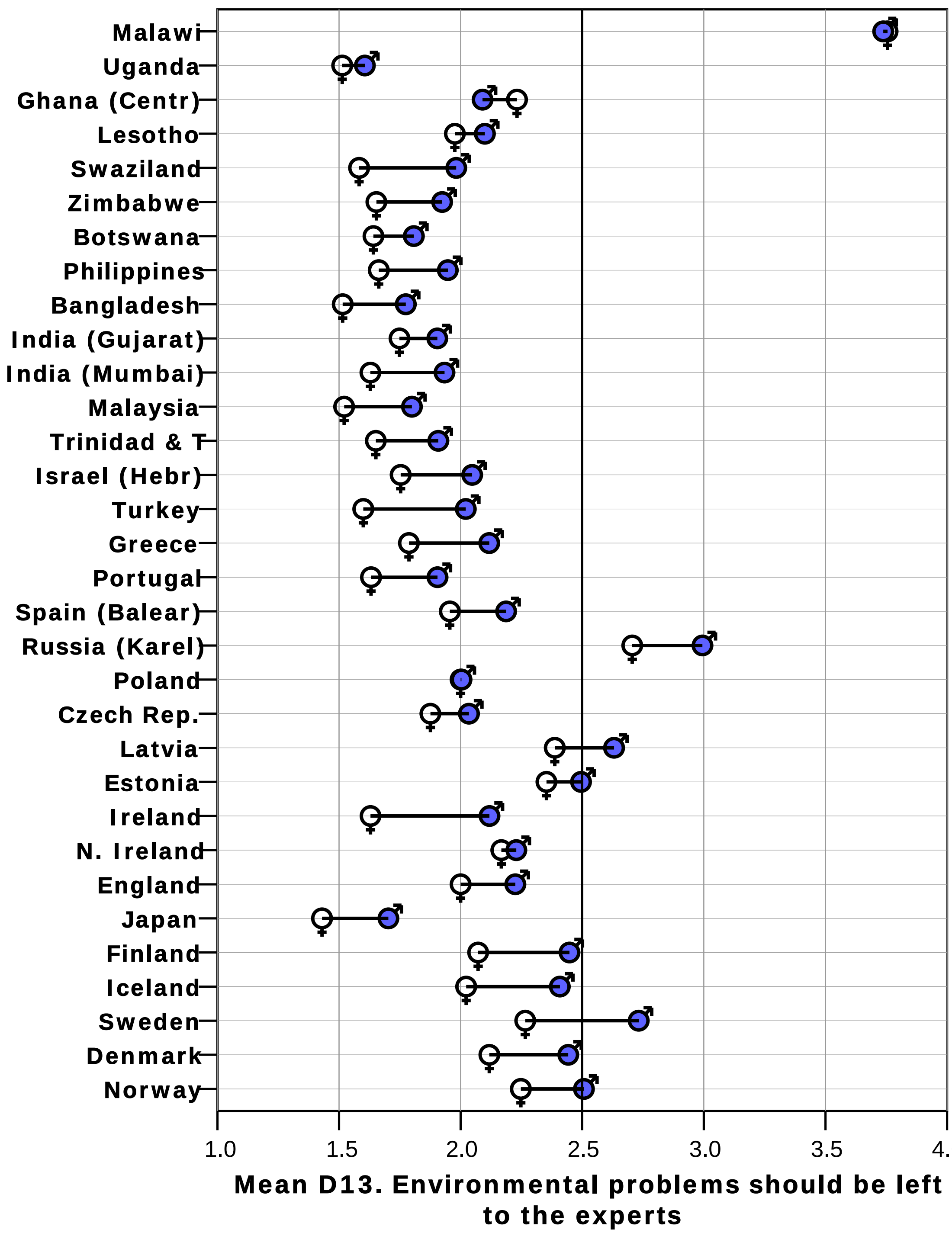
1 = not important, 4 = very important



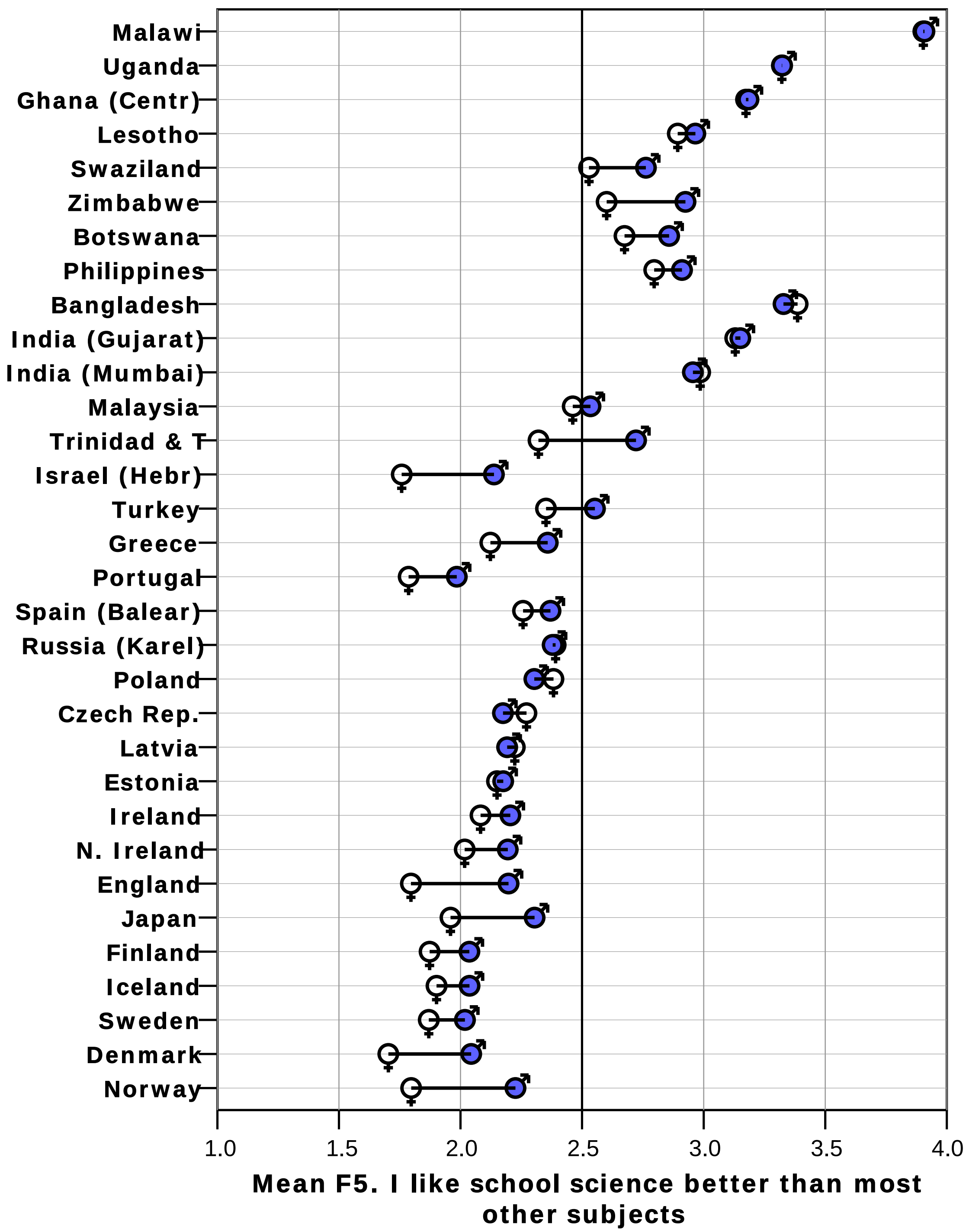
1 = not important, 4 = very important



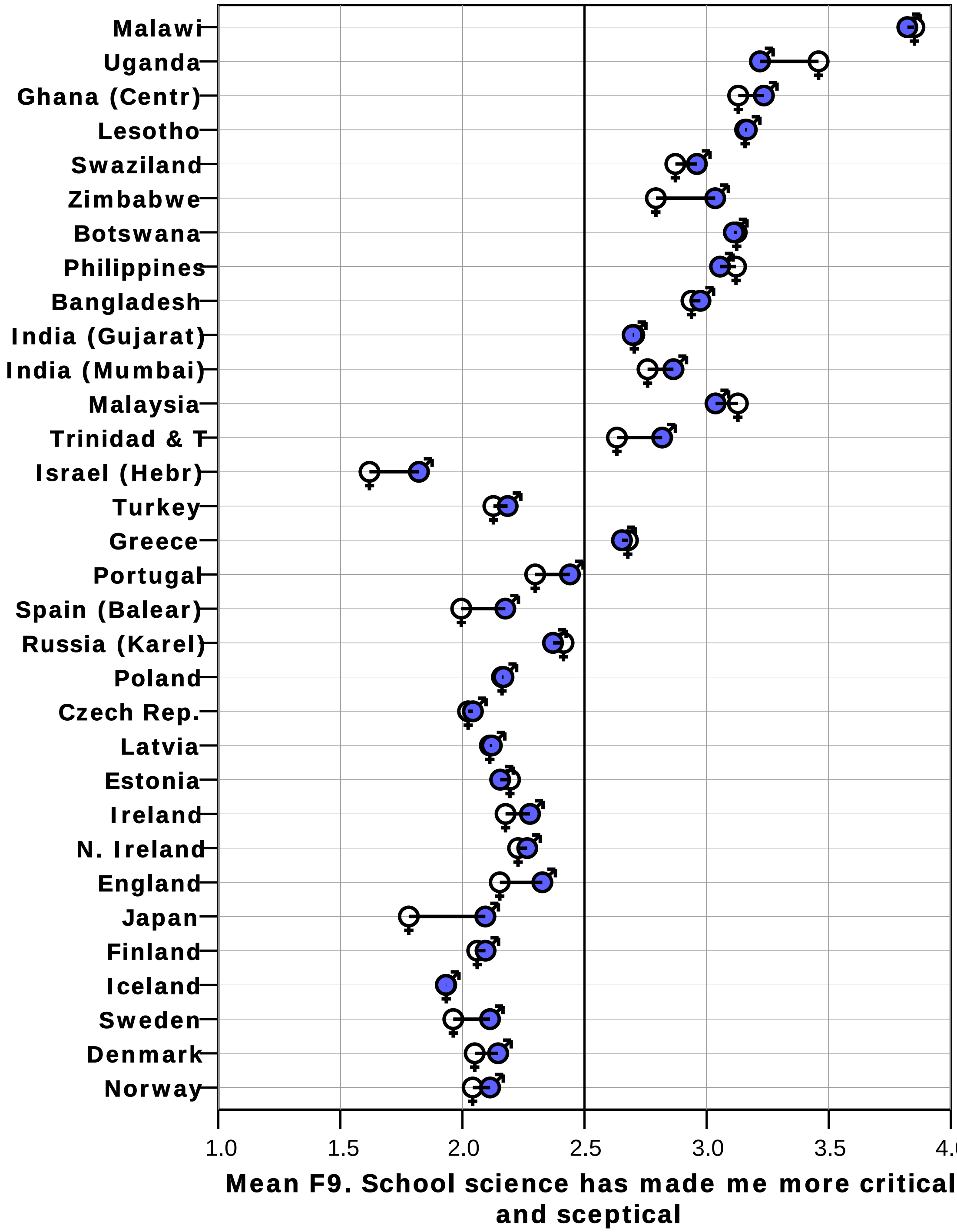
1 = disagree, 4 = agree



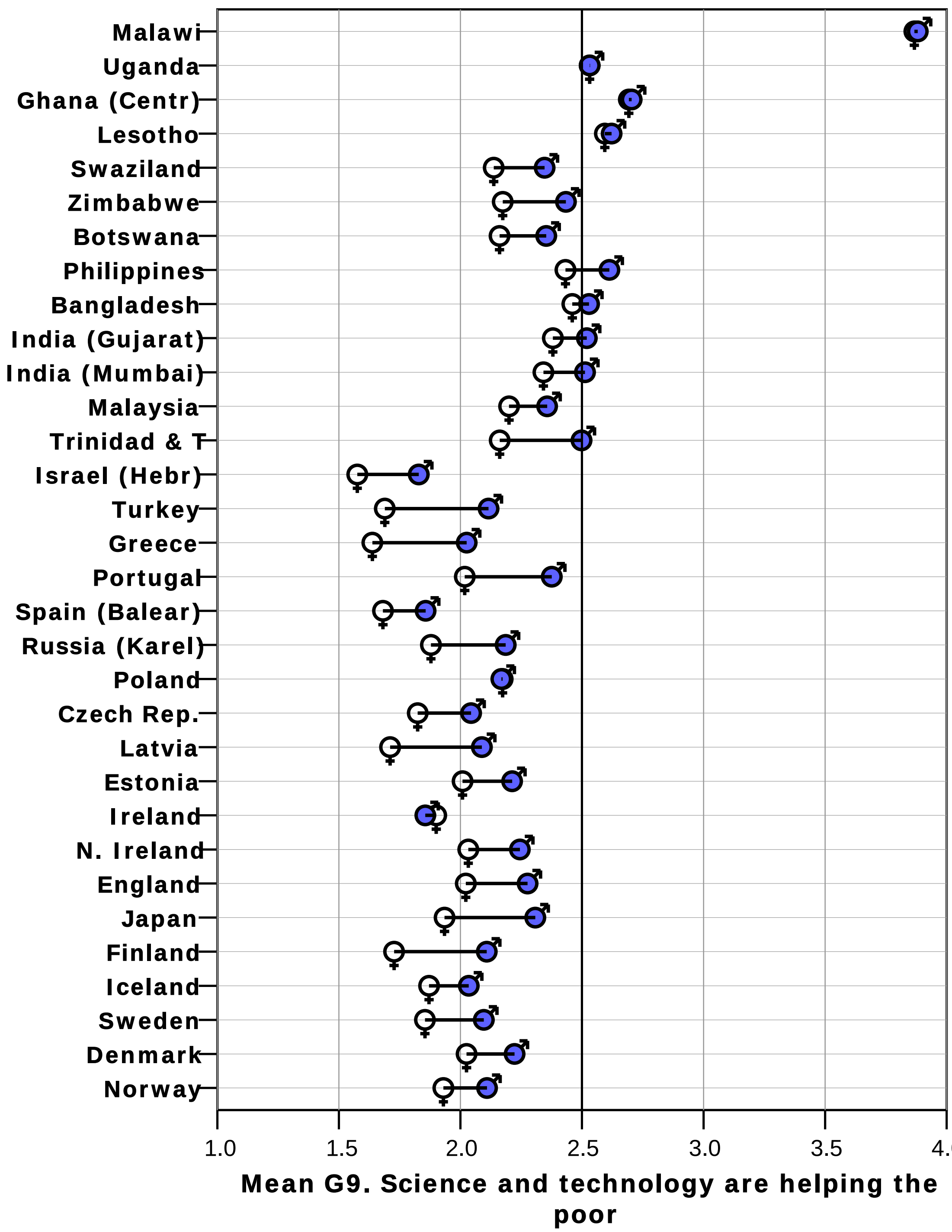
1 = disagree, 4 = agree



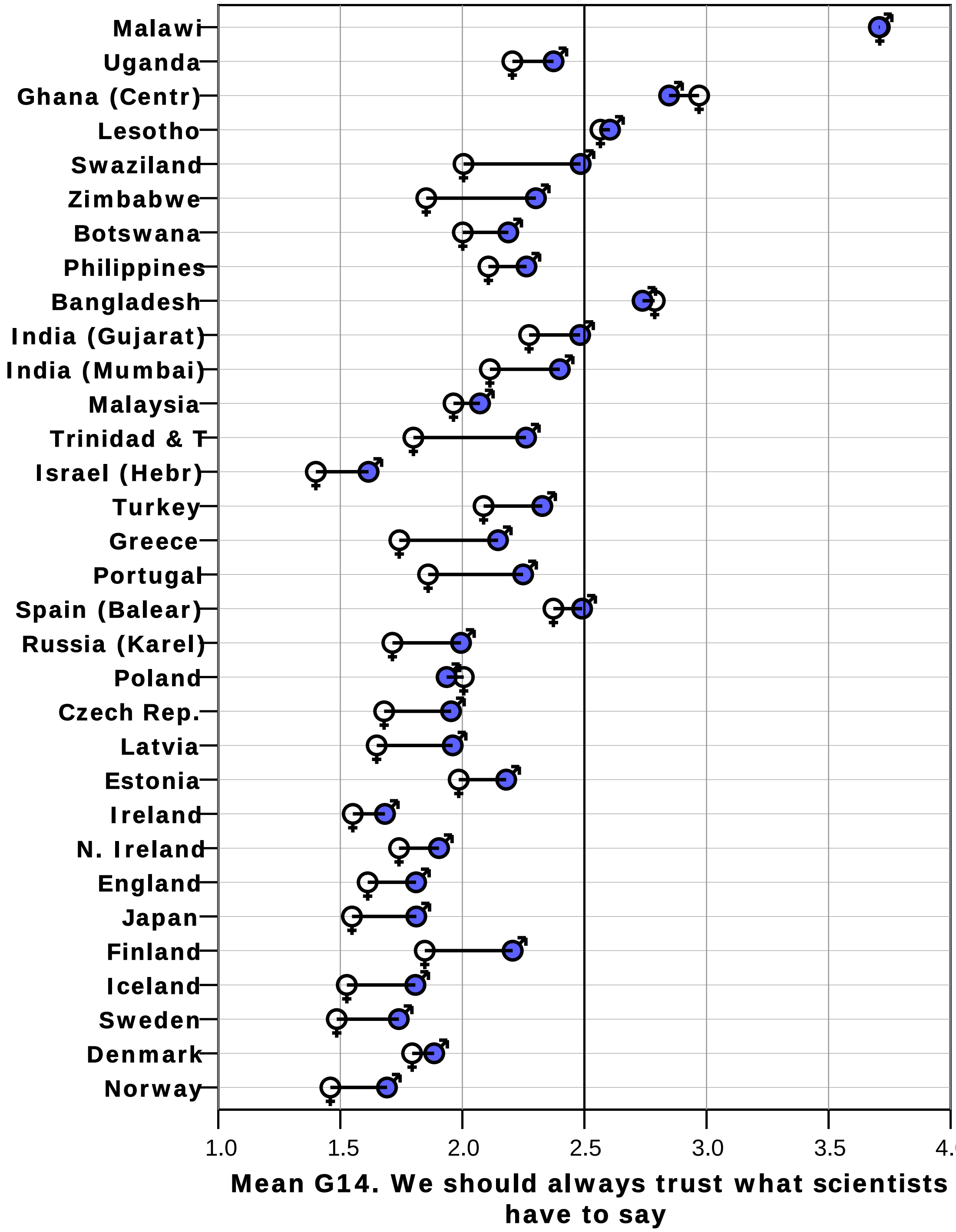
1 = disagree, 4 = agree



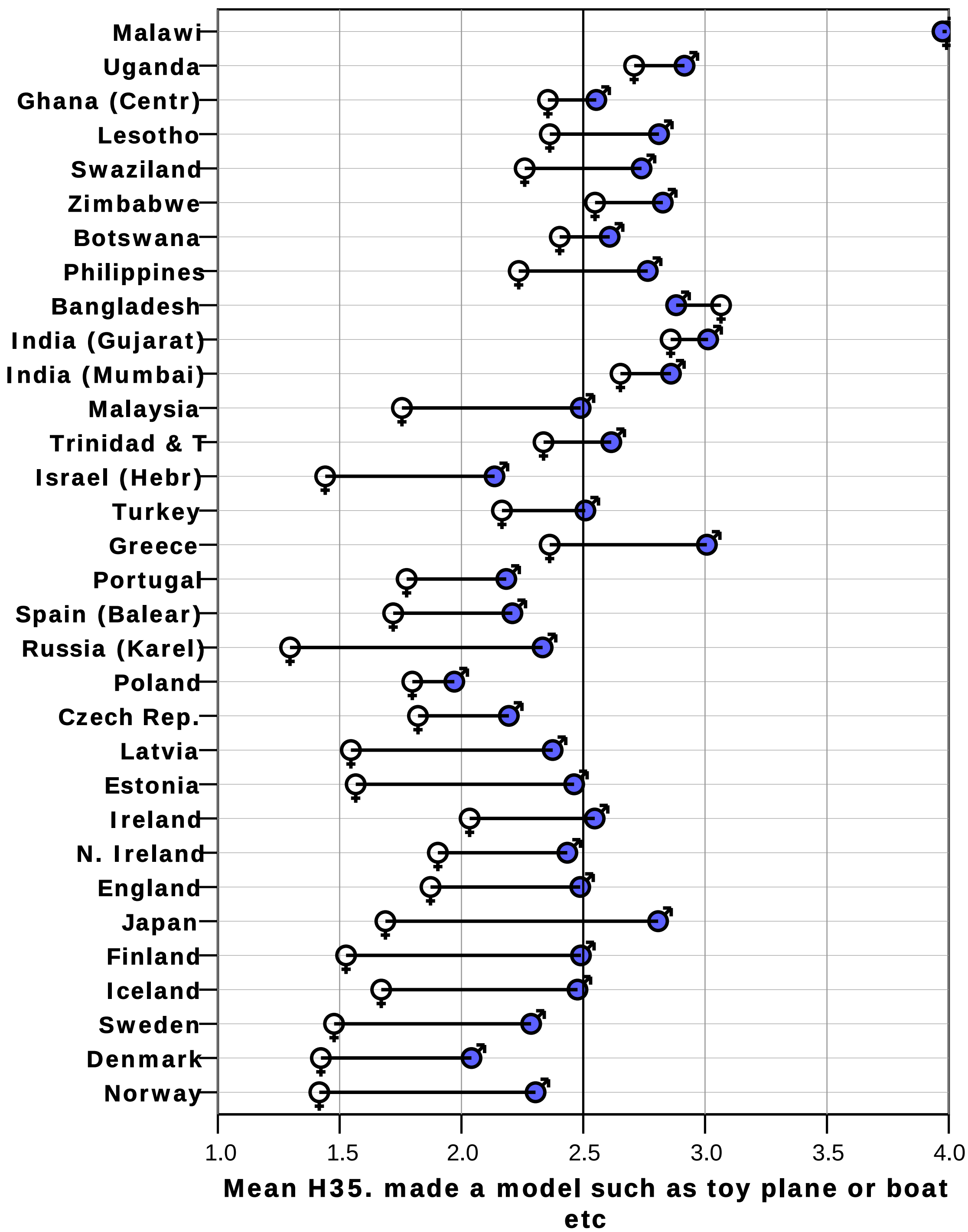
1 = disagree, 4 = agree



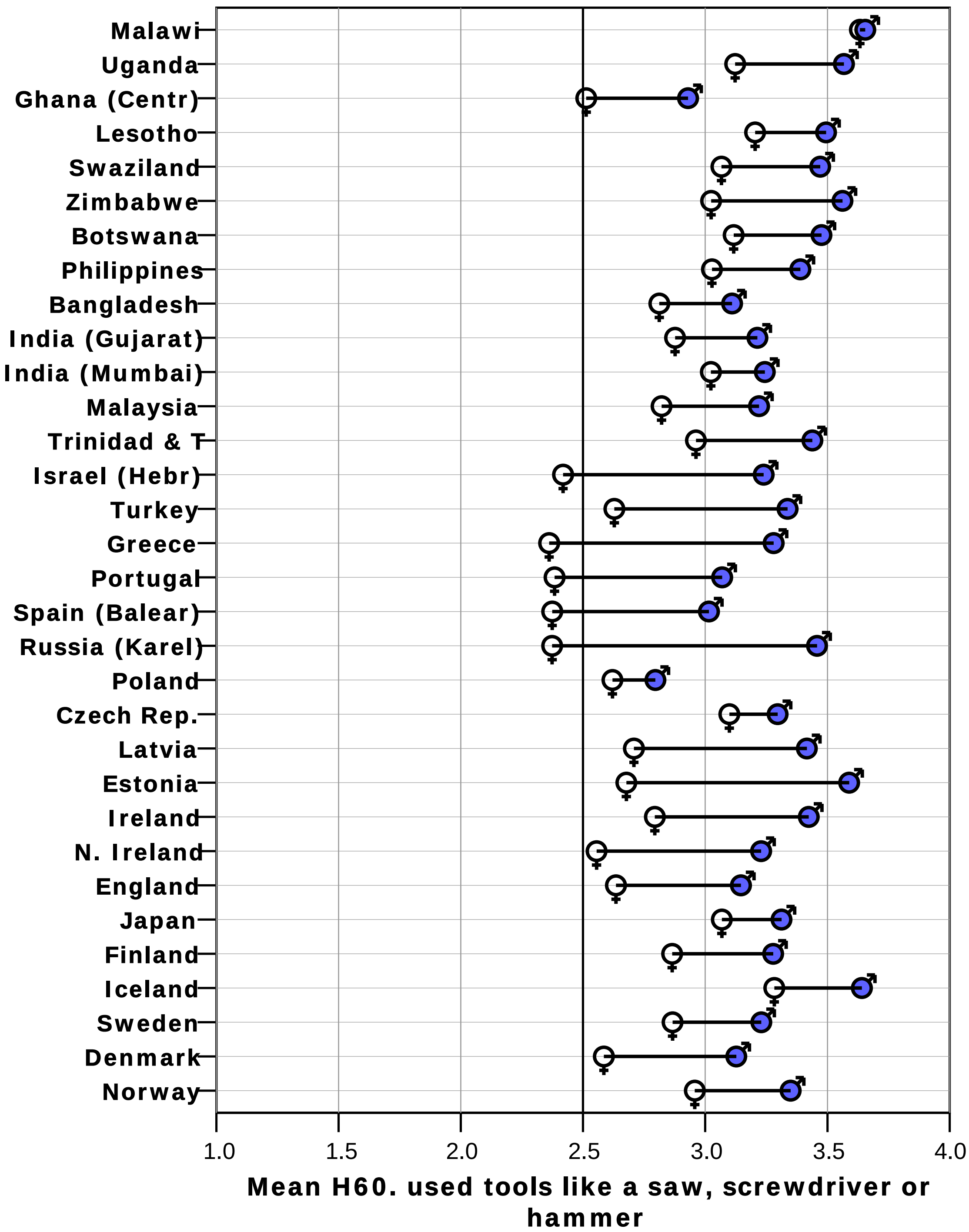
1 = disagree, 4 = agree



1 = disagree, 4 = agree



1 = never, 4 = often



1 = never, 4 = often

APPENDIX 3: The ROSE Questionnaire