People Science & Policy

Formative Evaluation of the Large Hadron Collider Communication Project

Appendices to the Report prepared for

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Appendix 1: Literature review

Introduction

This review provides important background data that will set the findings of the new research into context. The review is not limited to public and student perceptions of, and attitudes to, particle physics. The review was cast more widely to take into account other factors including attitudes to: the utility of science; basic 'blue sky' research; large-scale scientific facilities; the UK's place in world science; and science-based careers for young people. These are all topics that PPARC could use as 'hooks' to interest the target audiences. Underpinning all of the requirements of this project are the different target audiences; the general public, students and teachers.

This review therefore covers:

- attitudes to science by each of the target groups;
- the importance of the attitudes of young people, how these persist and the impact on future attitudes;
- attitudes to different types of science;
- a discussion of knowledge of science and its applications versus understanding of blue sky thinking and its uses; and
- different methods used to inform/educate.

The importance of encouraging dialogue between scientists and the public is widely recognised; the need to engage the public with developments in science is now a key aspect of science policy (House of Lords Select Committee on Science and Technology 2000).

General public (UK)

In general, the public is interested in and has a positive attitude towards science. A large study found that three-quarters of the British public are 'amazed' by the achievements of science (OST/Wellcome Trust 2000). This is largely because they see the direct benefits, which make their lives 'healthier, easier and more comfortable'. This positive view is largely due to the perceived direct benefits of science and engineering, which make lives '*healthier, easier and more comfortable*'. However, views are not totally driven by the need for science to be productive. In 2000, 72% of the public agreed that "*even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Government*". Alongside this, the majority agree that Britain needs to develop science and technology in order to enhance its international competitiveness.

The greatest interest was reported to be in health and medical discoveries, with least interest in energy and nuclear power. Interest in science and attitudes to science are affected by age, level of education and gender. Generally, as familiarity increases interest increases but, attitudes to science are, in reality, more complex than this. The OST and Wellcome Trust (2000) concluded that the public can be divided into different groups dependent on their attitudes to science; these groups have distinct profiles and are summarised below.

- *Confident believers* (17% of the sample): are supportive of science because they appreciate the benefits and have confidence in society and the political system to control developments. They are up-market and well-educated.
- *Technophiles* (20%): are less trusting of regulatory system but more confidence in scientists. They are up-market, well-educated, and have the highest level of science qualifications.
- *Supporters* (17%): are trusting of the regulatory system, but younger than confident believers. They have higher than average qualifications but less than technophiles, and their social class similar to average.
- *Concerned* (13%): are concerned about personal and society's ability to cope with changes. They are most likely to be female and have the greatest scepticism of authority.
- *Not sure* (17%): neither agree nor disagree, do not identify any benefits bought by science. They are poorly educated and under 35 with below-average incomes.
- *Not for me* (15%): are uninterested but think science is important. They are poorly educated but more to be likely over 65.

Research was conducted by MORI on behalf of NESTA (2005) to coincide with the launch of FameLab.[1] They found that the general public is positive about the need to be informed about new developments in science and technology, although only 40% actually felt sufficiently informed. The most common reasons given for wanting to be informed were:

- raise awareness/improve knowledge;
- implication/concerns for everyone; and
- information/results/research should be available to all.

Another recent survey by MORI (2005) confirmed the general findings of others; that overall public opinion of science is positive. There is also a general fear of the unknown among the public with regard to scientific developments. Opinions about science are not only affected by demographics and level of scientific knowledge but also by perceived level of risk of the processes/products/results of scientific advances. Scientists working for industry and the government were least trusted when compared with other employers or funders. Crucial factors in determining trust in scientists were competence, credentials, experience and honesty (MORI 2005). People are generally amazed by scientific achievements, yet have greater uncertainty with regard to the benefits of science being greater than any harmful effects (OST/Wellcome Trust 2000). This study also indicated a low level of confidence in regulation and the government.

A major quantitative survey was undertaken in 2002 as part of a study to help understand public attitudes towards science, risk and forms of governance (Poortinga & Pidgeon 2003). Various risk cases (eg climate change and radioactive waste) were put into context by comparing them with various personal and social issues. The most important issues were mainly personal ones, nevertheless, respondents were still interested in the various risk cases mentioned above. When considering trust in scientists, respondents trusted scientists working for environmental organisations and universities most and those working for government and industry least. There was an overall distrust of government,

[1] Fame Lab is a national competition to find the UK's best new talent in science communication.

which was not thought to be responsive to the needs of ordinary people; respondents were ambivalent with regard to their feelings of trust for scientists working for government. There was some concern, however, that the funding of science had become too commercialised and support for more public control over science was expressed.

People generally want to know the rationale behind scientific research, for example, the reasons why researchers want to do whole animal cloning (OST/Wellcome Trust 2000). The public also wants to learn about scientific developments *during* the research stage rather than hearing about them in the mass media after the research has been conducted (MORI 2005). However, the OST/Wellcome Trust (2000) found that the concept that increases in knowledge might bring more questions than answers, is difficult to communicate to the general public.

Those members of the public who do not think it is important to be kept up-to-date believe that such developments are either not relevant or too technical/specialised for the general public to understand (NESTA 2005). Two thirds of those surveyed for the OST/Wellcome Trust (2000) agreed that science and technology was too specialised for most people to understand. The public believe the following to be barriers to a greater of understanding of science and technology (NESTA 2005):

- a lack of appreciation by the public about how science affects them (35%);
- a lack of public interest (29%);
- scientific jargon/technical language/terminology (29%); and
- lack of education (28%).

These barriers were more likely to relate to the abilities of the public themselves rather than to scientists (NESTA 2005). NESTA concluded that the biggest barrier to a greater understanding of science by the public is lack of appreciation about how scientific developments affect them personally or society in general. This lack of appreciation about how science affects them is more apparent in the physical sciences than in any of the other sciences.

PSP has worked with CCLRC to help develop a communication strategy to engage with interested adults (PSP for CCLRC 2004). This research involved focus groups and a telephone survey. Over three-quarters of those surveyed agreed that '*Science and technology are making our lives healthier, easier and more comfortable*'**;** men (83% versus 73% of women) and those from the higher social classes (83% AB versus 73% E) were more likely to agree with this statement. Science was seen as a 'hard' (difficult) subject at school, despite this, people were largely interested in, and supportive of, science. Despite the generally positive view of science, there was a significant minority of people who were concerned about the control of science. Women, older people and those in the lower social grades were more likely to be concerned (PSP for CCLRC 2004).

Scientists were seen as rather special, but slightly detached people, dedicated to their work with the intent to make life better for the average person. It was thought that there was a role for CCLRC scientists in supporting communication work, both through the generation of ideas and offering audiences direct interaction with working scientists.
Locally awareness of the two sites funded by CCLRC was high, yet knowledge of the work undertaken at the two sites was very low. Both CCLRC laboratories were seen as

secretive and generally this was thought to be because the work was dangerous. Open days and school trips were long remembered in a positive light by those who had experienced them.

Interested adults (the target market for CCLRC communications) tended to be up-market and middle-aged. In the qualitative research, three main 'hooks' were identified as ways of engaging interested adults in science:

- the quality of UK science;
- new investments in UK science; and
- understanding how things work.

The telephone survey showed that these were all issues that would engage significant proportions of interested adults. Whilst there was a good deal of overlap amongst the people who were interested in the UK's position in world science and those interested in investments in UK science, there were some subtle differences, with the latter group tending to be younger and more ethnically and socially mixed. Such differences would allow CCLRC to develop differentiated messages for different occasions and audiences.

General public - European

In 2005, the European Commission published *Europeans, Science and Technology* and *Social values, science and technology* (European Commission 2005). It was reported that the 'majority of those interviewed would like more information on science and technology and seem[ed] rather dissatisfied at the way in which they are currently informed about research and progress, especially by scientists'. Perhaps more pertinent to this project was their finding that respondents regarded technosciences with a mixture of distrust and suspicion. It was further noted that lessons in science communication needed to be learnt from controversies such as the GM food debate.

The European Commission (2005) also highlighted that the correlation between scientific knowledge and support for science is low and that people are more interested in how the science will ultimately affect them and society rather than the details of how the scientific application/technology is developed. Furthermore, the pace of such scientific developments can be viewed both with awe and foreboding. A third of those respondents who indicated a lack of interest in science did so due to their inability to understand 'scientific and technological questions', and another third simply did not care (over one third of these were young people and students).

General public - USA

It is believed that although the American public tends to express a high level of interest in science, many lack confidence in their knowledge of science (National Science Foundation, Science and Engineering Indicators 2006). Those that are more highly educated are more likely to express high levels of interest in science and to be more confident in their knowledge base. Respondent's understanding of the nature of scientific inquiry was tested by way of a combination of a number of questions, including questions asking respondents to explain what it means to study something scientifically and specific questions on experimental design. Results indicated that nearly three quarters of those surveyed did not understand the concept of scientific inquiry (National Science Foundation, Science and Engineering Indicators 2006).

Young people

The importance of the need for young people to have a basic understanding of science is almost universally recognised amongst most policy makers. Yet, while the number of students taking biology post-16 has increased significantly over the last 20 years, the number taking chemistry has remained the same, and the numbers choosing physics and maths have decreased significantly (DfES 2006).

The general lack of knowledge of scientific developments in the general public and the young in particular does not bode well for successful public debate, and for the development of a future expert workforce to meet national needs. For example, engineering is recognised by young people as important and necessary for day-to-day life, but only a limited proportion (mainly boys) feel it is a future career for them (MORI 1998). Furthermore, the representatives of industry say that they need more high-grade scientists, technicians and engineers if the UK is to compete successfully in technology-intensive global markets (Association for Science Education 2006). The lack of students choosing to study science in post compulsory education in the UK also has a clear potential impact on the ability of research councils to carry out world-leading scientific research (RCUK 2006).

The importance of the need to engage young people is emphasised by the general principle that attitudes are enduring while knowledge often has a transient quality. It is argued that science education should be designed to encourage the curiosity of young people about the natural world around them, and help them acquire a broad appreciation of the important ideas and explanatory frameworks of science and how scientific enquiry works (Association for Science Education 2006). In addition, science is often seen as interesting when it stimulates a sense of awe and wonder (KCL 2000).

Pupils view school science differently from general 'science in society' because they tend to view science in school as more theoretical and link science outside school with technological spin-offs such as television and mobile phones (Bennett 2003). Pupils tend to value science education for career aspirations rather than as a subject of intrinsic value, and there is little recognition of the value of a generic science qualification as there is for mathematics and English (KCL 2000). There is also disparity between students' and teachers' notions of science, the former being associated with high-tech advances and social relevance, the latter with more theoretical aspects and the significant discoveries of the twentieth century (Monk & Osborne 2000).

Bennett (2003) summarised the key research findings on pupil's attitudes to science:

- School science is a hard subject.
- Science and school science is not relevant to everyday life and not relevant to most people.
- Pupils see science as causing environmental and social problems.
- School science is more attractive to males than females.
- Interest in science declines while in secondary school.
- Pupils are more negative about the physical sciences than the biological sciences.
- Pupils are more negative towards school science than to science more generally (or more precisely, the technological spin-offs).

- There is some evidence that curriculum materials which contextualise science and emphasise its applications are successful in fostering a more positive response to science in pupils.

Despite a number of efforts over the years there seems to be persistently negative attitudes towards science among high school children (Bennett 2003).

Haste (2004) looked into how 11-21 year olds view science in their future. Respondents agreed that science provided an overall benefit to health and quality of life. They were least enthusiastic, however, about nuclear power, developing robots, space exploration and trying to find evidence of life on other planets. Given the cue of a cosmologist, a medical researcher and an art historian, they saw the medical researcher as more accessible, less isolated and much more likely to be female, than the cosmologist. It was concluded that young people are quite ethically sophisticated and able to make distinctions between the benefits of science and the need to see these benefits in context. Haste (2004) identified four distinct groups based on responses to attitude statements. These groups are similar to those identified in the OST/Wellcome (2000) report. The groups are as follows:

- *Green* (not inherently anti-science): ethical concerns, concerned about the environment and scepticism about interfering with nature. They are more likely to be younger girls and those who are interested in a job related to science.
- *Techno-investor*: enthusiasm for investing in science, belief in the beneficial effect of science and trust in government and scientists. They are younger boys and young men in the workforce.
- *Science-oriented*: interest in science programmes and a belief that a scientific way of thinking can be widely applied. They are more likely to be young men in full-time education and in the workforce.
- *Alienated from science*: boredom with science and scepticism about its limitations. They are younger girls and young women in the workforce not interested in a job related to science.

As part of the Einstein Year[2] evaluation, Malek & Stylianidou (2006) asked 11 to14 year olds about their attitudes towards science and scientists. They grouped responses to various science statements and concluded that 'pupils express interest in topics that are about the effects of science on themselves but do not appear interested in the knowledge required to understand these effects'. Malek & Stylianidou's (2006) findings also supported others who have found that there is a drop of interest in science as age increases and that, in general, girls are less interested in science than boys. The pupils surveyed had generally positive attitudes towards scientists, but seemed to be deterred from being scientists by their strongly held opinions that scientists worked long hours, with repetitive work and strict guidelines. Young people's overall interest in science was calculated to be slightly below neutral, but the statements relating to space attracted comparatively high interest. The authors highlighted reasons that pupils had given for their interest in the origin of stars, planets and the universe. These tended to be philosophical as well as scientific.

[2] In 1905 Albert Einstein changed physics and the way we understand our world. One hundred years on Einstein Year celebrated the excitement and diversity of contemporary physics. During 2005 more than half a million people took part in over 500 events and explored what physics means to them.

> *"So I can find out if God really created it all."*
>
> *"I am interested in how many galaxies and planets there are, and what gases are on the planets."*

Three of the statements in which the young people were asked to indicate their level of interest related to particle physics; two of these statements elicited more than average interest:

- How a nuclear plant functions (less than average interest).
- How x-rays, ultrasound etc are used in medicine (slightly more than average interest).
- The origin of stars, planets and the universe (more than average interest).

In general, children tend to find biology the most interesting of the sciences (Cambell Keegan Ltd 2000). Physics has some appeal where it is linked to how things work, but less appeal where more abstract. The strongest criticism, in this paper, was for chemistry which respondents believed focused on abstract concepts rather than the application of the knowledge. This emphasises the importance of the need to link research findings to the real world. Relevance of scientific developments to personal life is also important. Topics which have been seen to have little relevance to every day life include molecular and atomic bonding (KCL 2000). Contemporary examples are important; of which one could be the LHC. Furthermore, there seems to be a universal enthusiasm for study of astronomy and space.

A review of the literature found that although girls out perform boys at GCSE in science, girl's attitudes to school science, particularly physical science, are significantly more negative than boys (Osborne *et al* 1997). Girls also tend to choose A-levels that they enjoy unlike boys who are more likely to relate their choice to potential career choices. In 2004/2005 male to female ratios for the science subjects at A-level in England were:

- Physics: 3.7 boys to 1 girl
- Chemistry: approximately equal
- Biology: 1 boy to 1.4 girls (DfES 2004/05)

Additionally, proportionately more young people from Asian background and fewer from Afro-Caribbean backgrounds are likely to continue their studies in science and engineering (Osborne *et al* 1997).

Other than school, Munro & Elson (2000) found that the following factors seem to have a significant influence on children's interest in science and science careers:

- parents and family;
- image of science subjects;
- image of jobs in science and engineering;
- gender; and
- the media.

The evidence also suggests that a significant factor in the decline of student numbers in physics is the availability of specialist teachers in that subject (Wood & Morris 2005). Smithers & Robinson (2005) conducted a survey of the state of physics education in England and Wales for 14-18 year olds. This survey showed that less than four in 10 teachers who teach physics to 14-18 year olds had physics as their main subject of qualification. Of further concern is the finding that teachers' expertise in physics as measured by qualification is the second most powerful predictor of pupil achievement in GCSE and A-level physics after pupil ability. It was also highlighted that the stock of physics teachers is diminishing; furthermore, many teachers with a physics degree were becoming maths and IT teachers rather than physics teachers. While non-specialists can provide a high standard of teaching, they are unlikely to have the subject knowledge or confidence to enable them to bring exciting contemporary physics into the classroom (PPARC 2006).

Attitudes to particle physics

There is very little research that looks specifically into perceptions of, and attitudes towards, particle physics. PPARC however, has previously commissioned some work that covers this with respect to schools. PPARC commissioned Creative Research to review PPARC's public understanding of science and technology programme.

Creative Research (2000a) found that awareness of PPARC was low; few of the students had heard of PPARC and there were mixed levels of awareness amongst teachers. The usability of PPARC's material was limited. Creative Research (2000a) concluded that most of PPARC's material was 'not accessible to the most able students and is sometimes over the heads of some teachers'. A number of key issues were highlighted with regard to the PPARC material, they were:

- the lack of relevance (to the curriculum);
- the high level of difficulty and detail; and
- a lack of clarity with regard to the target audience.

Levels of awareness of PPARC and its educational materials (Broadsheets and Teachers' Packs) were very high (over 90%) in a survey of physics teachers[3] (Creative Research 2000b). Teachers are open to and want to use various materials for classroom activities and to extend brighter students. PPARC material, however, was being used for only a small percentage of these activities; three quarters of teachers who had requested teacher's packs were not using them. *Frontiers* was widely read but not thought of as especially useful for lesson planning or curriculum enrichment. It was believed that PPARC material had the potential to inspire students but did not always realise this due to a number of weaknesses which are highlighted above. The most important criterion for selection of a resource was that it should inspire students (96%). Other criteria of high priority were:

- suitability for curriculum enrichment (79%);
- suitability for extending brighter students (78%).
- suitability for classroom teaching (75%);

[3] These findings are best considered as representing the most positive perspective of PPARC's materials as the sample profile is not necessarily typical of all teachers who have responsibility for teaching physics. This is because the sample was made up almost exclusively of physics graduates who were teaching physics as their man subject and who were teaching both A-level and GCSE physics/science.

- clarity of target group (71%); and
- relevance to national curriculum (68%).

It was thought that a range of formats for resources should be offered. A strong suggestion arising from the research was for a website designed specifically with teachers and students in mind. Many teachers also expressed an interest in having school visits from PPARC scientists. Such visits would provide inspiration for students through meeting real scientists who carry out real research. The limiting factor is the number of scientists relative to the number of schools.

Another part of Creative Research's review of PPARC's public understanding of science and technology programme was a survey of researchers to find out what science communication they were doing and explore ways in which they might be enabled to do more (Creative Research 2000c). PPARC funded scientists are encouraged to do outreach work by spending up to one per cent of their grant on suitable activities. Half of those surveyed had been involved in some form of outreach work. PhD students were least likely to have done something; many were keen but indicated that they had not been asked. The most frequent forms of outreach work included giving public lectures (3.4 days per respondent over the previous two years) and media interviews (4.3 days). The least frequent forms included taking part in SET weeks (0.4 days) and being involved in master classes for teachers/schools (0.6 days). It was suggested that PPARC could encourage more outreach work by a combination of more effective communication of what help/resources it already provides and by the provision of new information such as a database of good practice based on examples of successful work carried out by other researchers.

Prior to the above research, a survey of visitors to museums, science centres and visitor centres was conducted on behalf of PPARC (Creative Research 1999). Specifically, respondents were found to be more familiar with concepts relating to astronomy than with those relating to particle physics. Each respondent scored familiarity with concepts on a scale of 0-3 and an average score was calculated for each concept. Respondents were most familiar with the sun (2.9), stars (2.8) and planets (2.8) and least familiar with particle accelerators (0.9) and quarks (0.6). Interest in concepts was closely correlated with familiarity. There were differences between level of familiarity for all concepts in relation to gender, age, level of educational attainment. Gender differences were most striking with men significantly more familiar with, and more interested in, particle physics concepts than women.

With the exception of the quark, particle accelerator was the least familiar concept; over half had not heard of it before. Men were more likely than women to have heard of it (52% versus 38%) and to feel that they had a reasonable idea of its meaning (20% versus 7%).[4] One in four respondents were interested in finding out more about particle accelerators; levels of interest were significantly lower among adults with no science qualifications and amongst women.

[4] Caution should be given to this finding because, in general, men are more likely to say that they have heard of something than not.

Discussion of some of the methods used to inform/educate

Various strategies are needed when communicating with the different target audiences about science, therefore, different methods, tools and media need to be employed. The main finding of a Royal Society (2006) survey of scientists was that researchers do not give priority to science communication activities because they feel they need to spend their time on research, although many scientists (45%) wanted to be able to spend more time engaging with the public. Another key point is the willingness of researchers to get involved in activities organised by others, but for some, developing and delivering a science communication activity is outside their expertise (38% did not feel very well equipped) and takes them away from research for too long (16%). Two of the key findings of the Royal Society's survey were researchers' beliefs that:

- Engaging with non-specialists is needed to promote public understanding of science so that the public can become better informed and understand the relevance of science to everyday life.
- The most important audiences to engage directly are policy makers, schools and industry.

General public

Numerous reports have indicated that the media is seen by the public and science communicators as a vital part of any science communication strategy. Television tends to be the most commonly used source of information about science and the most preferred method for future science communication (MORI 2005). Although, there is also a general view that the Internet is a good way to communicate and that it is more important for people to know where to find the information than to have it (OST/Wellcome Trust 2000). Over half of the respondents surveyed by MORI (NESTA 2005) cited the government as having the main responsibility for providing information; this was followed by newspapers and television (MORI 2005). In general, people do not think that they are over loaded with information, but both scientists and the general public are equally concerned about the biased nature of media coverage related to science (OST/Wellcome Trust 2000).

Hargreaves, Lewis & Speers (2003) found that what and how people learn from the media indicates that 'the details or subtleties of media coverage are…much less important than the general themes of that coverage, in which certain ideas are repeated and associated with one another'. They conclude that 'while this does mean some information is communicated effectively to most people, it can result in widespread misunderstanding – even if the reporting is generally accurate'. Therefore, the media can be used to get the main themes across but is unlikely to reach the public with any details. The challenge remains as to whether this overall view is enough information to allow the public to develop a greater understanding and perhaps allay any concerns they have.

One-way information provision is not thought of as adequate for addressing public concerns likely to emerge in relation to new technologies (Grove-White, Macnaughton & Wynne 2000). Controversies of the GM food kind are more likely to emerge where the public believes there is a lack of knowledge. People generally make judgements by relying on the judgement of trusted others (individuals and organisations), but take it for granted that information provided by institutions will tend to be framed to that institutions advantage. It is important to establish connections between science, policy and the general interests of the public (Hargreaves, Lewis & Speers 2003). If educators and science communcators link concepts in physics and chemistry to real-life situations and include more ethical issues the popularity of these subjects will be raised (Planet Science, Science Museum & Institute of Education 2003).

Young people

The dominant educational paradigm continues to focus on *what* students know rather then *how* they use that knowledge. Yet, Seltzer & Bentley (1999) argue that knowledge is now the primary source of economic productivity. Therefore, they argue that 'learners (and future workers) must draw on their entire spectrum of learning experiences and apply what they have learned in new and creative ways'. Communicating with young people about CERN and the LHC will embed their learning in a meaningful context. This, along with other such learning, will allow young people to use their knowledge and skills creatively to make an impact on the world around them. It will also allow them to see how science can be relevant to their everyday lives and be a potential career pathway.

The RCUK submission to the House of Lords (2006) states that a process of fully engaged enquiry, where students both frame the questions, and develop the methods to investigate the answers to those questions, is more likely to be exciting and engaging for students and therefore most likely to lead to them to want to study at higher levels. It is also the process which is closest to the practice of science as experienced by scientists themselves (Gilbert 2006).

Knowing what factors influence student choice will influence the strategy needed to educate and inform them. The quality of teaching and the perceived difficulty of science (particularly physical science) are the main factors influencing students' subject choice for A-level; a curriculum that is less theoretical would also help (Osborne *et al* 1997). Others have found that factors which affect science subject choice by A-level students were positive experiences of extra curricular activities and the nature of in-class activities (Monk & Osborne 2000). Young people are also more interested in science in relation to high-tech advances and social relevance rather than the theory behind it (Bennett 2003).

Overall, research suggests that the main factor determining attitudes towards school science is the quality of the educational experience provided by the teacher (Osborne *et al* 2003). The teacher is the single most important source of variation in the quality of learning (Hattie 2003). The Roberts review (HM Treasury 2002) highlighted a number of issues that need to be addressed in order to improve the UK's supply of high level science and engineering skills. They are:

- shortages in the supply of physical science and mathematics teachers;
- poor environments in which practicals are taught;
- the ability of these subjects' courses to inspire and interest young people; particularly girls; and
- other factors such as careers advice.

Pupils express definite views on teaching methods, with a dislike for writing and an enthusiasm for practical work, especially where they have some real input into the design and interpretation (Association for Science Education 2006).Various groups of pupils respond differently to different teaching styles. There are, in general, positive attitudes to:

- varied teaching and learning activities;
- high level of involvement in class; and
- positive teacher-pupil relationships and support.

Other key approaches include experiential learning where there is a greater emphasis on more practical work and on critical evaluation of scientific data. There is also the need for role models that are not only academic but also from other science-related careers (Osborne *et al* 1997).

Osborne *et al*'s review of the literature, published in 2003, highlighted the distinction between individual and intrinsic interest and situational and extrinsic interest in students' attitudes towards science. Situational and extrinsic interest can be stimulated by good teaching that encourages interest and engagement. It is argued that opportunities to 'choose, challenge, [have] control over the pace and nature of learning, and collaboration' are essential for motivation. Greater engagement will be forthcoming if young people take control of their learning and have greater autonomy, for example, by doing practical work, extended investigations and having time for class/group discussions. In order for a student to engage, a task needs to interest them, have a high level of importance and be useful to them for the future.

Useable tools for addressing the teaching of concepts that are difficult for many young people to grasp can be developed (Association for Science Education 2006). They also suggested that other ways to help teachers provide the link between school science and science as it is encountered outside school can be through discussions and debates in class. Science is a fast moving discipline and science teachers need constant updating on the most recent developments in their specialism. The Association for Science Education (2006) highlights that excellent professional development could improve teachers' knowledge of science, science processes and research, and would encourage them to demonstrate competence in a tangible way.

Braund & Reiss (2004) suggest that the need for science to inspire and interest young people can be partially addressed by improvements in communication between Big Science and young people. Their review of research assessing the impact on students of visiting industrial sites has shown that students are left with a more accurate awareness of that industry. Secondary school pupils, for example, appeared to be more motivated, have more confidence, understand more clearly the relevance of school science and had an insight into career opportunities following visits. Similar findings might be elicited from visits to CERN or other large-scale facilities. Such a visit is an excellent way to give pupils a real appreciation of Big Science (Braund & Reiss 2004). Ways forward for the strengthening of science education include systematic efforts to increase the use of out-of-school activities in the learning of science and the development of strategies for linking research, policy formation, classroom practice, and teacher education (Association for Science Education 2006).

The lack of girls choosing physics is of particular concern. A Gender Equity Project in Dallas began in 2003 with an aim to increase the number of girls taking chemistry, physics and technology courses in high schools (Sanders & Nelson 2004). Teachers attended workshops on specific topics such as teacher expectations and stereotype threat. One teacher who did not have gender equality in his classroom asked a colleague to observe him. His colleague reported that the teacher had spent 80% of his time responding to boys and only 20% to girls. The teacher then implemented changes in his teaching practice by becoming aware of a number of gender-based patterns that are below most teachers' level of consciousness. He paid attention to:

- which students he called on;
- how much time he spent waiting for their responses;
- how much eye contact he maintained;
- which types of questions he asked specific students; and
- whether he accepted or refused called-out answers.

He was then observed again by his colleague, even though he felt that he had paid too much attention to the girls, his colleague concluded that his attention had been 50/50. Changes in teaching practice resulted in more girls enrolling in advanced exams for physics from 31% to 50%. Another teacher videotaped his own lesson and found that he was allowing the boys to interrupt the girls. He explained this to the class whose behaviour improved resulting in girls becoming more confident as the boys learnt to wait their turn. Gender equitable teaching practices have subsequently been rolled out into mainstream schools in Dallas.

Scientists believe that talking at schools and colleges is an effective means of communication, particularly for those aged 15-24 years (NESTA 2005). The Researchers in Residence scheme places PhD students into secondary school science departments for placements of four working days. The biosciences element of this scheme was evaluated during 1998-1999 (Woodfield, Ritchie & Clayden 1999). Overall it 'was perceived as highly effective by participants. Pupils, teachers and researchers saw it as a powerful mechanism for introducing real world science to the classroom and as an effective method of promoting science and higher education amongst pupils'. The following were found to be effective in promoting science in the classroom:

- introducing fresh faces who spoke about science and research as part of their everyday life; and
- providing the opportunity to meet researchers who were former pupils.

Placements often made science more exciting and challenged existing stereotypes and had a greater impact, than existing staff, in promoting science. PhD students are effective role models because they are generally younger than the teachers and are doing science on a daily basis. Furthermore, where the placement was female it helped to dispel the myth that science research is not a career path for women. Experts were able to introduce applied methods related to the theories that the children had been learning about in science lessons. Being able to demonstrate these techniques was invaluable to allowing the pupils to understand how what they were learning could be applied and could be something in which they could have a career. In order to have an impact on pupils it was important for pupils and researchers to be able to interact freely. There was more interest in the placement sessions from younger pupils (those doing their GCSE's) than A-level students who had already chosen science subjects. Some researchers also took the students to their place of work and introduced them to other scientists; these visits were highly valued by all those who took part. There were various benefits for the teachers too. They felt their horizons had been broadened and it had helped them think of alternative ways of teaching the curriculum topics.

The scheme was also successful in increasing pupils and teachers awareness and understanding of contemporary bio-science research. Placements that were most successful in meeting this objective were when the researcher:

- had direct contact with pupils;
- was able to input in teaching session; and
- had opportunities to present non-curriculum led lessons.

Researchers in Europe

In 2005, the European Commission launched 'Researchers in Europe' initiative focusing public and media attention on the role of scientists (European Commission 2006). The project was run by the British Council across 12 of the EU member states and Israel. It had different kinds of events that were geared towards three audience segments:

- café scientifiques for young and adult members of the general public, examining the impact of scientific issues on society and people's lives;
- youth conferences and science in schools for 14-18 year old students thinking about their future careers; and
- informal contact-making for young researchers working abroad, both with the local community and among themselves.

The objectives and intended outcomes of holding these different events were threefold:

- to break down existing barriers between researchers and the public through café scientifiques, and so create a better understanding of the contribution that researchers make to society;
- to encourage more young people to consider a career in research through science in schools activities and attendance at youth conferences, and so address the current imbalance between supply and demand of young scientists within Europe;
- and to support the creation of social networks for young researchers working abroad through making a time and space for meeting up, and so enrich their experience and the positive aspects of being a mobile researcher.

The evaluation conducted by the European Commission (2006) showed that the café scientifiques were well attended and enjoyed by participants. Participants on average, answered with a score of 3 or above (on a scale of 1 to 5 with 5 as the maximum) when asked to what degree their opinions about researchers and the work they do had been positively altered as a result of the event.

The science in school events were run in 63 secondary schools and included topics such as particle physics. The EC felt that is was important to involve speakers working at the forefront of scientific research and discovery. By meeting young people face to face and talking to them about their lives, about research and about the concrete applications of their work, they proved that a career in research is an empowering and exciting option for the curious and creative. It was also important therefore that the researchers should communicate in terms that young people would understand and that they shattered the stereotypes of researchers. The evaluation showed that the students enjoyed the event. When asked whether they found science more appealing as a result of the event, they answered with an average score of 3.8 and 70% of all participants considered that a career in science was more appealing as a result of the event.

The youth conferences were on climate change and the results of the evaluation also yielded similar results to the events in schools. Furthermore, the young people were very responsive to the researchers, perhaps in part because they met in a relaxed and fun environment; this helped facilitate genuine dialogue between the two groups. It was argued that the Youth Conferences demonstrated that the most difficult subjects could be tackled and enjoyed by combining the right resources (good communicators, an interesting environment, stimulating and fun activities) with an adequate length of time.

References

Association for Science Education (2006) *Science Education in Schools, Issues, evidence and proposals: A Commentary by the teaching and learning Research Programme*. ASE, TLRP, EPSRC.

Bennett J (2003) *Teaching and learning science*. Continuum: London.

Braund M & Reiss M (eds) (2004) *Learning science outside the classroom*. RoutledgeFalmer: London.

Cambell Keegan Ltd (2000) *Qualitative Research into Children's Attitudes Towards Science*. DfEE.

Creative Research (2000a) *PPARC publicity evaluation report findings and research*. PPARC.

Creative Research (2000b) *PPARC PUST programme: findings from a survey of teachers*. PPARC.

Creative Research (2000c) *PPARC PUST survey among research community: report of findings*. PPARC.

Creative Research (1999) *Levels of understanding of astronomy and particle physics: report of a survey among museum visitors*. PPARC.

CCLRC (2004) *Developing communications between CCLRC and interested adults*. PSP.

DfES (2006) *Review of school science* presentation to the Royal Society seminar *Improving the supply of scientists*. 13 June 2006.

DfES (2004/05) *GCE/VCE A/AS Examination results for young people in England 2004/05 (Final)*. DfES.

European Commission (2006) *Researchers in Society*. British Council.

European Commission (2005) *Citizens, science and technology.* Special Eurobarometer Issue, European Commission, Research Directorate-General.

Gilbert J (ed) (2006) *Science education in schools: issues, evidence and proposals*. TLRP: London.

Grove-White R, Macnaughton P & Wynne B (2000) *Wising Up – the public and new technologies.* Lancaster University.

Hargreaves I, Lewis J & Speers T (2003) *Towards a better map: science, the public and the media*. ESRC.

Haste H (2004) *Science in my future*. Nestle Trust.

Hattie J (2003) *Teachers make a difference: what is the research evidence?* Australian Council for Educational Research Annual Conference on Building Teacher Quality.

HM Treasury (2002) *SET for Success: the supply of people with science, technology, engineering and mathematical skills*. Report of Sir Gareth Roberts' Review.

KCL (2000) *Pupils and parents views of school science curriculum: a study funded by the Wellcome Trust*. KCL.

Malek R & Stylianidou F (2006) *Einstein Year Evaluation: Results from the survey of pupils' attitudes to science and scientists.*

Monk M & Osborne J (2000) *Good practice in science teaching*. Open University Press: Birmingham.

MORI (2005) *Science in Society: findings from qualitative and quantitative research*. Conducted for the Office of Science and Technology, Department of Trade and Industry.

MORI (1998) *Views of Engineering as a Career*. EMTA.

Munro M & Elsom D (2000) *Choosing science at 16: the influences of science teachers and careers advisers on students' decisions about science subjects and science and technology careers*. CRAC.

National Science Foundation, Science and Engineering Indicators (2006) Chapter 8 *Science and Technology: Public Attitudes and Understanding*. National Science Board.

NESTA (2005) *Public attitudes towards information about science and technology*. MORI.

Osborne J *et al* (2003) Attitudes towards science: a review of the literature and its implications. *Int J Sci Educ*, **25(9)** 1049-79.

Osborne J *et al* (1997) *Attitudes to science, mathematics and technology: a review of research*. KCL.

OST/Wellcome Trust (2000) *Science and the public. A review of science communication and public attitudes to science in Britain*. Office for Science and Technology and the Wellcome Trust.

RCUK (2006) *RCUK submission to House of Lords Science & Technology Select Committee Inquiry into 'Science Teaching in Schools'*. RCUK

Planet Science, Science Museum & Institute of Education (2003) *Student review of the science curriculum: major findings*. NESTA.

Poortinga W & Pidgeon N (2003) *Public Perceptions of Risk, Science and Governance.* UEA, ESRC, MORI, The Leverhulme Trust

PPARC (2006) *House of Lords Science and Technology Committee Inquiry to examine science teaching in schools: response on behalf of PPARC*. PPARC.

Royal Society (2006) *Factors affecting science communication: a survey of scientists and engineers*. Royal Society: London.

Sanders J & Nelson SC (2004) Closing the gender gaps in science. *Educational Leadership* 74-77.

House of Lords Select Committee on Science and Technology (2000) *Science and Society*.

Seltzer K and Bentley T (1999) *The Creative Age.* Demos.

Smithers A & Robinson P (2005) *Physics in schools and colleges: teacher deployment and student outcome*. The Gatsby Charitable Foundation.

Wood J & Morris A (2005) *Report of the Working Group on Physical Science and Maths Education*. NERF.

Woodfield, K, Ritchie, J and Clayden, M (1999) *They all wear white coats don't they? Challenging stereotypes in promoting science in schools: an evaluation of the Researchers in Residence Biosciences Scheme*. Scottish Centre for Social Research and the Wellcome Trust.

Appendix 2: Methodology

The project comprised of:

- a review of existing UK research on the general public's knowledge of, and interest in, particle physics (see Appendix 1);
- eight focus groups with adult members of the general public who were interested in science;
- eighteen depth interviews (13 paired and 5 single) with science teachers; and
- four focus groups with young people.

All discussions were recorded and participants were paid an incentive for taking part in the research.

Adult focus groups

Sample

We ran eight focus groups each with about eight members of the general public located as follows.

Region	Male	Female
North	ABC1 aged 40+	C2DE aged 20 to 39
Midlands	C2DE aged 20 to 39	ABC aged 40+
South	ABC1 aged 20 to 39	C2D aged 40+
South West	C2DE aged 40+	ABC1 aged 20 to 39

A recruitment questionnaire (Appendix 3a) was agreed with PPARC to ensure that we recruited an agreed cross-section of individuals, however people who had no interest in science were excluded from the project. Recruitment was subcontracted to a specialist market research recruitment company.

Questionnaire

Participants completed a short questionnaire (see appendix 5) whilst waiting for the group to start. This was designed to assess their general interest in science and to allow an estimate to be made of the relative numbers of those who were more unreservedly pro-science and those who although interested had concerns.

Discussions

Each focus group lasted approximately one and a half hours and was broadly structured around the topic guide at Appendix 4a.

Following a brief introduction to the evening the participants introduced themselves and a few questions about general perspectives on science were used as an ice breaker. Thereafter the conversation focused down firstly onto CERN and secondly the LHC. Two sets of shuffle cards (see appendix 6) were used to support and focus the LHC discussions.

General issues explored included the UK's role in science, possible risks and benefits associated with the LHC, costs and value for money. The final focus was to identify those issues that would be most likely to capture people's attention and thus provide useful hooks for the PPARC communication effort.

One member of PPARC staff observed some of the groups.

Teacher interviews

Sample

Depth interviews with teachers were agreed as the most effective method for enabling us to understand how teachers might use the LHC project in their lessons and the support they would need to do so. The majority of the interviews took place in pairs to allow an interchange of ideas between teachers. For the paired interviews the teachers were always from different schools.

Our sample included teachers from a range of schools to represent a cross-section of educational achievement (measured by percentage of students achieving five A to C grades at GCSE), catchment area (urban, suburban and rural) and school specialism.

In total we interviewed 30 science teachers over seventeen depth interviews (13 pairs and 4 singles). The interviews were located as follows

Region	Paired depths	Single depths
North	2	1
Midlands	2	1
South	3	
South West	2	1
Greater London	4	1

A recruitment questionnaire (Appendix 3b) was agreed with PPARC to ensure that we recruited an agreed cross-section of teachers. Recruitment was subcontracted to a specialist market research recruitment company.

Interviews

Each interview lasted approximately one hour and was broadly structured around the topic guide at Appendix 4b.

After an introduction to the project, the teachers introduced themselves and their schools. Thereafter the conversation focused on the teaching of physics and whether, and how, PPARC could use the work of the LHC to support teachers.

Young people's focus groups

Sample

A recruitment questionnaire (Appendix 3c) was agreed with PPARC and recruitment was subcontracted to a specialist market research recruitment company. Friendship pairs/triplets of young people were recruited. This enabled the group to settle more quickly than recruiting individual young people who did not know each other. Students with no interest in science were excluded from the project.

We ran four focus groups each with about eight young people to the following profile.

Region	Male	Female
North	14-16 (years 10 and 11)	
Midlands		17-19 (6^{th} form)
South	17-19 (6^{th} form)	
South West		14-16 (years 10 and 11)

Discussions

Following a brief introduction to the session the participants introduced themselves. As an ice-breaker the participants were asked about their favourite subjects at school (years 10 and 11) or their subject choices (6^{th} form). We also explored perceptions of school science and outside interests, including visits to science-related attractions. Thereafter the conversation focused down firstly onto CERN and mainly the LHC. Two sets of shuffle cards (see appendix 6) were used to support and focus the LHC discussions. General issues explored included the UK's role in science, possible risks and benefits associated with the LHC, costs and value for money. The final focus was to identify those issues that would be most likely to capture young people's attention and thus provide useful hooks for the PPARC communication effort.

Appendix 3 Recruitment Questionnaires

a. Adults

Briefing

We want to recruit 9 people for 8 to show in each group.

People who think that science is of no interest to them should be excluded from the project.

Date	Location	Male	Female
25 July	St Albans	ABC1 aged 20 to 39	C2D aged 40+
1 August	Bristol	C2DE aged 40+	ABC1 aged 20 to 39
8 August	Birmingham	C2DE aged 20 to 39	ABC aged 40+
9 August	Manchester	ABC1 aged 40+	C2DE aged 20 to 39

Introduction

Hello my name is… and I work for…… We are looking for people who live in your area to take part in some research to explore what people think about science. Could you spare me a few minutes to answer some questions please?

Q1	Do you or any of your close relatives work in any of the following occupations? SHOW CARD		
	Market research	1	CLOSE
	Scientific research	2	
	Journalism	3	
	Public relations	4	
	Marketing	5	
	Teaching	6	
	Manufacturing	7	CONTINUE
	Public services e.g. NHS, local authority	8	
	Other	9	
Q2	Are you…		
	Working full time	1	AT LEAST 6/9 TO BE WORKING FULL-TIME
	Working part-time	2	
	Retired/not working	3	
	Unemployed	4	CODE AS E
	Student	5	CODE AS C1
Q3	Job Title (WRITE IN)		
Q4	Job Description (WRITE IN)		
Q5	Qualifications (WRITE IN)		
Q6	How many people are you responsible for? (WRITE IN)		
Q7	CODE SOCIAL GRADE		

	A/B	1	REFER TO QUOTA
	C1	2	
	C2	3	
	D	4	
	E	5	
Q8	CHECK WHETHER RESPONDENT IS MALE OR FEMALE		
	MALE	1	REFER TO QUOTA
	FEMALE	2	
Q9	What was your age last birthday?		
	20-39	1	REFER TO QUOTA
	40+	2	
Q10	Do you have children of your own?		
	Yes	1	ENSURE SOME WITH CHILDREN IN EACH GROUP
	No	2	
	I am going to read out a statement and I would like you to say whether you agree or disagree with it.		
Q11	I am not interested in science and I don't see why I should be		
	Agree	1	CLOSE
	Disagree	2	Q12a
	Don't know	3	
	THIS SHOULD RESULT IN ABOUT 8 OUT OF 10 PEOPLE BEING ELIGIBLE. IF THE NUMBER FALLS SIGNIFICANTLY BELOW THIS PLEASE CONTACT YOUR SUPERVISOR		
QA.	Have you EVER attended a group discussion or depth interview before?		
	Yes	1	ASK QB
	No	2	RECRUIT
QB.	Have you been to a group discussion or depth interview in the last 6 months?		
	Yes	1	CLOSE
	No	2	GO TO QC
QC.	How many group discussions/depth interviews have you been to in the last 2 years? (i.e. 6 months - 2 years ago)		
	None	1	GO TO QE
	1 or 2	2	GO TO QD
	More than 2	3	CLOSE
QD.	Did you go to any groups/depths between 2 and 7 years ago?		
	Yes	1	CLOSE
	No	2	GO TO QE

QE.	What was the subject of the discussion group(s)/depths you took part in before? (WRITE IN SUBJECT MATTER AND APPROX - WHEN IT WAS FOR EACH OCCASION). **IF ABOUT SCIENCE - CLOSE**. THIS IS VERY IMPORTANT. THE RESPONDENT MUST NEVER HAVE PARTICIPATED IN A DISCUSSION ON THE SAME SUBJECT. OTHERWISE RECRUIT.

b. Teachers

Briefing

We want to recruit: 32 teachers in 16 pairs. The teachers should teach physics either as a subject in its own right, or the physics component of GCSE science. At least half of the teachers should have a physics degree. The geographical distribution is as follows:

Manchester, 3 pairs
Birmingham, 3 pairs
Bedfordshire/Hertfordshire, 3 pairs
Swindon, 3 pairs
Greater London, 4 pairs in 2 locations

The teachers in each pair should work in different schools and overall the schools should represent a cross-section of educational achievement (measured by percentage of students achieving five A to C grades at GCSE), catchment area (urban, suburban and rural) and school specialism (science specialist, other specialist and non-specialist).

Introduction

Hello my name is… and I work for…... We are………. Could you spare me a few minutes to answer some questions please?

Q1	Do you teach physics, either as a single subject, or the physics component of GCSE science?		
	Yes	1	
	No	2	CLOSE
	Do you teach 'A' level physics or equivalent?		
	Yes	1	14-18 PARTICIPANTS MUST TEACH 'A' LEVEL
	No	2	
Q2	What subject was your degree in?		AT LEAST HALF SHOULD HAVE DEGREES IN PHYSICS
	Biology	1	
	Chemistry	2	
	Mathematics	3	
	Physics	4	
	Other science or engineering	5	
	Other (please write in)		
Q3	Do any of your close relatives work in any of the following occupations? SHOW CARD		
	Market research	1	CLOSE
	Journalism	2	CLOSE
	Public relations	3	CLOSE
	Marketing	4	CLOSE
	Scientific research	5	CONTINUE
	None of the above	6	CONTINUE

Q4	How would you describe your school's catchment area?		
	Urban	1	ENSURE A MIXTURE ACROSS THE WHOLE SAMPLE
	Suburban	2	
	Rural	3	
Q5	Does your school have specialist status		
	Yes	1	ENSURE AT LEAST 2 NON-SPECIALIST PER REGION
	No	2 GOTO Q7	
Q6	What is the specialism?		
	(WRITE IN)		
			ENSURE AT LEAST 2 SCIENCE-SPECIALIST PER REGION
Q7	Is you school state funded or independent?		
	State funded (including voluntary aided)	1	NO MORE THAN 20 TO COME FROM INDEPENDENT SCHOOLS
	Independent	2	
Q8	Approximately what proportion of your school's students achieve 5 or more A*-C GCSEs?		
	Less than 35%	1	ENSURE A RANGE OF ATTAINMENT IN EACH REGION
	36% - 55%	2	
	56% - 70%	3	
	Greater than 70%	4	
Q9	MALE	1	ENSURE SOME MALE AND SOME FEMALE IN EACH REGION
	FEMALE	2	
Q10	What was your age last birthday?		
	25-34	1	ENSURE A RANGE OF AGES IN EACH REGION
	35-44	2	
	45-54	3	
	55+	4	
Q11	Have you EVER attended a group discussion or depth interview before?		
	Yes	1	ASK Q12
	No	2	GO TO RECRUITMENT SCRIPT
Q12	Have you been to a group discussion or depth interview in the last 6 months?		
	Yes	1	CLOSE
	No	2	GO TO Q13
Q13	How many group discussions/depth interviews have you been to in the last 2 years? (i.e. 6 months - 2 years ago)		
	None	1	GO TO Q15
	1 or 2	2	GO TO Q14
	More than 2	3	CLOSE

Q14	Did you go to any groups/depths between 2 and 7 years ago?		
	Yes	1	CLOSE
	No	2	GO TO Q15
Q15	What was the subject of the discussion group(s)/depths you took part in in the past? (WRITE IN SUBJECT MATTER AND APPROX - WHEN IT WAS FOR EACH OCCASION).		
	IF ABOUT SUPPORT FOR TEACHING SCIENCE - CLOSE. THIS IS VERY IMPORTANT. THE RESPONDENT MUST NEVER HAVE PARTICIPATED IN A DISCUSSION ON THE SAME SUBJECT. OTHERWISE GO TO RECRUITMENT SCRIPT		
	IN A NUTSHELL: NB: If you have any queries at all, please call your Manager • At least half of each group/set of depths must be **brand new** recruits. • The remaining half can have attended up to a maximum of 2 groups/depths in the last 2 years (ie. 6 months -2 years ago) • Those who have been to 2 groups/depths in the last 2 years must have had a 5 year gap before that • **None** to have attended any group/depths in **last 6 months** **None ever** to have attended a group/depths on the same subject matter (see QI)		
	RECRUITMENT SCRIPT: Provide date, time and venue AND Ask the teacher to bring with them one or two examples of materials that they have used to support their teaching. This might be something they have received in a mail shot, found on a website, found at a show or been given by a colleague.		

c. Young people

Briefing

We want to recruit: 32 students in 8 groups. The geographic and demographic distribution is as follows:

25 July St Albans 1 group male, 17-19 (6th form)
1 August Bristol 1 group female, 14-16 (years 10 and 11)
8 August Birmingham 1 group female, 17-19 (6th form)
9 August Manchester 1 group male, 14-16 (years 10 and 11)

All students should have an interest in science and technology. It is acceptable for the students to be recruited in friendship pairs/triplets.

Introduction

Hello my name is… and I work for…... We are………. Could you spare me a few minutes to answer some questions please?

Q1	Are you at school or college full time?		
	Yes	1	
	No	2	CLOSE
Q2	How old are you		
	WRITE IN		
			REFER TO QUOTA
Q3	Are you studying any of the following subjects. MULTICODE		
	Science	1	
	Physics	2	
	Biology	3	
	Chemistry	4	
	None of these	5	CLOSE
Q4	I am going to read out some statements and I would like you to say whether you agree or disagree with each.		
Q4a	I enjoy science at school		
	Agree	1	
	Disagree	2	
	Don't know	3	
Q4b	It is important to know about science in my daily life		
	Agree	1	
	Disagree	2	
	Don't know	3	
Q4c	I am not interested in science		
	Agree	1	
	Disagree	2	
	Don't know	3	
	IF AGREE AT 4c and DISAGREE AT EITHER 4a or 4b		CLOSE

Q5	MALE	1	REFER TO QUOTA
	FEMALE	2	
Q6	Have you EVER taken part in a research project before?		
	Yes	1	ASK Q7
	No	2	RECRUIT
Q7	Have you taken part in a research project in the last 12 months?		
	Yes	1	CLOSE
	No	2	RECRUIT

Appendix 4: Topic guides

a. *Adult Focus Groups*

ALL GROUPS WILL HAVE 2 PSP MODERATORS

Introduction

	Welcome and introduce self
	Introduce PSP and independence from the client
	Introduce second moderator and client (where present)
	Has anyone been to anything like this before?
	I have here a list of things I'd like to cover but really want to hear your views on the issues we'll be introducing.
	There are no right or wrong answers. Everyone is entitled to their own view, so I'd like to hear from everyone because everyone's view is valid.
	You don't have to answer all of the questions.
	You are free to leave before the end of the session, if you wish.
	I would like to tape record the discussions, just to save me taking notes, so I can listen to what you're all saying.
	No one will be identified in the report. All the information will be collected together and anonymised.
	This is just one session of 8 that we are running with adults around the country on this project. We are also running groups with young people and teachers.
	Is everyone happy for me to record the session?
	SWITCH ON TAPE AND MIKE. IN VIEWING ROOMS THE RECORDING WILL HAVE BEGUN BUT ALL PARTICIPANTS ARE ADVISED OF RECORDING AT RECRUITMENT
	Introduce the project: As you may have guessed, tonight we want to talk about science and we will be giving you some information during the evening and asking for your views. I'll tell you more about how the information will be used at the end of the session.
	The report will not be published. It is to help in the development of other work, again I'll say more about that at the end.
	Our client tonight is the Particle Physics and Astronomy Research Council. PPARC is the UK's science funding agency for particle physics. While Government funded, operates independently of Government in allocating funding. It funds research, education and public engagement with science in the aforementioned areas.
	Make it clear PSP is independent of PPARC and not expert in these areas of science.
	Standard warm up round the room of introductions Ask for name, occupation and what it is about science that interests them.

Interest in science	
	When you were invited here you will have been asked about your interest in science. What did you think of when you thought about ‘science’?
	SECOND MODERATOR TO MAKE CARDS OF DEFINITIONS/DESCRIPTIONS GIVEN
	What makes you think of these things as ‘science’?
	IF GROUPS OF TOPICS/ISSUES EMERGE ASK PARTICIPANTS TO RANK AND EXPLAIN RATIONALES FOR RANKINGS
	What we would like to focus on for the rest of the evening is some physics experiments that will be going on over the next few years.
CERN	Has anyone heard of CERN? (Conseil Européen pour la Recherche Nucleaire)
	READ OUT DESCRPITION OF CERN
CERN is the European Organization for Nuclear Research, the world's largest particle physics centre. It is based in Switzerland near Geneva and straddles border between France and Switzerland. Founded in 1954, the laboratory was one of Europe's first joint ventures and now includes 20 Member States.	
It has nothing to do with nuclear power or nuclear weapons. It is a laboratory where scientists study the building blocks of matter and the forces that hold them together. They are trying to understand the formation of stars, earth, everything.	
CERN exists primarily to provide the necessary machines for scientists to do this. The machines are accelerators and detectors. The accelerators are used to accelerate fragments of atoms (the building blocks of matter) almost to the speed of light and then collide them together. The detectors make the particles produced by the collisions visible.	
	Do you think Britain would be involved in this sort of thing?
Britain was a founder member and continues to make a significant contribution. Many of the scientists there are British and a previous director was British.	
	PAUSE FOR REACTION FOLLOW-UP ON

	ANY COMMENTS
	PROBE: What do you think is good about it? What do you think is bad about it? What else might you want to know about the work of CERN? If you had to tell a friend about it what would you want to be able to tell them? Would you want to tell other people about CERN?
Large Hadron Collider	Tonight we want to focus on a new piece of equipment that will become operational this summer. The **Large Hadron Collider**
[Hadrons are atomic particles such as protons and neutrons.]	
The LHC will probe deeper into matter than ever before. It will recreate on a small scale the conditions that existed billionths of a second after the Big Bang and so help test theories about the Big Bang and the origin of the universe. It will help to improve our understanding of the basic laws of the universe and enable physicists to test the theories that have been developed about how the universe works, came into being and evolved.	
It is one of the biggest scientific experiments ever.	GET IMPRESSION OF THE IMPACT OF THIS STATEMENT
History has shown that the greatest advances in science are often unexpected. Although we have a good idea of what we hope to find at the LHC, nature may well have surprises in store. One thing is certain, the LHC will change our view of the Universe.	
	PAUSE FOR REACTION FOLLOW-UP ON ANY COMMENTS
IF ASKED: It is safe.	
Cost	
£4 billion between all the countries taking part. The UK contribution is about £1 per adult per year.	
	PAUSE FOR REACTION. FOLLOW-UP ON ANY COMMENTS
	PROBE: Does this seem like a lot of money? From what you've heard so far, do you think what scientists will learn is worth the money?
Interest in LHC	What I'd like to do next is look at the LHC in more detail. Here are some of the things they might find out and a few other pieces of information about the LHC. I'd like you to try to rank them in order of how much they

	interest you.
	LAY OUT PRE-PREPARED CARDS WITH LHC RESEARCH TOPICS AND ASK PARTICIPANTS TO RANK THEM AS A GROUP EXERCISE
	CARDS:
	1. Answering questions Einstein couldn't
	2. Where is antimatter?
	3. What is dark matter?
	4. Why does matter have mass?
	5. The Big Bang
	6. Origins of the universe
	7. How gravity works
	8. Fundamental laws of nature
	The next set of cards look at some of the spin-offs from building the equipment at CERN.
There are estimated to be around 17,000 particle accelerators in the world, over half of them used in medicine for imaging and therapy.	1. Medical applications
In industry particle accelerators are used to improve the quality of manufactured goods, to sterilize medical equipment and food, to make semiconductors for the computer industry, to improve aircraft engines and artificial hips, to investigate how car engines wear out, to look for contraband and to help survey for underground tunnelling.	2. Engineering advances
The GRID is another aspect of the underlying machinery that needs to be in place to support the LHC experiments. Vast computing power is required to analyse the huge amounts of data generated by the LHC experiments. We are familiar with the World Wide Web as a service for sharing information over the Internet. It has revolutionised information sharing and communications over the last 5-8 years. The GRID goes beyond simple communication between computers and aims to turn the global network of computers into one vast computing resource. The GRID is a service for sharing computer power and data storage capacity over the Internet. It will allow users to access software, data and computing power around the world as if it were on their own desktop computer. Originally developed for particle physicists, the GRID is already being used by	3. The Grid

other scientists, for example using spare capacity on domestic computers to help model the spread of malaria strains in Africa.	
CERN's expertise is a much valued resource for the computer industry, where the demand for computing power and network capacity (bandwidth) have largely stimulated and contributed to major developments, most notably the World Wide Web. The worldwide web was invented at CERN by Tim Berners-Lee, who is British.	4. Computers and the Internet
	5. UK involvement, in international science
	6. Leading the USA in science
	7. Opportunities for UK business
	8. Opportunities for UK scientists
	9. Careers in science and engineering for young people
	EXPLORE RATIONALES FOR RANKING AND REASONS FOR DIFFERENCES IN RANKINGS BETWEEN INDIVIDUALS.
	If you worked in the press office at CERN and had to write a headline for a press release, based on what you've learnt tonight, what would you say?
	GENERAL BRAINSTORM TO GENERATE ONE OR MORE HEADLINES
	Why would you say that? Why would you pick out that point and not others?
Conclusion	Thank you very much for your input tonight. For the particle physics community the LHC is an exciting opportunity for them to test theories that have been developed over the 20th century and they are keen to share the findings with the general public. Also, it is tax payers' money and they feel that you have a right to know how it is being spent.
	The findings from this evening's session will be put together with the findings from other sessions around the country so that the Particle Physics and Astronomy Research Council can build a picture of what is most likely to interest the general public and why and build a communications programme.

b. Teacher Topic Guide

	Welcome and introduce self
	Introduce PSP and independence from the client
	Introduce second moderator and client (where present)
	Have either of you been to anything like this before?
	I have here a list of things I'd like to cover but really want to hear your views on the issues we'll be introducing.
	There are no right or wrong answers. Everyone is entitled to their own view.
	You don't have to answer all of the questions.
	You are free to leave before the end of the session, if you wish.
	I would like to tape record the discussions, just to save me taking notes, so I can listen to what you're both saying.
	No one will be identified in the report. All the information will be collected together and anonymised.
	This is just one session of 16 that we are running with teachers around the country on this project. We are also running groups with adults and young people.
	Are you both happy for me to record the session?
	SWITCH ON TAPE AND MIKE – IN VIEWING FACILITIES RECORDING WILL HAVE STARTED BUT ALL PARTICIPANTS ARE INFORMED ABOUT RECORDING AT RECRUITMENT
	Introduce the project I want to talk to you today about teaching science, physics in particular and about whether and how you use information about current scientific research in your teaching. I'll tell you more about how the information will be used at the end of the session.
	The report will not be published. It is to help in the development of other work, again I'll say more about that at the end.
	Our client is the Particle Physics and Astronomy Research Council. PPARC is the UK's science funding agency for particle physics. While Government funded, it operates independently of Government in allocating funding. It funds research, education and public engagement with science in the aforementioned areas.
	Make it clear PSP is independent of PPARC and not expert in these areas of science.
	Introductions

Background	
Establish:	Nature of school – urban/rural/suburban
	GCSE results/type of catchment area
	Specialism of school, if any
	Years in teaching
	Subjects taught and level at which taught
	Degree subject and any subject specific training in physics/teaching physics if not a physics graduate
	Membership of ASE, IoP
	Awareness of PPARC and PPARC materials

	for schools
CERN	What we'd like to focus on today is some research that is being done at CERN. Have either of you heard of CERN? (Conseil Européen pour la Recherche Nucleaire)
	IF NECESSARY READ OUT DESCRIPTION OF CERN
CERN is the European Organization for Nuclear Research, the world's largest particle physics centre. It is based in Switzerland near Geneva and straddles border between France and Switzerland	
It has nothing to do with nuclear power or nuclear weapons. It is a laboratory where scientists study the building blocks of matter and the forces that hold them together. They are trying to understand the formation of stars, earth, everything.	
CERN exists primarily to provide the necessary machines for scientists to do this. The machines are accelerators and detectors. The accelerators are used to accelerate fragments of atoms (the building blocks of matter) almost to the speed of light and then collide them together. The detectors make the particles produced by the collisions visible.	
Founded in 1954, the laboratory was one of Europe's first joint ventures and now includes 20 Member States. Britain was a founder member state and continues to make a significant contribution. Many of the scientists there are British; a previous director was British.	
	PAUSE FOR REACTION FOLLOW-UP ON ANY COMMENTS
	PROBE: Is this the sort of thing you think Britain should be involved with? Why? Why not? What do you think is good about it? What do you think is bad about it? What else might you want to know about CERN?
	Have you ever talked to your students about CERN and the work done there? IF SO, PROBE: What was discussed, when, why, with which group(s) of students, etc.
	If you were going to tell your students about CERN what would you want to be able to tell them?
Work at CERN has improved physicists'	

basic understanding of matter.	
There have also been some important spin-offs from the work at CERN. For example, the worldwide web was invented at CERN by Tim Berners-Lee, who is British. Cancer, medical and industrial imaging technology for making images of the inside of the human body and opaque objects, radiation processing, electronics, measuring instruments, new manufacturing processes and materials.	
There are estimated to be around 17,000 particle accelerators in the world, over half of them used in medicine for imaging and therapy. In industry particle accelerators are used to improve the quality of manufactured goods, to sterilise medical equipment and food, to make semiconductors for the computer industry, to improve aircraft engines and artificial hips, to investigate how car engines wear out, to look for contraband and to help survey for underground tunnelling.	
	Have you ever heard about the GRID? IF YES, what is your understanding of it?
The GRID is another aspect of the underlying machinery that needs to be in place to support the LHC experiments. Vast computing power is required to analyse the huge amounts of data generated by the LHC experiments. We are familiar with the World Wide Web as a service for sharing information over the Internet. It has revolutionised information sharing and communications over the last 5-8 years. The GRID goes beyond simple communication between computers and aims to turn the global network of computers into one vast computing resource. The GRID is a service for sharing computer power and data storage capacity over the Internet. It will allow users to access software, data and computing power around the world as if it were on their own desktop computer. Originally developed for particle physicists, the GRID is already being used by other scientists, for example using spare capacity on domestic computers to help model the spread of malaria strains in Africa.	

CERN's expertise is a much valued resource for the computer industry, where the demand for computing power and network capacity (bandwidth) have largely stimulated and contributed to major developments.	
	PAUSE FOR REACTION FOLLOW-UP ON ANY COMMENTS
	PROBE: Is this the sort of thing you think Britain should be involved with? Why? Why not? What do you think is good about it? What do you think is bad about it? What else might you want to know about the work of CERN? Have you ever talked to your students about how basic research is used?
Large Hadron Collider	I want to focus on a new piece of equipment at CERN that will become operational this summer. The **Large Hadron Collider**. Have you heard about it? IF YES, What have you heard? Where did you hear about it? Have you considered using any of this information in your physics classes? Why? Why not? With which age groups might you consider introducing the LHC and the experiments it will be used to conduct?
	IF NOT, DESCRIBE:
[Hadrons are atomic particles such as protons and neutrons.]	
The LHC will probe deeper into matter than ever before. It will recreate on a small scale the conditions that existed billionths of a second after the Big Bang and so help test theories about the Big Bang and the origin of the universe. It will help to improve our understanding of the universe and to test the theories that have been developed about how the universe works, came into being and has evolved.	
There are technological spin-offs for the engineering world in making and building the machines and equipment used at CERN.	
History has shown that the greatest advances in science are often unexpected. Although we have a good idea of what we hope to find at the LHC, nature may well have surprises in store. One thing is certain, the LHC will change our view of the Universe.	
	PAUSE FOR REACTION FOLLOW-UP ON ANY COMMENTS

	PROBE: Do any of these topics interest either of you? Is this the sort of thing you think Britain should be involved with? Why? Why not? What do you think is good about it? What do you think is bad about it? What else might you want to know about the LHC project?
IF ASKED: It is safe.	
Cost	
£4 billion between all the countries taking part. The UK contribution is about £1 per adult per year.	
	PAUSE FOR REACTION. FOLLOW-UP ON ANY COMMENTS
	PROBE: Does this seem like a lot of money? From what you've heard so far, do you think what scientists will learn is worth the money?
Interest in LHC for physics lessons	How, if at all, might the LHC project help you in your teaching of physics? Do you think you might use the LHC and the findings from the experiments in your physics teaching? Why? Why not? What would you want to be able to tell your students?
	With which age groups might you consider introducing the LHC and the experiments it will be used to conduct?
	What elements of the curriculum at A-level/GCSE do you find it particularly hard to teach/convey to students? What sort of materials might help you with this aspect of the curriculum? Could the LHC project help at all?
	What about running debates and teaching the new science curricula? Do you think you could include the LHC in your lessons? For example in a discussion on the funding of fundamental science, who decides what science is done or how science is increasingly done in international collaborations.
	LOOK FOR SIGNS THAT THEY FEEL THAT THEY WOULD NOT BE ABLE TO HANDLE THIS LEVEL OF MATERIAL.
Presentation	Did you bring some materials with you that you particularly like to use in your science teaching? IF SO, [AND ALL WERE ASKED TO DO SO] LOOK OVER THE MATERIALS AND ASK: Why did you choose to bring this with you? What do you

	particularly like about it? Content? Presentation? How did you find it? ASK IF CAN KEEP COPY OR WHERE A COPY CAN BE OBTAINED.
	SHOW PPARC MATERIAL AND GET FEEDBACK
	How do you prefer to receive materials – post, web, etc. What is the best way to inform you about new materials that might help you in your science teaching?
	MOVE ON TO DISCUSS HOW THE LHC MIGHT BE PRESENTED TO TEACHERS TO SUPPORT THEM IN THEIR PHYSICS TEACHING.
Video snippets	FOR EACH ASK: WHETHER WOULD USE, WHICH AGE GROUPS, DIFFERENCES BETWEEN ABILITY GROUPS, GENDERS AND ETHNIC GROUPS
Role plays	
Cartoons	
Discussions	
Teaser mail outs	
	Physics seems to attract more boys than girls, do you find this is the case in your schools? IF SO, why do you think this is? What, if anything have you done to counter this tendency? Do you think the LHC project might help to engage more girls with the subject? And what about different ethnic groups? Do you find young people from some ethnic groups are more likely to be interested in physics than others? IF SO why do you think that is? What, if anything have you done to try to counter this? Do you think the LHC project could be used to engage a wider range of young people than currently?
	And how do you find materials that you use in the classroom? What formats do you prefer? Any other ways/formats? REFERENCE SPECIFICALLY TO LHC PROJECT
Web (on-line results data/photos of equipment)	
CD (results data/photos of equipment)	
Mail outs of paper-based materials	
Handouts for students	
Wall posters	
	TEST OUT THE ATTOWORLD PROPOSITION

	I'd like to get your views on a proposal that has been put forward as a way of communicating science to young people called Attoworld.
Attoworld is a proposal for a professionally produced science show targeting years 10, 11 and 12. It will use live actors, a 'real' physicist and a range of multimedia and interactive tools to engage the audience in a one hour long immersive event exploring particle physics, the origin of the Universe and what it is like to work as a particle physicist.	
The aim is to engage students who are not particularly interested in particle physics. It will be exciting but also provide some real learning. In its full form it would require significant funds (£100,000 – £150,000) to develop and run it.	
	From this description what would you imagine the show might be like?
	If such a show was available locally would you take your students to see it? Which age groups? Why? Why not?
	If it could go to your school to be performed there would you want to arrange for it to come? For which age groups? Why? Why not?
	Do you think students learn anything from this kind of activity that in effect helps you to deliver the curriculum? What? Why not?
	Do you think this kind of activity helps to make students more interested in science? Why? Why not? Which age groups does this work best for? And which does it work least well for? Do you think it would encourage more to consider studying physics and university?
A version also exists, which is more of a standard schools lecture, a bit like the Royal Institution Christmas Lecture.	CHECK FAMILIARITY WITH THE RI LECTURES Which is more appropriate - an immersive, multimedia show or a more conventional (but well produced and interesting) schools lecture? Why? Is it different for different aged students? Will it work for physics?
	What are the reasons for/barriers to using this kind of resource?
	THIS IS LIKELY TO STIMULATE

	FURTHER CONVERSATION ABOUT USING THE LHC PROJECT IN TEACHING
CPD	Would you personally, as a teacher, be interested in knowing more about the LHC project? Do you think there would be demand for a CPD/INSET course on the LHC? EXPLORE THE MOTIVATIONS AND BARRIERS TO BEING ABLE TO ATTEND SUCH A COURSE.
Conclusion	
	Thank you very much for your input. For the particle physics community the LHC is an exciting opportunity for them to test theories that have been developed over the 20th century and they are keen to share the findings with the general public. Also, it is tax payers' money and they feel that you have a right to know how it is being spent.
	The findings from this discussion will be put together with the findings from other sessions around the country so that the Particle Physics and Astronomy Research Council can build a picture of how teachers can use the project in their teaching.

c. *Student Focus Groups*

ALL GROUPS WILL HAVE 2 PSP MODERATORS

Introduction

	Welcome and introduce self
	Introduce PSP and independence from the client
	Introduce second moderator and client (where present)
	Has anyone been to anything like this before?
	I have here a list of things I'd like to cover but really want to hear your views on the issues we'll be introducing.
	There are no right or wrong answers. Everyone is entitled to their own view, so I'd like to hear from everyone because everyone's view is valid.
	You don't have to answer all of the questions.
	You are free to leave before the end of the session, if you wish.
	I would like to tape record the discussions, just to save me taking notes, so I can listen to what you're all saying.
	No one will be identified in the report. All the information will be collected together and anonymised.
	This is just one session of 4 that we are running with young people around the country on this project. We are also running groups with adults and teachers.
	Is everyone happy for me to record the session?
	SWITCH ON TAPE AND MIKE. IN VIEWING ROOMS THE RECORDING WILL HAVE BEGUN BUT ALL PARTICIPANTS ARE ADVISED OF RECORDING AT RECRUITMENT
	Introduce the project: As you may have guessed, today we want to talk about science and we will be giving you some information during the day and asking for your views. I'll tell you more about how the information will be used at the end of the session.
	The report will not be publicly available. It is to help in the development of other work, again I'll say more about that at the end.
	Our client is the Particle Physics and Astronomy Research Council. PPARC is the UK's science funding agency for particle physics. While Government funded, operates independently of Government in allocating funding. It funds research, education and public engagement with science in the aforementioned areas.
	Make it clear PSP is independent of PPARC and not expert in these areas of science.
	Standard warm up round the room of introductions Ask for name and school year. For years 12 and 13 ask subjects studied, for years 10 and 11 ask favourite subject and reason. WRITE NAME AND SUBJECTS ON CARDS
	We will come back to school subjects a bit later, but thanks for that.

NB BEAR IN MIND COMMENTS FROM TEACHERS TO FOLLOW-UP WITH STUDENTS

Information	Activities
School science	IF ANY STUDENT HAS SAID SCIENCE OR A

	SCIENCE AS FAVOURITE SUBJECT/SUBJECT BEING STUDIED ASK THOSE IN THE GROUP:
	Could you say a bit more about what you like about studying science?
	What aspects/topics do you particularly like/enjoy?
	PROBE FOR MENTIONS OF PHYSICS AND FOCUS ON THESE IF THEY COME UP
	FOR THOSE NOT STUDYING SCIENCE/DID NOT GIVE SCIENCE AS A FAVOURITE SUBJECT:
	Why didn't you choose science for A-level?/Although you didn't give science as a favourite subject, do you enjoy it at all? [BUILD ON RATIONALES GIVEN FOR FAVOURITE SUBJECT IN INTRODUCTIONS]
	Which topics in science do/did you enjoy, if any? PROBE FOR ANY MENTION OF PHYSICS
	ASK ALL EXCEPT YEARS 12 AND 13 NOT DOING SCIENCE SUBJECTS:
	Do you see yourself continuing to study science in the future? Why? Why not?
	What subject(s) do you think you will study? Why?
	Do you have any ideas about what jobs you might go into?
Interest in science	When you were invited here you will have been asked about your interest in science. What did you think of when you thought about 'science'?
	SECOND MODERATOR TO MAKE CARDS OF DEFINITIONS/DESCRIPTIONS GIVEN
	IT IS LIKELY THAT IT WILL BE POSSIBLE TO IDENTIFY GROUPS OF TOPICS FROM THIS, FOR EXAMPLE THERE MAY BE A NUMBER OF THINGS THAT CAN BE CALLED 'MEDICAL'.
	FOR EACH TOPIC GROUP ASK: There are a group of things here that could be described as…. what makes you think of these things as 'science'?
	ONCE THE GROUPS HAVE BEEN IDENTIFIED AND PARTICIPANTS HAVE AGREED ON THE GROUPINGS, CREATE A CARD FOR EACH GROUP.
	ASK PARTICIPANTS TO RANK THE TOPICS ACCORDING TO THEIR INTEREST.
	EXPLORE RATIONALES FOR RANKING

	AND REASONS FOR DIFFERENCES IN RANKINGS BETWEEN INDIVIDUALS.
Out of school activities	What sort of things do you do in your spare time? Do you ever go to museums? What sort of museums (PROBE FOR SCIENCE)? What about art galleries or science centres? Has anyone ever been to the Science Museum in London? Have you been to NEAREST SCIENCE CENTRE? IF YES: What did you enjoy about it? What didn't you enjoy? Would you go again? What could have been better?
	What we'd like to concentrate on for the rest of the time is some physics experiments that will be happening over the next few years.
CERN	Has anyone heard of CERN? (Conseil Européen pour la Recherche Nucleaire). If yes, where did you hear about it? Was it at school/from a teacher?
	READ OUT DESCRIPTION OF CERN
CERN is the European Organization for Nuclear Research, the world's largest particle physics centre. It is based in Switzerland near Geneva and straddles border between France and Switzerland. Founded in 1954, the laboratory was one of Europe's first joint ventures and now includes 20 Member States.	
It has nothing to do with nuclear power or nuclear weapons. It is a laboratory where scientists study the building blocks of matter and the forces that hold them together. They are trying to understand the formation of stars, earth, everything.	
CERN exists primarily to provide the necessary machines for scientists to do this. The machines are accelerators and detectors. The accelerators are used to accelerate fragments of atoms (the building blocks of matter) almost to the speed of light and then collide them together. The detectors make the particles produced by the collisions visible.	
	Do you think Britain would be involved in this sort of thing?
Britain was a founder member state and continues to make a significant contribution. There are British scientists, engineers, technical support and administrators.	
	PAUSE FOR REACTION FOLLOW-UP ON

	ANY COMMENTS
	Is this the sort of place you might like to work in the future? Why? Why not? IF YES, What attracts you to this type of work place? PROBE FOR CONTEXT (INTERNATIONAL AND BASED OVERSEAS) OR TYPE OF WORK (PHYSICS RESEARCH)
	PAUSE FOR REACTION FOLLOW-UP ON ANY COMMENTS
	PROBE: Is this the sort of thing you think Britain should be involved with? Why? Why not? What do you think is good about it? What do you think is bad about it? What else might you want to know about the work of CERN? If you had to tell a friend about it what would you want to be able to tell them? Would you want to tell other people about CERN?
Large Hadron Collider	Today we want to focus on a new piece of equipment that will become operational this summer. The **Large Hadron Collider**
[Hadrons are atomic particles such as protons and neutrons made from quarks and/or gluons, bound together by their strong interactions.]	
The LHC is the next step in research that began more than a century ago. Then, scientists had just discovered X-rays and electrons. Understanding these gave us a much greater understanding of the Universe and has led to things like televisions, electronic devices, medical tools and computers.	
	Have you studied these at school? Was anyone especially interested in these topics? Why? Why not?
The LHC will probe deeper into matter than ever before. It will recreate on a small scale the conditions that existed billionths of a second after the Big Bang and so help test theories about the Big Bang and the origin of the universe. It will help to improve our understanding of the universe and to test the theories that have been developed about how the universe works, came into being and has evolved.	
	Do you think people should know about this research? Would you like to know what they find as a result of these experiments? What would be the best way for those involved to tell you about the experiments?

	PROBE FOR TV, RADIO, NEWSPAPERS, MAGAZINES, WEB, SCHOOL, SCIENCE CENTRES AND MUSEUMS, ANY OTHER WAYS
	Would you expect your science teacher to cover this in science lessons? Why? Why not?
	Is this the sort of work you might like to do? Why? Why not? IF YES, What attracts you to this type of work?
There are technological spin-offs for the engineering world in making and building things.	Would you like to work on these types of engineering projects? Why? Why not?
History has shown that the greatest advances in science are often unexpected. Although we have a good idea of what we hope to find at the LHC, nature may well have surprises in store. One thing is certain, the LHC will change our view of the Universe.	
	PAUSE FOR REACTION FOLLOW-UP ON ANY COMMENTS
IF ASKED: It is safe.	
Cost	
£4 billion between all the countries taking part. The UK contribution is about £1 per adult per year.	
	PAUSE FOR REACTION. FOLLOW-UP ON ANY COMMENTS
	PROBE: Does this seem like a lot of money? From what you've heard so far, do you think what scientists will learn is worth the money?
Interest in LHC	What I'd like to do next is look at the LHC in more detail. Here are some of the things they might find out and a few other pieces of information about the LHC. I'd like you to try to rank them in order of how much they interest you.
	LAY OUT PRE-PREPARED CARDS WITH LHC RESEARCH TOPICS AND ASK PARTICIPANTS TO RANK THEM AS A GROUP EXERCISE
	CARDS:
	1. Answering questions Einstein couldn't
	2. Where is antimatter?
	3. What is dark matter?
	4. Why does matter have mass?
	5. The Big Bang
	6. Origins of the universe

	7. Fundamental laws of nature
	8. How gravity works
	The next set of cards look at some of the spin-offs from building the equipment at CERN.
The worldwide web was invented at CERN by a Tim Berners-Lee, who is British. Other spin-offs include medical and industrial imaging technology for making images of the inside of the human body and opaque objects, radiation processing, electronics, measuring instruments, new manufacturing processes and materials.	
There are estimated to be around 17,000 particle accelerators in the world, over half of them used in medicine for imaging and therapy. In industry particle accelerators are used to improve the quality of manufactured goods, to sterilize medical equipment and food, to make semiconductors for the computer industry, to improve aircraft engines and artificial hips, to investigate how car engines wear out, to look for contraband and to help survey for underground tunnelling.	
CERN's expertise is a much valued resource for the computer industry, where the demand for computing power and network capacity (bandwidth) have largely stimulated and contributed to major developments, most notably the World Wide Web.	
There are estimated to be around 17,000 particle accelerators in the world, over half of them used in medicine for imaging and therapy.	1. Medical applications
In industry particle accelerators are used to improve the quality of manufactured goods, to sterilize medical equipment and food, to make semiconductors for the computer industry, to improve aircraft engines and artificial hips, to investigate how car engines wear out, to look for contraband and to help survey for underground tunnelling.	2. Engineering advances
The GRID is another aspect of the underlying machinery that needs to be in place to support the LHC experiments. Vast computing power is required to analyse the huge amounts of data generated by the LHC experiments. We are familiar with the World Wide Web as a service for sharing information over the Internet. It has revolutionised information sharing and	3. The Grid

communications over the last 5-8 years. The GRID goes beyond simple communication between computers and aims to turn the global network of computers into one vast computing resource. The GRID is a service for sharing computer power and data storage capacity over the Internet. It will allow users to access software, data and computing power around the world as if it were on their own desktop computer. Originally developed for particle physicists, the GRID is already being used by other scientists, for example using spare capacity on domestic computers to help model the spread of malaria strains in Africa.	
CERN's expertise is a much valued resource for the computer industry, where the demand for computing power and network capacity (bandwidth) have largely stimulated and contributed to major developments, most notably the World Wide Web. The worldwide web was invented at CERN by Tim Berners-Lee, who is British.	4. Computers and the Internet
	5. UK involvement, in international science
	6. Leading the USA in science
	7. Opportunities for UK business
	8. Opportunities for UK scientists
17. Careers in	9. Careers in science and engineering for young people.
	EXPLORE RATIONALES FOR RANKING AND REASONS FOR DIFFERENCES IN RANKINGS BETWEEN INDIVIDUALS.
	If you worked in the press office at CERN and had to write a headline for a press release, based on what you've learnt today, what would you say? PROBE FOR SCHOOL PROJECTS, SCIENCE CENTRE PROJECTS, GENERAL PROJECTS
	GENERAL BRAINSTORM TO GENERATE ONE OR MORE HEADLINES
	Why would you say that? Why would you pick out that point and not others?
	GENERAL BRAINSTORM TO GENERATE A SCHOOL SCIENCE PROJECT
Conclusion	
	Thank you very much for your input. For the particle physics community the LHC is an exciting opportunity for them to test theories that have been developed over the 20th century and

	they are keen to share the findings with the general public. Also, it is tax payers' money and they feel that you have a right to know how it is being spent.
	The findings from this afternoon's session will be put together with the findings from other sessions around the country so that the Particle Physics and Astronomy Research Council can build a picture of what is most likely to interest the general public and why and build a communications programme.

Appendix 5. Attitude Questionnaire

Public Attitudes to Science

Q1 **Please write your name here**

____

Q2 **Please say whether you agree strongly, agree, neither agree nor disagree, disagree or disagree strongly with each of the following statements**

	Agree strongly	*Agree*	*Neither agree nor disagree*	*Disagree*	*Disagree strongly*
I am not interested in science and I don't see why I should be	❑	❑	❑	❑	❑
Because of science engineering and technology there will more opportunities for the next generation	❑	❑	❑	❑	❑
Britain needs to develop science and technology in order to enhance its international competitiveness	❑	❑	❑	❑	❑
Science and technology are making our lives healthier, easier and more comfortable	❑	❑	❑	❑	❑
In general scientists want to make life better for the average person	❑	❑	❑	❑	❑
It is important to know about science in my daily life	❑	❑	❑	❑	❑
The more I know about science the more worried I am	❑	❑	❑	❑	❑
It is important to look after the environment	❑	❑	❑	❑	❑
I cannot follow developments in science and technology because the speed of developments is too fast	❑	❑	❑	❑	❑
Science is getting out of control and there is nothing we can do to stop it	❑	❑	❑	❑	❑
The speed of development in science and technology means that it cannot be properly controlled by the Government	❑	❑	❑	❑	❑
Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the Government	❑	❑	❑	❑	❑
I would like to understand more about the origins of the universe	❑	❑	❑	❑	❑
Scientists should tell the public more about what they are doing and why	❑	❑	❑	❑	❑

Thank you very much for your help

Appendix 6. Shuffle Cards

Scientific topic cards	Spin out cards
Answering questions Einstein couldn't	**Medical applications**
Where is antimatter?	**Engineering advances**
What is dark matter?	**The Grid**
Why does matter have mass?	**Computers and the Internet**
The Big Bang	**UK involvement, in international science**
Origins of the universe	**Leading the USA in science**
How gravity works	**Opportunities for UK business**
Fundamental laws of nature	**Opportunities for UK scientists**
	Careers in science and engineering for young people

Appendix 7: Additional Information

Mass and matter

A large amount of the mass needed to make the Universe work the way it does is unaccounted for. Scientists don't know where the missing mass is, they call it dark matter. At the Big Bang scientists think that equal amounts of matter and antimatter should have been produced but all the universe we know of is made of matter. Scientists don't know what happened to the antimatter. Neither do they know why do some particles have mass and others don't. The experiments run on the LHC may give is the answers to these questions.

CERN

CERN is run by 20 European Member States. The current Member States are: Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

India, Israel, Japan, the Russian Federation, Turkey, UNESCO and the USA **have observer status** and Algeria, Argentina, Armenia, Australia, Azerbaijan, Belarus, Brazil, Canada, China, Croatia, Cyprus, Estonia, Georgia, Iceland, India, Iran, Ireland, Mexico, Morocco, Pakistan, Peru, Romania, Serbia, Slovenia, South Africa, South Korea, Taiwan and the Ukraine **are involved in projects based at CERN**.

How the LHC works

The LHC is a particle accelerator which accelerator beams of subatomic particles (protons are one sort of hadron) at very high speeds and collide them together. What results from the collisions will be analysed using four detectors. It is a huge machine that runs in a circle for 27 km (the length of the London Underground Circle Line) in a tunnel 100 metres under Geneva. The tunnel housed an old collider and has been reused to keep costs down.

Particles are fed into the LHC and, rather like pushing a child on a swing, every time they pass around the collider they are given an extra nudge to increase their speed until they are travelling almost at the speed of light. Two beams circulate in opposite directions and when they are going round the LHC 11 thousand times per second (the maximum speed), they are allowed to collide 'head on'.

To keep the beams travelling in a curve and in the right direction requires superconducting magnets cooled to a degree or so above absolute zero (-273°C). Inside the tubes that carry the particle beams is a vacuum that is better than the vacuum of outer space. Inside the LHC is probably the coldest and emptiest place in the Universe.

Four main experiments/detectors

ATLAS (A Toroidal LHC Apparatus) is a 'general' particle physics experiment that will explore the fundamental nature of matter and the basic forces that shape our universe. It will search for new discoveries in the head-on collisions of protons of extraordinarily high energy.

The ATLAS detector is the size of a five storey building and weighs 7,000 tonnes. Its innermost sensors contain nearly as many transistors as there are stars in the Milky Way (10,000M). It uses a different detector system to the CMS and will be used to 'check' the CMS results.

ATLAS is one of the largest collaborative efforts ever attempted in the physical sciences. There are 1800 physicists (including 400 students) participating from more than 150 universities and laboratories in 35 countries.

CMS (Compact Muon Solenoid) is a 'general' detector that uses a different detector system from Atlas. CMS and Atlas will 'check' one another's results. The CMS contains the biggest superconducting magnet ever built, smaller but heavier that Atlas. The detectors will have to collect and process quantities of data that are equivalent to the world's population conducting 20 telephone calls simultaneously.

ALICE (**A** **L**arge **I**on **C**ollider **E**xperiment) will study the collision of heavy nuclei (eg lead) in experiments that will look for the existence of quark-gluon plasma. The plasma is theoretically one of the earliest states of matter – existing only billionths of a second after the Big Bang.

ALICE involves an international collaboration of more than 1000 physicists, engineers and technicians from 30 countries.

LHCb (Large Hadron Collider Beauty) experiment aims to discover why we're not made of antimatter. In the Big Bang, the beginning of our Universe, matter and antimatter were created in equal amounts. But somehow the antimatter disappeared and our Universe formed from just the matter that remained. Physicists think a strange effect called "CP violation" plays an important part in the story.

Particles

Atoms are the building blocks of the world we are familiar with. Atoms (except hydrogen) are made up of protons, electrons and neutrons (hydrogen has no neutrons).

Protons have a positive electrical charge, every atomic nucleus contains one of more protons. The mass of the proton is 1,836 times the mass of the electron and slightly less than the mass of the neutron.

Neutrons have no electrical charge. They are found, along with protons, on the nuclei of many atoms.

Electrons have a negative electrical charge and are much smaller than protons or neutrons. They are not found in the nucleus but orbiting round it. Typically, atoms contain equal numbers of protons and electrons.

Protons and neutrons are no longer considered elementary particles as we now know that they are made up of smaller particles called **quarks**.

Neutrons and protons belong to a class of particles called **baryons** which are made up of three quarks. **Hadrons** are tiny particles composed of quarks (and which take part in the strong interaction) so a proton is also a hadron.

Appendix 8. Headlines

We asked participants to use what they now knew about the LHC to write headlines that they thought would capture other people's imaginations. The headlines could have a positive, neutral or negative slant, but the key was that they should attract attention.

Adults

- The new Big Bang is created, see how the world was made.
- Back to the Future for Jobs
- Big Bang in Swiss Alps
- Largest scientific experiment in history about to begin
- Huge Swiss Donut Hots up
- "Superman" Collides Head On
- History of the Universe Discovered
- Universal Big Bang Theory
- We know what is life, the universe and everything?
- Wanna know the meaning of life?
- Scientists re-create Big Bang
- The LHC? How many of us know what's going on around us?
- Our planets future is in the hands of UK Scientists Not USA
- Boffins Challenge "Big Bang" Theory
- 48 Million pounds on tunnel. Is it money well spent?
- Going to the ends of the earth to find our origins
- Why science has gone underground
- Hit or Miss Swiss
- 60 year, still no consensus
- Tunnel vision to the past
- Brits spend 48 million to discover where they came from.
- Is it worth spending 48 million on a tunnel?
- 48M seeking the beginning of life.
- Britain invests to discover the truth of the beginning
- Big Bang Investigated
- Biggest Scientific Experiment Brings Opportunities to Britain's Young Scientists and Business
- Where we came from
- How it all began
- Who are we?
- Where do we come from?
- Do we have the answers?
- Where it all started
- The Big Bang! Did it really happen?
- Biggest Crash in the world due this Monday!
- Who needs a Hadron Collider --- We Do!
- Who'll be at the Atom Bash this year?
- Experiments at the speed of light to prove the origins of the universe.
- CERN - Chases Anti Matter
- CERN – Biggest ever experiment.

- CERN – Trying to solve the Big Bang
- CERN – Questions Einstein couldn't answer
- Studying Small Matter
- Large Hybrid Hammer
- Speed of Light
- Trying to prove Theories
- What Really Happened in the Big Bang
- The Biggest Bang Ever
- CERN To Discover
- Big Bang Exposed
- Secrets of the Hadron Collider
- Big Collision in Europe
- Einstein's Missing Tool Kit
- 27 Miles of Tunnel –only two vehicles and they still crash!
- Big Bang Proved!
- Tunnel Disaster In Switzerland
- Mind Over Matter
- A Science Orgy – The Big Bang Revealed
- A "Tunnel vision" of the Future
- Life as we know it.
- Research Centre provides Jobs for the next generation.

Students

- The origins of the universe
- Einstein out done
- Opportunities for younger people to be involved
- Biggest experiment ever, is it important, will you pay?
- Does it matter to know about matter?
- Big Bang returns
- £48 million per year, where does it go?
- Why focus big except, big bang, money?
- Big Bang is a huge thing
- God doesn't exist
- For £1 you can recreate the universe.
- Einstein's unanswered questions - answered
- How it REALLY all began
- £48 million a year – do you know, does it matter?
- Big Bang returns
- Bangers and smash
- Origins of the universe explained