Response on behalf of the Royal Astronomical Society to the House of Lords Science and Technology Committee inquiry – Science teaching in schools

1. The Royal Astronomical Society (RAS) represents astronomers and geophysicists, some of whom are teachers, others support school activities. The RAS Education Committee is responding to this call for evidence, and our response will focus on the questions related to our specialist areas.

2. The RAS welcomes the higher profile of astronomy in the English national curriculum (and the new GCSE specification) as an excellent way of engaging young people in science. Scotland already bases much of its science teaching through the flagship topic of Space and the Scottish Space School engages with around 3000 pupils each year (aged between 5 and 18). Scotland also has an environmental science curriculum (KS2 and KS3) which touches on many topics in geophysics (such as volcanoes, earthquakes, continental drift, the earth's core, climate change). Astronomy, Space Science, Geophysics not only encourage young people to take up science because they find it exciting and mind-stretching, it sustains their interest over many years leading them to pursue a career in science and also motivates them to become teachers of science. It is forever new and challenging. Many young people have decided whether they are interested in science or not, before they reach secondary school, so that although the present concern may be to get more young people to study science at A-level, the problem must be tackled from Key Stage 2 (KS2) onwards with consistency, dedication and cash.

The current situation:

3. The RAS does not have figures on the retention levels of science teachers at KS3 and KS4, but anecdotally amongst Fellows we find that science teachers at this level do not feel valued (either in terms of salary or respect in the community). Many enterprises have support schemes (such as mentoring) for graduate recruits, there should be similar active programmes for young teachers; most authorities have these in place but we are not certain how effective they are. There is a big problem being a 'Science Teacher' in a secondary school for KS3 and KS4; people who have a PhD in physics or maths are good at physics and maths, but they can find it difficult to teach biology or chemistry since they have no knowledge of those subjects (and consequently may not be very good at it), and vice versa with biology and chemistry graduates. By analogy teachers of French are not expected to teach Dutch even though they are both 'European languages'. Science subjects should be taught by people specialising in that subject. Whereas teachers teaching inside their specialist area can often inspire young people into considering a career in science, when teachers are non-expert (or worse not interested) in the science subject they have to teach, it can completely turn-off the young person ("You are not teaching A-level X next year, are you Sir??")

Attracting science teachers:

4. Although many pupils may realise that a course in astronomy or even space science is possible at university, many pupils are not even aware the 'geophysics' exists as a discipline (and that training in physics is necessary), and so numbers for geophysics course at university are dropping (British Geophysical Association review of geophysics education in the UK). Significantly more places are being made available for scientists to undertake a PhD in astronomy, with no more funding provided for posts after that. Up to 50% of astronomers with a PhD can find a post-doc position for three years, but then it becomes increasingly difficult to stay in the astronomy-research field. This gives rise to a pool of potential science teachers, but the RAS sees no attempt being made to exploit this opportunity. The RAS organises 'career sessions' for young astronomers at the annual National Astronomy Meeting, and the young scientists do not regard teaching as a post-PhD career. In the RAS 'Careers in Astronomy' study, we make the point that astronomy graduates should be recruited to teach astronomy in school, as physicists are recruited to teach physics etc. There should be active recruitment campaigns at events like the National Astronomy Meeting, UK Solar Physics Meeting, British Geophysical Association meetings, etc, to encourage young scientists to become teachers.

5. Schemes such as the Undergraduate Ambassadors and Science and Engineering Ambassadors introduce people to schools and the modern curriculum, so that seeds can be planted that teaching can be an exciting and rewarding profession. Are any attempts made to encourage the seeds to grow, perhaps by extending the schemes to classroom assistant level and through mentoring schemes?

6. The RAS welcomes the higher profile of astronomy in the national curriculum, and would like to see greater availability of additional training for science teachers. Science Learning Centres do run a wide range of courses, including some which focus on astronomy/space and topics in geophysics, but there are problems for teachers wishing to take up the opportunity (see paragraph 12). In today's culture of suing for every problem, teachers need extra training and financial back-up particularly in the area of science where 'risky' activities such as experiments or visits are undertaken.

Teaching science:

7. Why do young people not consider a career in science? Astronomy is a science which many young people find exciting. Their enthusiasm should be exploited from primary school (KS2) onwards, so that by KS3 they have a long-standing interest not only in the astronomy but in the underlying physics and maths. Similarly with topics in geophysics (as reported in the British Geophysical Association review of geophysics education in the UK), meteorology, oceanography, the practical application of physics to modern issues such as planetary resources, climate change, weather, engage young people more than the traditional approaches to the subject. Most young people have no idea what a scientist actually does, apart from possibly doctors, vets, and more recently forensic scientists (from television dramas and documentaries). Visits by young people to places, and work experience opportunities in places, where science is done are essential – for them to see scientists in 'their natural habitats' doing their jobs. In the South East there are science-related places to visit, but some regions have few opportunities. If young people see teachers who are not enjoying the subject they teach, they will have no desire to go into teaching themselves.

8. It is very difficult to take young people out of school for a day, due to the intensive curriculum, the cost, the risk of accident, and the reluctance of venues to support visits (they have little free time, and money, to make the venue 'safe' and to provide speakers and demonstrators). Good venues do risk assessments before allowing schools to visit, and schools increasingly ask to see them. Post-SATS at KS3 is a popular time for visits, but these can be expensive since coaches must be hired. For an independent school this is not a problem, but it is a real barrier for some state schools. For A-level students it can be easier, since a minibus is the more usual type of transport needed. (It is often easier to take children from primary schools for a visit to a science venue, and these visits can have a profound, long-term impact.)

9. Since astronomy is frequently undertaken using computers at large telescopes, the Bradford Robotic Telescope (BRT) closely mimics the real experience of observing, whilst avoiding the need to provide and staff the laboratory/observatory. This is an excellent example of what can be achieved to raise the enthusiasm of young people for science. The BRT complements the Faulkes and Liverpool robotic telescopes, which are more suited to special astronomy projects in schools and local Astronomical Societies. Access to the BRT is via an extensive web-site, giving young people and their teachers a taste of the real world of experimentation. It is designed to meet learning outcomes in the English national curriculum for students from 10 to 16 years old (KS2, KS3 and KS4). Being web-based means there is no practical limit to the number of schools on-line at one time. For KS2, the wide-field applications are important, allowing young people to see the constellations (which may be new for them due to light pollution in cities), the Moon and the planets. As they progress to KS3 and KS4, the projects develop, leading the students onto the Faulkes and Liverpool telescopes for advanced projects. (See appendix A for more information on BRT). This approach of web-based practical learning could be extended to other areas; Drax power station and Shell Moss Moran gas plant are under consideration.

10. Another option to support teachers is to produce material jointly, with scientists and teachers working together. CCLRC produced a CD and supporting website ‘seeingscience’ with modules which addressed KS3 learning outcomes using astronomy and space science together with other science modules. This was funded by CCLRC itself with no outside funding. The project was produced with CCLRC scientists and LEA KS3 advisors, so that it was firmly curriculum based and was produced in a form ready for teachers to use. So far 11,000 copies of the CD have been mailed out to schools in the UK (and abroad) in response to requests from teachers (there has been no direct mail-shot), and ‘School Science Review’ said that the CD was ‘worth its weight in gold’. (See appendix B for more information) Members of CCLRC staff started to produce a companion CD for KS4, but the funding (£130K was needed) from CCLRC’s resources was cut.

11. The Science and Engineering Ambassador scheme is an example of good practice, where scientists are given training, CRB clearance and insurance cover so they can visit schools. Many young people are naturally very interested in astronomy, space science and geophysics topics, which is a challenge for the teachers who are hard-pressed to keep up with the core curriculum needs. The RAS maintains a list of astronomers who will visit schools (through the Association of Astronomy Education), and other groups such as the Institute of Physics also maintain lists. Support of this work, and funding, would enable the people on the list to participate more often and enable the parent organisations to keep the lists up to date. The teachers contacting lists like this are often the teachers with no contacts or support of their own but with enough enthusiasm, or desperation, to search out resources.

12. Professional support for teachers is available, but who will pay? The RAS Education Committee investigated the possibility of training teachers to use robotic telescopes (the Faulkes telescope was used as an example), and the cost of taking 100 teachers out of school for one day (in four venues) and providing professional astronomer support (on an expenses-only basis) was prohibitive. The BRT has put resources into using the telescope in the Initial Teacher Training programmes and extensively uses the web to train the teachers, thus avoiding this problem. Most teachers are allowed only a few days a year for CPD, so this time tends to be used for the essential skills such as assessment, new GCSE topics and teaching-related courses. The school naturally asks what benefit is received by it, and for a science teacher to take a science-based course which is used for a few lessons, this is not cost effective. When a science teacher is away for the day, the school will have to pay up to £160 for a supply teacher, assuming there is a supply teacher available to teach science. If teachers want to extend their knowledge, especially by taking courses in geophysics or space science topics, this would be an even more serious problem, both for the school and for the teacher finding an appropriate course (at a suitable time). The BNSC partnership report ‘Bringing space into school science’ suggested that bursaries would be needed.

Produced by:
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Astronomy Secretary
On behalf of the Royal Astronomical Society
For 19 June 2006

Documents used in this response:

‘The PhD and Careers in Astronomy in the UK’: A report from the Royal Astronomical Society (available on-line at http://www.ras.org.uk/images/stories/ras_pdfs/careers%20in%20astronomy.pdf)

‘Geophysics Education in the UK’: A Review by The British Geophysical Association (draft)

‘Bringing Space into School Science’: A report commissioned by the British National Space Centre partnership (available on-line at: http://www.pparc.ac.uk/ed/barstow.pdf)

Appendix A
Contribution to the RAS response to:
The House of Lords Science and Technology Committee:
Looking at Science Teaching in Schools: May/June 2006
John Baruch – University of Bradford.

Summary:

1. The UK Robotic Telescopes can play a unique role in inspiring young people and their teachers with science.
2. The UK robotic telescopes provide access to a range of practical science experiences providing an effective alternative to no laboratory experience in their National Curriculum studies.
3. The Bradford Robotic telescope (BRT) has shown that it can support primary school teachers and deliver inspirational practical science to all school students at Key Stage 2, continuing through the science turn-off years to KS4.
4. The Faulkes and Liverpool telescopes can inspire a significant fraction of the school student secondary science cohort especially in the sixth form reinforcing their interests in the STEM areas.

Background

The UK has benefited from a unique programme of robotic telescope development for education. There have been three major developments: The Liverpool Telescope, the Faulkes Telescopes and the Bradford Robotic Telescope within a world scene of around 200 robotic telescopes. The Faulkes and Liverpool telescopes are research instruments with an educational slant. They have a field on the sky of about one sixth the diameter of the Moon or five arc minutes, typical of a research instrument. The Bradford telescope is designed to support basic astronomy education especially the practical aspects and includes a research slant. It has five cameras recording aspects of the night sky, including broad panoramas of the constellations, deep sky cameras for galaxies, and night time web cameras to follow the stars setting over Mount Teide and rotating around the pole star.

These robotic telescopes are inspirational in the classroom. One explanation of the electricity that they create for learners is that it takes the students into the world outside the classroom where they can request their own data from real world facilities to support their own learning programmes. When the data is delivered to them they process it themselves to extract their learning. This process more closely reflects their developing understanding of the world, with extensive input from the Internet and television supplementing the views of teachers and parents.

A New form of Laboratory Experience

The Faulkes and Liverpool telescopes allow the students to actually drive the telescope in half hour slots. The students plan their observing and execute it to obtain the data which they then process. In this way it provides superb practical experience but with only about two half hour slots per lesson the practical experience is limited to a very small number of students. The Bradford Robotic Telescope operates in a service mode and observations are requested by the students. In the normal course of events the data will be returned to the student for the next lesson. Each student will then have their own data for processing and to develop their learning. The telescope can support every student in the class doing this and in 1000 classes besides. The secret is that most students' knowledge of the sky is limited to 25 or so objects which the telescope can process in half an hour. This is the benefit of delivering the basic levels of understanding. The simplest of research programmes may consider thousands of objects to observe and so the number of students using the system will be severely constrained.

Using robotic telescopes is inspirational in the classroom. This appears to be because the students are being serviced by a real robot operating in the outside world that also services other students and real astronomers in their research.

All three telescope systems can be used by a whole class either to drive the telescope or to submit an observing request.

There are indications that the Bradford Robotic Telescope experience can be expanded to cover major sections of the science part of the National Curriculum with developments being initiated with a number of partners to give school students real time web access to the systems at Drax power station and the Shell Moss Moran gas plant

Three UK Robotic Systems?

Whilst Faulkes and Liverpool systems focus on the telescope, the Bradford system focuses on the teachers' concern for delivering the national curriculum and provides in-depth support for the teacher. The Bradford system is essentially an extensive web site focussed on the National Curriculum for England and Wales which is supported by the robotic telescope providing a practical avenue to support learning and understanding.

The Faulkes telescope provides slots for classes to control the telescope and so is limited to a tiny fraction of the UK students, the Liverpool telescope is essentially a research telescope which devotes 5% of its time to education, The Bradford system can support all the children in the UK. The way in which all three systems associate research with education is inspirational in the classroom.

All robotic telescopes in the world apart from the Bradford and Liverpool systems are designed to be driven remotely. This means that the user has a half hour slot which is easily wasted if the user is not an experienced driver or the weather is adverse. Even with the best conditions remotely driven telescopes can only support around 1000 users per year. The Bradford and Liverpool telescopes are completely autonomous robots which work much quicker, can merge identical requests with single observations and schedule observing at the optimum time.

Only the Bradford system is dedicated to providing understanding at the most basic levels. Experience over years of development has shown them that they can support the education of all school children in the UK. The Liverpool telescope goes beyond the basics and so the number of different objects that are requested grows with the number of users. This provides a clear cap on the number of users which again is less than a 1000 per year.

Together these telescopes can inspire all UK School students with the STEM subjects. At the basic levels the Bradford Robotic Telescope can deliver practical observations to all school students in the UK. The Faulkes and Liverpool telescopes can maintain that inspiration into A level and specialist astronomy groups in years 12 and 13.

Telescope Funding

The Faulkes telescopes are funded by an American philanthropist as a global service to school children. As such their funding appears secure. The Liverpool telescope is part of the suite of telescopes available to UK astronomers with support from a Canadian philanthropist and 40% of the costs supported by PPARC. The Bradford telescope was initiated as a pilot programme and it is nearing the end of its development. The plan was to switch off the BRT in the summer 2006. The group has been lobbied extensively with the case that to switch it off and disperse the team would be a serious loss to UK education which leads the world in this area. A programme to generate a sustainable funding model and immediate funds was launched in autumn 2005. Funds are required to provide a robust system responsive to the demands of a million or more UK users and to pump prime sustainable operations.

Facts on BRT

The Bradford Robotic Telescope now has around 7,000 users, more than 500 of these are teachers who have logged in over 2,500 of their students to work in class groups. Quite a number of the teachers are still experimenting with the system and have yet to log in a class group.

The system is effectively a large web site devoted to the teaching of the astronomy sections of the National Curriculum from ages 10 to 16 which is supported by a robotic telescope. We can confirm that much of science is taught by teachers who are working outside their areas of expertise; typically in secondary education biologists teaching astronomy. In primary education the situation is much worse with many of the teachers having no science at all.

John Baruch
31/5/2006

Appendix B
Contribution to the RAS response to the House of Lords Science and Technology Committee: Science teaching in schools

Summary by Dr Helen Walker
CCLRC Rutherford Appleton Laboratory
16 June 2006

<u>seeingscience CD and web site</u>

Web address: http://www.seeingscience.cclrc.ac.uk/

seeingscience is a unique set of interactive science resources for KS3, produced by scientists at CCLRC and LEA KS3 Advisors. The material covers several topics, focussing on the work of the Synchrotron group and Space Science group. The material is free and the CD will be supplied on request. 'School Science Review' said that the CD was 'worth its weight in gold'.

SPACE – This covers the QCA KS3 unit of work 7L 'The Solar system and Beyond', through an 'ideas and evidence' approach. All lessons include lesson objectives (WALT) and differentiated outcomes (WILF). Suggested starter and plenary activities are included in addition to the main lesson activities.
Our Solar System – covers the Sun, Moon, planets, the orbits of the Earth and the Moon and other planets. A time lapse video of 24-hours at CCLRC Rutherford Appleton Laboratory illustrates day and night, and leads to a discussion about the seasons. Pupils discover what a model can demonstrate and what are the limitations.
Because I said so! – is about history of astronomy and the people who are responsible for our views of astronomy today, using documentary 'evidence' from five different types of source; primary sources (postcard and diary) and secondary sources (books, newspapers and the internet). Present day astronomers at CCLRC Rutherford Appleton Laboratory explain what they do and what they hope to find in space.
Mission to Pluto – starts with the criteria used to classify an object as a planet, and whether Pluto meets them. Pupils interactively design their own mission to Pluto within a payload constraint, and explain what evidence their selected instruments would gather.

BRIGHT LIGHT – This section looks at how particles are accelerated in a particle accelerator known as a synchrotron to produce the extremely bright light (X-rays and ultra violet) which is used to determine the structure of many different materials. The synchrotron is a very versatile scientific tool, and it spans many sciences including biology, chemistry, materials, physics, medicine, environment and archeometry.
Life – can anthrax lead to a cure for cancer? Early results from the synchrotron suggest it might. Pupils explore how scientists work to control the outbreak of a disease, and there is a game Outbreak to play.
Food – powerful X-rays from the synchrotron are being used to discover what happens at the atomic level when chocolate is made and what changes take place as chocolate cools. The discoveries are used to 'iron out' production line problems. Microbes in food fluoresce under ultra violet light from the synchrotron. Microbe growth is being studied with the aim of producing safer food. Pupils emulate the work of scientists in these two areas.
Materials – how do you decide if the materials you wish to use are suitable for the job, e.g. the Thames Barrier, the Coliseum? Scientists looked at how different additives could affect the setting properties of cement and the deep penetrating X-rays produced by the synchrotron can reveal the chemical changes taking place. Pupils will make cement samples with different additives and test their strengths.
Environment – using the synchrotron two problems are examined; how to clean up heavily polluted sites and atmospheric pollution caused by sulphur dioxide. The latter gives an opportunity for cross-curriculum links with ICT.