House of Commons

Science and Technology Committee

Practical experiments in school science lessons and science field trips

Ninth Report of Session 2010–12

Volume II

Oral and written evidence

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The Science and Technology Committee

The Science and Technology Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Government Office for Science and associated public bodies.

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Oral evidence

Taken before the Science and Technology Committee

on Wednesday 15 June 2011

Members present:

Andrew Miller (Chair)

Gavin Barwell
Stephen McPartland
Stephen Metcalfe
David Morris
Stephen Mosley
Pamela Nash
Graham Stringer

Examination of Witnesses

Witnesses: **Kevin Courtney**, Deputy General Secretary, National Union of Teachers, **Greg Jones**, Practising Science Teacher affiliated with the National Union of Teachers, **Professor Chris King**, Earth Science Teachers' Association, **Dr Stuart Hitch**, Practising Earth Science Teacher affiliated with the Earth Science Teachers' Association, and **Darren Northcott**, National Official, Education, NASUWT, gave evidence.

Q1 Chair: Good morning, gentlemen. Thank you for coming in. It would help us for the record if each of you introduced yourselves in a moment. As we have a very large panel, if we do not have time to take responses in detail from each of you on every question, please feel free to write in subsequently with any additional thoughts you may have. As you know, the inquiry is not just about today's session. We are looking into the matter much more deeply. We have had some fascinating responses on The Student Room, which we are also analysing. Perhaps you would be kind enough to introduce yourselves.
Kevin Courtney: I am Kevin Courtney. I am the Deputy General Secretary of the National Union of Teachers and I am very pleased to be here. Thanks for the invitation.
Dr Hitch: I am Stuart Hitch. I teach geography and geology at King Edward VI Grammar School in Chelmsford. I am with Chris King from ESTA.
Greg Jones: I am Greg Jones. I am an NUT member, a science teacher and also a health and safety adviser for the NUT in the Leicestershire area.
Professor King: I am Chris King. I am representing the Earth Science Teachers' Association here, but I am at Keele University and I train science and geology teachers.
Darren Northcott: I am Darren Northcott. I am a national official for education at the NASUWT.

Q2 Chair: Thank you very much. Given the tremendous experience that the five of you represent, perhaps you could each briefly give us your interpretation of why the UK is doing relatively worse in science compared with other countries. Secondly, was school science better when you started your careers? I am thinking back to the excitement that used to occur in the laboratories and in the field when I was at school. It just seems to me that the edge has been dulled now.
Kevin Courtney: I think I would agree with that. I started teaching in 1983 as a physics and lower-school science teacher. The degree of excitement in lessons was then, I think, sometimes quite palpable. The central question that needs to be addressed is the focus on examination results and league table position that is an understandable desire of all parties in Government. It is the product of the education system. You want to see the best possible results, but there are unintended consequences of that focus, we think. The question is, "What is the easiest way to get a child to a particular grade in a particular exam?" Certainly, if your school is in a challenging position in the league table, then that is where you have to focus. We would like to see children enjoying science and being enthused by it, but sometimes that can take longer than preparing a child to answer an examination question in science. Fundamentally, we think that is where the problem is. You said you have a lot of people on the panel. I would like to talk about some other areas and some other unintended consequences. Should I carry on?
Chair: No, just hold it there.
Kevin Courtney: Sure.

Q3 Chair: Anybody else?
Darren Northcott: On your point about the performance of our system relative to others, I think you are referring there to the OECD's PISA survey in which there was quite a lot of media interest. It is important to get that into perspective. The results in our system were broadly in line with the rest of the OECD, to be fair. Clearly, there were some countries that performed slightly better than the UK in that survey, but it is important to say that the performance in this country is in line with the typical OECD average. That is an important point to bear in mind. Clearly, everyone wants science to be even better, but I think we need to avoid what might perhaps be described as "a moral panic" about our performance relative to other countries. That is an important point that I would want to stress.
Professor King: I will not do this very much, but can I bang the drum for earth science here? If you look at Taiwan, Korea and Japan, which are the higher-performing countries in PISA, they all have a quarter of their science curriculum as earth science. That means that they train earth science teachers. They have a substantial amount of the curriculum in earth

science, and that is not something we see in this country. That is one aspect of an answer to that question, although I would certainly support what Darren said. We are not terribly far away.

Chair: Coming from a geology background myself, I approve of that.

Greg Jones: I would like to say thank you very much for inviting me to this meeting today. I would like to reiterate what Kevin said about the decline in the amount of practical work and field trip work that has happened over the years. I have been a teacher for over 30 years and certainly the freedom that teachers had in the curriculum in the late 1970s and early 1980s has obviously been whittled away over a period of time. We have got to the point now where the constraints of the curriculum are such that the amount of practical work that is being done is very small indeed. We are getting to the point now where actually it is so much easier for students to say to staff, "Just tell us the answer", rather than go through the evidence themselves, do the experiments and get the results, even though they might not be very good results. Doing the work for themselves makes them good scientists.

That is the issue. We have got away from producing some very good scientists over the years in large numbers. The numbers have dropped significantly over a period of time. There are, therefore, as a result, fewer science teachers being produced. I know from talking to Chris about the problems in recruiting teachers into teacher training courses at universities, or equally doing GTP courses, that the numbers are smaller. Why? It is because science teachers themselves come from a smaller cohort. The question might be, "Why are we not producing enough scientists?" That is our whole idea; we are going to be looking at those issues.

My concern would be that nowadays we have too much in our National Curriculum. Science gets squeezed and has continually been squeezed over a period of time. Trying to get three science subjects now into the curriculum where previously we did have time means that we have now reduced it down to a double science programme. Therefore, it is three into two and that means something has to go. The amount of coursework that is being done has reduced significantly. In fact, one could argue that very little coursework is done at GCSE level now, although more so at A-level.

There is a concern about field trips. The number of field trips that take place is a lot smaller than it used to be. There are fewer field centres which are actually open and able to put on those facilities. I do not think it is the fact that teachers do not want to do them but there are the constraints, and, equally, the constraints that are felt by management of schools to allow students to go away from their other subject areas for a period of time is a bigger issue.

Professor King: This is something, again, we were talking about outside. We know that schools are very good now at getting children to pass exams. The results are clear nationally. They are not terribly good at producing inspired scientists and pupils who want to go on to do science in the future. That is a different question, and that, I think, is probably the main focus of what we are talking about here. It is how we inspire young people into science through practical work and through fieldwork.

Darren Northcott: I think Greg makes some very important and real points about the experience of science in the secondary sector, and I think that is right. My experience is as a primary and early years teacher and I think that is an important part of your consideration as well. One story you can tell regarding the early years and the primary sector is that there is a lot more science going on than was certainly the case when I went to school. Much of that was driven by the introduction of the National Curriculum. The primary sector took science much more seriously. I think there was quite a positive increase in the amount of science that took place in the primary sector. It is a general mixed story in that respect. There has certainly been an improvement over the years in the primary sector.

Q4 Chair: My experience in terms of the early years is that that is true where you have a science-qualified teacher. Is that right?

Darren Northcott: That is an interesting point. Perhaps you could explore that. I am certainly not a science-qualified teacher, but I taught a lot of science in the primary sector that I thought was very engaging.

Q5 Chair: Somebody opened the door for you here. What do you say, Dr Hitch?

Dr Hitch: I would like to go back to the initial gist of the question, which was, "Has the edge been taken off it?" Where the specifications allow fieldwork and actually require it, looking at geology particularly, there is a requirement at AS and A-level within one of the boards that fieldwork is carried out. So, no, I do not think the edge has been taken off it at all. However, I would totally agree with Greg that there is an amazing amount of pressure being put on schools because of curriculum congestion, particularly in relation to students being allowed out of school due to controlled assessment, which is taking place all the way through from Year 8 to Year 11. The pressures upon the students are immense. The pressure on timings as to when you can take the field trips is being placed on teachers as well. I think there are big issues in the future on this.

Kevin Courtney: I agree with that. I want to come back on the primary point that you, Chair, and Darren were talking about. You and Darren are absolutely right to say that there is some really good science that goes on in primary schools. My wife is a social studies graduate. She is a teacher rated as "Outstanding" by Ofsted every time they see her. She does a lot of science without being science-qualified. I think that is partly my influence. I am a scientist and we talk about these things at home. I am sorry; that is far too arrogant. There is a need to have training for primary teachers who are not science-qualified in making sure that experiment and experience is an important part of the primary curriculum and it is there in the early years. It is an example. As you get towards Year 6 and the SATs, though, that does get squeezed enormously. It does not happen in Year 6 at all

because of the preparation for the tests. I do not want to just harp on about that point, but it is very real. How you find a way to cope with that is something that really matters, I think.

Q6 Stephen Metcalfe: As I am sure you are aware, safety has featured quite heavily and it is key to our inquiry. Do you find that the health and safety guidelines which are issued are a facilitator or do they deter people from getting involved in practical field trips?

Greg Jones: Field trips are one thing. There are obviously risk assessments that need to be done in any scientific set-up, whether it is a field trip or an experiment. The question is whether people are reinventing the wheel; other people have already been doing these experiments for a period of time. In most cases, certainly within secondary school science schemes of work, there would be risk assessments done and therefore teachers could carry on and follow those without any problem at all.

I think the issue is about wanting to do experiments that are not necessarily part of the requirements, as Stuart was saying. That comes down to teacher confidence to think outside the box and to do experiments. Yes, there are requirements to do risk assessments and to understand the health and safety implications, but scientists are pretty good at doing this anyway. That is our science training. We are very good at understanding the risks even though we might not formally write them down. I think the issue has been blown up, as it were. I am sorry about the pun on that.

Q7 Stephen Metcalfe: I am sorry to interrupt, but when you say that you might not necessarily write them down I accept exactly what you are saying. However, do you think that that culture has changed now that you are required much more to write them down and therefore there is a much greater need to spend more time keeping records, thereby explaining what you might do, than doing the work itself?

Greg Jones: I do not think so. That was the case several years ago when a lot of the health and safety requirements came in, certainly from local authorities requiring you to conduct experiments according to the policies that the local authority might have. But we have been down that road long enough now and those kinds of things become automatic. I do not think it is stopping people from doing the experiments. It is the time factor of doing it and, equally, the financial implications of it. Getting the right kind of experiments into a syllabus requires, in some cases, very sophisticated equipment. The requirement to fund that in large upper schools is something that has to be taken into account in terms of the budget and the implications of that. I do not think that risk assessments and health and safety issues stop scientific experiments or field trips happening. In certain situations, in a particular individual's case, they may be thinking with a lack of confidence, but I do not think it prevents it entirely.

Professor King: I think that is true for experiments, but I am not sure it is so true for fieldwork. There is an awful lot of health and safety paperwork that you need to go through. The reason for that—and I have been doing this for some years—is that whenever there has been an incident there has been more paperwork. What I have been arguing for a long time—and I will continue to argue today—is that there is another way of doing this. If we trained people to deal with fieldwork situations in a healthy and safe way, and also, as part of that training, highlighted the value of fieldwork and how you can do it most effectively so that it would be a very cost-effective way of dealing with the issue, then we would be in a much better place today. I do not know if you know this, but there is no qualification and no accredited course in fieldwork in the country. If you want to do something accredited, there is something called a mountain leadership certificate, but that is much harder and much more difficult and complex than is needed. We need a simple accredited course that is supported by all our groups of people here. It would not cost a lot of money, and teachers across the board—scientists, geographers and historians—could all do these things. It would enable them to do fieldwork more effectively rather than having the paperwork, which is more likely to have the opposite effect.

Darren Northcott: On field trips, there has been some quite positive work in the recent past. I am thinking about the Learning Outside the Classroom Manifesto that was taken forward by the previous Administration. Part of that was a quality badge scheme so that providers of external learning opportunities, field trips and so on could be accredited to make sure that they were safe. They could make sure that children and young people were being given effective learning opportunities. When schools and colleges were thinking about field trip opportunities and learning outside the classroom, that quality badge scheme meant that the staff in those schools could be reassured that the best possible health and safety standards were being adhered to. That took the burden off the schools in terms of paperwork and these things that we have talked about. The feedback from our members has been that that has been extremely positive. If more work could be done to extend that scheme and give schools the reassurance that, "This place is going to be safe and it will give your pupils a really valuable learning experience", that would certainly be a positive step.

Q8 Stephen Metcalfe: Following on from that, do you feel that when you conduct a risk assessment, however burdensome it is, whether it is relatively straightforward or quite complex, it is to protect the students, or do you feel that it is more to protect the staff, the school and the institution in case something goes wrong? Greg Jones was saying that, instinctively, as a teacher, you know how to protect the students, but what you may need to do is to protect yourself in case something goes wrong. Is that your experience or am I wrong?

Professor King: There is certainly an element of that there, in that, whenever there is an incident, there is more paperwork. The logical way of dealing with that, to me, is to train teachers more effectively. To come back to the Outdoor Manifesto, it was supposed to

have two main strands. One was the badging strand, and that has been very effective. The other thing was supposed to be supporting teachers to do fieldwork more effectively. What happened there was, that a lot of money went to consultants, some things were put on the website and nothing happened beyond that. So that strand never took off in the same way that the other one did. I think that is what we need to focus on now.

Greg Jones: When you are talking about risk assessments, I do not think the idea of risk assessment is to identify whether it is for students or staff. It is actually for the conduct of that experiment, irrespective of who happens to be near, doing whatever. It is the issue about what you are trying to achieve and how you minimise the risks in achieving it. Those are the things that you have to consider. It is not a "watch your back" kind of idea. It is not about that. It is about making sure that you have documented exactly what needs to happen. It is for the support of everybody, whether it is technicians or students, whether they are observing or taking part, or whether it is staff or somebody visiting the classroom.

Q9 Stephen Metcalfe: Do you feel you get enough guidance on how complex the risk assessment should be, because I think the NUT says that there is a shortfall in the Health and Safety Executive's guidance which can lead to over-complex assessments?

Kevin Courtney: We think that is right, but the way of dealing with it is the way that both Professor King and Greg have talked about in both the areas of outdoor learning and practicals in school. It is training for teachers. It is not getting rid of the health and safety requirements because they are there to protect all participants and people do have to reflect on the risks of an experiment. You have to be responsible about it.

The question of whether young teachers coming through teacher training institutions at the moment to teach science in secondary schools are sufficiently prepared for experimental work is something that we think should be looked at. That obviously then includes looking at how you do the risk assessment in a controlled way that is not burdensome but is meeting the proper requirements. The NUT would also like to agree with Professor King about the need to have a particular accredited course on field studies. I think this fits with other evidence. By and large we agree with the recommendations in the evidence you have received from the Countryside Alliance Foundation. They talk about making it part of the standards of teachers. I do not think we would do it in that way, but having the training there is really important.

Greg Jones: Could I reply to your idea about risk assessment being more burdensome and filling in large forms, et cetera? Earlier, I did raise the idea that people are reinventing the wheel and some of these wheels are very complex when they probably do not need to be. To simplify things would be useful. The trouble is that, if you simplify it too much, you end up not doing the job that was intended. That is where bodies like the ASE would be crucial in looking at the kind of risk assessments that are done. CLEAPSS does risk assessments, and there are lots of other consultants who set themselves up to be able to do risk assessments for different experiments. The exam boards equally have knowledge of those kinds of things. To be honest, there is too much out there and teachers in schools often have to make decisions about, "Do I have that one or that one, or that one or that one? Which is the one that I need to do?"

Q10 Chair: Does that make them risk-averse?

Greg Jones: No, I think it confuses the situation because they will say, "Does that one look better than that?" It should simplify things, but equally there should be a base level.

Q11 Chair: Could I push that a bit further? Particularly in terms of laboratory experiments, does it result in a greater number of teachers demonstrating a process rather than encouraging students to participate in the experiment themselves, which, from the earlier questions, we agreed is probably the best way of exciting children?

Greg Jones: The reason why demonstrations have increased is not because there is more danger, therefore the risks are greater and so you let the teachers do it rather than the kids. The issue is one of time. If you do not have time in the curriculum, then you demonstrate it. Hopefully, you will get the results that you need in order to show the evidence to support the hypothesis that you had and the bit of theory that goes with it. However, you are taking the fun out of science for the students. The teachers have fun teaching science because they are the specialists and they are the ones who should be enthusing. We have to keep that enthusiasm. A lot of students say that science is no longer the fun it was and they had more fun in high school—in Leicestershire, we have an 11 to 14 system—because there is not the exam constraint. I think that is the issue. It is constraining by exams that has done it. If you could free up the curriculum a bit more and allow that time to be spent on practicals and not exams to the same extent, you would help the situation.

Q12 Stephen Metcalfe: Dr Hitch, did you wish to come in?

Dr Hitch: I was going to go back to what you were initially asking about the risk assessment deterring field trips. I would say that, no, it does not. There is an awful lot that goes into a risk assessment, and, when one starts to assess all the different elements of it, it does take a considerable amount of time. But, no, in my experience, I have not been deterred from going on field trips because of the risk assessment of health and safety.

Q13 Stephen Metcalfe: Do you know of anybody who has been? You may feel more confident perhaps than others.

Dr Hitch: I will come back to that in a minute, if I can, because that is something on which both Chris and I would agree in terms of geology teaching. Confidence in the field is really important. The scientists are confident in the lab. We are more confident, I would suspect, in the field. During my

degree, I think I did something like 82 to 85 days of fieldwork; so my experience in the field is pretty solid. In terms of others being deterred, I cannot think of anyone who has said, "No, I am not doing it because of health and safety."

Professor King: But new teachers in training might be inspired by doing fieldwork—if they have a good teacher training course they will be—but they then see what has to happen after that and how all these things should be done. That can be a disincentive, yes.

Q14 Stephen Metcalfe: I have two very quick questions and I would ask you all to be brief, otherwise we will be here all day. First, have any of you ever been involved in an incident where safety or a lapse in safety was a factor? Secondly, just for absolute clarity, Greg Jones, you said that time is more of a constraint than the perceived bureaucracy around health and safety. Is any part of that time factor because of changes in legislation and regulation requiring you to do more before you can do practical work? Then I will call it a day.

Kevin Courtney: I have been involved in questions of lapse of safety as a union rep, representing a science teacher. The experiment was to put some sodium in a bowl of water. I do not know whether you know what happens, but the sodium runs around and sometimes, at the end, there is a little bit of a pop when it jumps out. The safe way to do it, if you do it as a demonstration, is to put the children on the other side of a plexiglass screen so that they are safe. In the incident in question, a drop of sodium managed to come over the screen and burn a child on the face. It was a very minor thing. There was a question also of whether the children should have been wearing safety glasses. There was CLEAPPS evidence that you did not have to do that, but there was some parental concern about it and the head teacher looked into whether the teacher got it right or not. There are questions, but, in that case, we were able to point to what the guidance was. You cannot eliminate every risk and the matter was settled satisfactorily.

Stephen Metcalfe: Have we kidded ourselves that we can eliminate every risk? Is that why we are now talking about the safety glasses or goggles? Perhaps 30 years ago, we would have all stood round a tray and watched it whizz around a bit.

Chair: That would have been very dangerous because it always does pop out.

Q15 Stephen Metcalfe: Yes, but funnily enough, that was the exact experiment we talked about when we were deciding on this inquiry. That was the one thing we remembered doing ourselves at school.

Greg Jones: It is because kids enjoy that and it is fun for them to do it but, equally, they have to understand the risks. Taking your point about experiments, I was involved in an incident which had nothing to do with an experiment but a student decided to put a pair of scissors into an electrical socket. There is no risk assessment for that. Okay, accidents do happen, and obviously we minimise the risks. You hope you educate students not to do that kind of thing and the reasons why. Are there some things that you no longer do? We know that there are carcinogens that we will not use any more because of that issue. As time has passed, there have been developments, but it does not stop people doing things just because you have a few more hurdles to go through because of the benefits in the end. Everybody remembers sodium, and potassium is even more exciting. They know that because it produces an even more interesting effect.

Professor King: Fieldwork is inherently risky, but the most risky thing you can do in fieldwork is to drive there and the most risky thing you can do outside is orienteering. Fieldwork itself, if you look at the statistics, is very safe. Accidents happen because it is an inherently risky environment. I had somebody who had a badly sprained ankle on one occasion, but we dealt with it. He was taken down the hill by other people and that is what you do in those circumstances. These things are going to happen, but this is part of being out in the field.

Darren Northcott: You cannot eliminate risk. I think you are right. From our experience as a union representing members, you get incidents that happen, but, with the best will in the world, they are going to happen. You do sometimes represent members who have been put in circumstances where there has been an issue, particularly with a student, and I have to say that that issue has resulted from the lack of a risk assessment being undertaken. We go back and look over the case and think, "If a risk assessment had been undertaken, this field trip or this experiment may have been done perfectly satisfactorily in terms of it being a quality learning experience, but this issue would not have happened." Again, I think that underlines the importance of risk assessment and the fact that teachers and other staff in schools need support in order to be able to undertake proportionate but effective risk assessments.

Dr Hitch: I would say, no, I have not been involved in an incident in relation to health and safety. However, I would say, as a practising teacher, that my expectation is that I do cover every risk, and, as a result of that, it does put a lot of pressure on me. When one is in the field with a group of students, the pressure is there. You have students with special needs, maybe, or special dietary requirements, if it is a residential field trip, or they may require medication. All of that is going around in your head while you are still teaching whatever it is that you are teaching. Yes, we put the risk assessment in place.[1] We try to cover absolutely everything, but, in doing that, it does increase the pressure when you are delivering the subject.

Chair: We are going to have to move on quickly.

Q16 David Morris: Thank you, Chair. It was said before that field trips are getting smaller. To what extent do you think it is important to teach science on field trips and what do you think the relative merits of fieldwork are?

Professor King: As far as earth science is concerned, earth scientists know that you can only study the earth by going and having a look at it. That is almost a given. We were asked why we thought that earth

[1] Note by witness: When completing a risk assessment it is felt that there is an expectation from others that we cover absolutely every possibility and this does add to the pressure felt when taking groups into the field."

scientists were more effective in doing fieldwork in school systems than other scientists and I think that is the answer. It is because it is part of your training. You do a lot of it in your degree. You know how to do it and you also know the value of it in all sorts of ways.

Moving on beyond that, in other areas of science, on our teaching training course at Keele we try to inspire the biologists, the chemists and the physicists also to understand what the value of outdoor science is and to conduct fieldwork in their areas of science. This is very successful, but we are relatively unique. That does not happen on many teacher training courses and there is quite a lot of evidence indicating that. Again, there is a training issue here. I know I keep banging on about training, but if you do not equip people with knowing how to do it well, to understand the reasons for doing it and the ways of doing it safely, we cannot expect fieldwork to flourish in this country in the way that it could do and in the way that it could inspire young people.

Darren Northcott: Can I just add to Professor King's point there? Initial teacher training is obviously very important, but there is also continuing professional development that is important as well. It does not stop as soon as you get qualified teacher status and start working in a school. You need to have structures there that enable teachers to update and expand their skills in the use of fieldwork in teaching and learning. That is critically important as well, and that is often underemphasised in our system. The experience of many teachers in respect of CPD is rather uninspiring to date. That is an area that we need to think about as well.

Q17 David Morris: In your experience, how often do science field trips involve overnight stays, and do you consider that longer and more immersive field trips would be better than day trips, for example, trips to museums and science learning centres?

Greg Jones: Biology field trips are specifically the ones which are more directly related to what Professor King was talking about in terms of geology. There are less residential experiences for chemists and physicists. Not many nuclear power stations allow you to stay overnight. The issues about how you bring it back into the classroom and the links that you make with what you are doing in terms of the content of the course is the crucial bit. For biologists, it is very important. It is not written into a syllabus that you must go on a field trip to get this particular module of work done. It is ideal. Those are the kinds of things that could be done. The issue then would be how every school in the country, if they are all doing this, fits in the fieldwork. There are particular crucial times of the year. For example, July is a month when A2s have not started but ASs have finished. That is a clear slot in the year, but if everybody tried to use that period you would have a great problem trying to get them out on field trips at that particular time. It is freeing up the time, as I said before, to allow it to occur at different times and for different lengths of time.

It is not necessarily about the content in which you are interested. It is about working in teams. It is the soft outcomes that people get as scientists working with others, living and breathing that science for a period of time rather than a lesson-by-lesson situation in a school. It is a different experience and that is what is important. If they are going to become scientists for the future, they need to live and breathe it every day.

Chemists and physicists find that issue harder because there are not necessarily the residential experiences for them, but there are certainly day visits. The Science Museum is a regular visit, but, equally, you can involve local industry. They can go in and see those processes work for themselves and then apply them when they come back to the classroom situation. They will have a better understanding. It is, after all, consolidating learning and that is how you get the best results

Kevin Courtney: There is a continuum between just being outside the classroom and a longer residential trip. Greg and Chris are absolutely right. There are fewer opportunities for physics and chemistry teachers. There are the TDA adverts on becoming a teacher, which have inspirational features such as a teacher demonstrating the solar system in the playground. That might look a bit airy-fairy. However, if you want to talk to some kids about the speed of sound, you can do it on a white board, but, if you have enough space, you can take them out so that some children can knock two stones together and the others are far enough away to see the stones going together before the sound reaches them. It is so much more effective as a demonstration of the point if they can try and engage with that in trying to estimate the speed of sound. Being outside the classroom is often really important in getting the point over.

What else do you need to do? Professor King was talking about an accredited course and Greg was talking about making sure that it is written in as a requirement for there to be such studies. We support that, but we think that there are some other unintended consequences. This is not meant as a political point, but I think it is an unintended consequence in the approach to academy funding. The local authority is currently the body that spends a lot of money on outdoor education. If you move all the money into individual schools and you do not have it as a requirement on them because they are not under the National Curriculum but the league table pressures are still there, you could well find yourself with outdoor education becoming even more of a problem. People need to think through what the unintended consequences are of those moves on funding. I think that is a very important thing for you to look at.

Dr Hitch: In terms of geology field trips, they tend to be residential, in my experience, on the basis that most geology that is accessible is in remote areas. We have talked a lot about the soft skills that field trips bring, but, also, in academic terms, it puts things into a context. It is just amazing when you are in a field with a student and they say, "Wow, that now makes sense." The real value of fieldwork to me, as an academic, is that they understand things.

Q18 David Morris: It is a motivation.

Dr Hitch: You can motivate them in a classroom. It is not motivation; it is realisation, I think. They are

actually seeing things and understanding them. They may well have been motivated by it before, but it is that realisation that they can understand it.

Q19 David Morris: Do you think in your experience collectively that going out on field trips should be mandatory instead of an option?

Greg Jones: Yes. Back in the 1980s, we used to do a course called SCISP, which was the Schools Council Integrated Science Project. It was the three sciences put into a course which was very thematic. Part of that requirement was to do field trips. It made it an essential part. Those scientists that I had at that time were probably some of the most talented scientists I have ever had. They blossomed entirely because of that field trip. It was a requirement. That course no longer exists, but you could instil that enthusiasm again if you made it a requirement.

Professor King: I would argue differently. Rather than being mandatory, it should be assessed. If it is not going to be assessed, then lots of teachers are going to look for different ways of doing things and that probably is not going to be so successful.

Q20 Stephen McPartland: I would like to ask Dr Hitch and Mr Jones what the major differences are that you two currently experience in arranging field trips or practicals.

Greg Jones: I have not arranged field trips myself for a number of years. I mentioned the one earlier. That is mainly because of the constraints in terms of the physics and chemistry curriculum. It has become a bigger problem in most recent years. I would like to concentrate more on the practical elements and the fact that there are financial issues in doing experiments in a lot of schools now with reducing budgets. They are reducing technician time and the numbers of technicians. The squeeze on schools to do the experiments is becoming very real and has been for a period of time. As I said earlier, that is to do with the time constraints but, equally, its value. It is not valued by exam boards in the way that exams are. I used to do A-level physics practicals, which were a very big challenge for the staff to set up, but they were very well done by students. Out of the hour and a half they spent doing a physics A-level practical, the amount of practical time was probably no more than half an hour. An hour was spent using the practical results and the evidence that they had gathered in a practical set-up that they then had to apply. In effect, it was applying their knowledge. It was not a practical exam for an hour and a half; it was the application of practicals.

I think that kind of thing ought to be encouraged more. You are spending more time doing the practicals and assessing them, as Professor King has said, because of the value that they have. We create scientists who, by nature, are inquisitive and do practicals to support the theory that they may have come up with in the first place or to generate a theory as a result. To spend time doing those practicals and then make them valued in an exam, the coursework requirement is less than 20%. We used to have GCSE or O-level courses, as they were then, which were 100% coursework. It was obviously moderated by exam boards. These were all Mode 3 exams. I am going back to the 1980s now. However, that changed and the National Curriculum came in. Exam boards changed those requirements.

I think we have swung too far into the assessment route, which has meant that practicals get squeezed vastly. Investigations in physics used to be great fun for students. The time factor has now reduced them so that students want to be told what they need to investigate. It is not for them to take ownership. What makes them better scientists is when they take ownership of the experiments that they are doing and run those experiments through to a conclusion. Whether it is the right or the wrong conclusion, one could argue that that makes you a better scientist.

Dr Hitch: I think some might argue that I run too many field trips, and that raises the first issue, namely, the congestion within the curriculum. We have had increasing pressure over the last 12 months with controlled assessments. Students are doing controlled assessments throughout their entire GCSE course. We have issues with staffing of those trips. If you are in a classroom just one person can teach the class, but as soon as you go out of the classroom you are looking at additional staffing. You are looking at increased costs. The costs to students are getting to the stage of being prohibitive, particularly for residential field trips. They are really starting to hit. Again, we have noticed that in recent times with the number of parents coming back and saying, "We simply cannot afford to send them on these field trips." There are some big issues. It is interesting that I have not mentioned health and safety, because, as I said before, I do not see that as something that is causing us a major problem in running field trips at the moment.

Q21 Stephen McPartland: If I could just focus on Dr Hitch and Mr Jones a little more if you do not mind, there seems to be a difference between the geography field trips and science practicals. There is a perception that fieldwork has reduced over the past number of years. How true is that in terms of geography? In science, has the number of practicals reduced as a result of there being a lack of qualified technicians and teachers? Are those two separate issues or is there a general issue here?

Greg Jones: With regard to science practicals and the experience that students have right the way through, if you start at primary school level and the actual number of pupils doing science, the constraints of literacy and numeracy in recent times mean that science has been squeezed out of the primary curriculum, which takes the fun out of it. Kevin indicated earlier about what happens in Year 6. The secondary curriculum allows more science, but it is constrained in the end because of exam boards. The numbers of experiments that you do over a period of years decreases as you get older up to the end of Key Stage 4. By the age of 16, you will have done the least amount of experimenting compared with what you did at the age of 11. It actually reduces. It then increases again when you specialise at A-level, fairly obviously, because you are only doing three subjects, or maybe one, depending upon your AS or A2 choice.

The requirement to do experiments by the exam boards is not there. They could make it a requirement that you have to do experiments and they will be tested. They could be done in an exam in terms of, "You will refer back to this experiment." We probably all remember Van de Graaff generators. I have the kind of hair that actually does stand on end. We have those experiments which people know all about and we teach those. But then there are others which could be referred to in an exam and, if you had those in the specification for the exam, they would happen. If you do not put them in, they don't necessarily happen.

Talking about the training of teachers, over my teaching career, the quality of those scientists coming through and feeling confident in doing experiments has got less. It is much more now about students wanting to be told the answer to everything. Why? This is, as I mentioned earlier, because of target setting and exam grades, et cetera. I think that is true for teacher training as well. Teachers are the same students five or six years on, which is an issue. They would rather feel confident about doing less practical work because that is what they have been used to. I think we have swung too far the other way. They need to have that confidence put back into them. That can only happen if it is instilled more.

Dr Hitch: I am very fortunate that I have not seen any reduction in fieldwork in the time I have been teaching at my school. We are very fortunate. However, I think the pressures are now coming upon us and there will be reductions in the amount that we teach.

In terms of geography, the students get at least one day in each of the Key Stage 3 years. They get three days at Key Stage 4. When we get to A-level, they go on a residential trip. In terms of geology, the groups are small and that causes problems for residential trips. So we put two groups together to make economies of scale and to make it more time-efficient as well. At the moment I am very fortunate, but in the future there is going to be a lot of pressure to reduce the number of days that we go out.

Q22 Graham Stringer: Does the prospect of doing experiments attract young people or does it put them off science?

Greg Jones: I think it attracts them because they see it as different from what they are doing in terms of other subjects. Science is definitely different. There is a fun element. You can have fun in science and maybe you cannot have quite the same fun in history or other such subjects.

Q23 Graham Stringer: Your own experience is valuable, but is there any hard evidence on this?

Greg Jones: What, now?

Q24 Graham Stringer: At any time, yes.

Greg Jones: I do not know. If you did student surveys. I interviewed some students who were doing AS courses earlier this week about how they viewed their science recently compared with how it was in high school. They said that it had become less fun. Obviously, they are at a higher level and they are going to be going on to university to do science courses. The rigour has been put in, you could argue, but if you do not do the experiments you are taking away some of that fun. There always has to be an academic challenge there. Doing experiments is not less academic at all. In fact, one could argue that a bigger academic challenge is to interpret the fact that you do not have very good results and why that might be the case.

Kevin Courtney: It is not impossible, though, for there to be a difference amongst children and some of them would be not as comfortable doing practical work. In a class of 30 children, most of them will engage with the experiment, but some of them will be more comfortable with the theory. People are different from one another. Stephen Hawking became a theoretical scientist. There are differences in the way that people approach these questions. I guess the feeling that we have and the anecdotal reports from members show that experimental work is often the way to engage children with the excitement of science, and that is important for science teachers.

Q25 Graham Stringer: You have touched on this point before, but in doing experiments what is the real importance? Is it the gaining of practical skills about how to read a thermometer or whatever it is, or is it learning about the scientific method and being able to interpret the results? What is the important point?

Professor King: Having seen a lot of lessons as a teacher trainer, I can tell you from my own experience that there is a wide variation in quality of practical work. That is partly because some schemes say that you should do a practical so our training teachers do the practical without really getting to grips as to why they are doing it. If you are an experienced teacher, though, as we all are, you will know that you do the practical work for a reason. The reason, often, is that it is a problem-solving situation. We have this question and we are going to tackle it through doing this practical work. We are going to evaluate the evidence that we have and we are going to see if we can answer the question. That is when practical work works really well. If you can build into that children predicting things and testing their predictions, then the quality moves up even higher. That really does inspire people.

Darren Northcott: I think that is absolutely critical. Good teachers start with a learning objective. They start with what they want young people to learn and then they think through the different approaches they can adopt to support pupils' learning. One of those approaches is fieldwork. One of those approaches is practical learning. I think it is always important to start not with practical learning or fieldwork but with learning objectives. What do we want these children to learn and then how can we best achieve that? That is where you begin to get really effective use of practical work and fieldwork because it links closely to learning objectives. It is not done for its own sake; it is done to advance children's learning in some important ways.

Q26 Graham Stringer: I have two questions, but I will try and put them into one because we are running out of time. This partly goes back to Stephen's question originally. Are there any experiments now

that, in practice, just do not happen in school laboratories? For example, is the fountain experiment still done? Are bomb calorimeters still used in physics laboratories or have they gone because it is felt that they are just a bit too dangerous at the moment?

The second question goes back to some of your answers that there is a tendency in modern teaching for both the students and the teachers to want to know the answer. I have some sympathy with that. I always thought that a sixth former doing experiments to find out the latent heat of fusion of water when everybody knew what it was was a bit of a waste of time. Is it not more important to do experiments that have never been done before, that children themselves can design, so that they are pushing back the frontiers of knowledge in a way in that very narrow area? Is that not more important? There are two questions there.

Greg Jones: You asked whether old experiments are coming back. The question is: how is the exam course composed and what kind of themes are you covering? It is then looking at what kinds of experiments go to support that. The bomb calorimeter went out years ago. Why? It was because that element of thermodynamics had disappeared out of the syllabus. But other elements have come into it, and with those elements can come practicals. When one talks about whether students feel that they are on a treadmill and are doing experiments for the sake of it or whether they are learning something intrinsic, they are trying to be scientists, are they not? It is how you set them up and what context you have for that experiment.

Earlier, I mentioned the physics investigations. We used to have the freedom for students to do their own. They came up with the idea. They tested the hypothesis. They produced the equipment in some cases or they designed the equipment. For that to happen for every student would be difficult at Key Stage 4. At A-level, it is possible, although it still requires a lot of support from technicians and staff, and equipment, in terms of finance, to provide that element. At Key Stage 4 and in GCSEs, it is done, in effect, through experimentation by doing coursework. But, if everybody is doing the same coursework, are they all going to get the same answers? Is it going to be collaborative work?

You asked the question, "Are they actually learning anything or what are they learning?" Are they learning to be good scientists by doing practicals? It is an element of a scientist's work. It is not the only element and, equally, it is not to the exclusion of other things. It should not be. It should be an integral part. I do not think I got switched on to science purely by reading science textbooks. I think it had something to do with the motivation that was instilled in me by the teachers that I had and the experiments which were part of those lessons. Now, if you talk about the number of lessons in a week which occur for students where there is no experimentation whatsoever, certainly at Key Stage 4, it is a lot. There are no experiments being done in some weeks, and that, to me, is tragic.

Professor King: You asked earlier what evidence there is for what we do having an impact. I can think back to a survey that we did in the Earth Science Teachers' Association some years ago. We asked all the people present what it was that turned them on to science. To a person, they said that it was fieldwork. It was going out there and doing things. It was seeing how it worked. The whole room responded in a similar sort of way.

Q27 Graham Stringer: That was fieldwork rather than experiments in a laboratory.

Professor King: We are talking about groups of geologists here, so it was fieldwork. We do experiments in geology but not in the same sorts of work.

Kevin Courtney: In some senses, the word "experiment" is used quite loosely when we are talking about what is going on in a science practical. Measuring the latent heat of a substance is not an experiment; it is a measurement. It is not testing a theory and proving or disproving it. There are times when you are doing practical work in order that the children experience it. You are doing the ripple tank experiment. You are watching the diffusion of the water waves. You are getting them to show themselves what happens in order that they have had the experience of it. This is what has really gone. The independent investigations that students used to be able to engage with much more, which Greg mentioned, are much closer to putting forward a theory, designing an experiment and testing it to see whether the theory stacks up or not. We have to be clear. We want young people to have the practical experience. Sometimes it is an experiment, sometimes it is a demonstration and sometimes it is learning the skill of reading a thermometer. It is a skill that children need to be taught at some level. There are a variety of different things going on in that practical work.

Q28 Pamela Nash: I would like to direct these questions to Dr Hitch and Mr Jones because I know that we are running extremely short of time. In your particular subjects, have you noticed any difference in the impact on girls and boys in your classes when it comes to equality in working in a laboratory and in the field?

Dr Hitch: No, generally not. We only have small numbers so the class sizes are relatively small. We work very closely with the students and I would say that in the field and when we do lab work, with the calibre of students that I have, there is no noticeable difference between the ways in which the girls and the boys work. In terms of their final grades, they are about the same. There is no major difference at all, but I am only talking about A-level.

Greg Jones: There has been some evidence in the past about the fact that girls do better at coursework than boys because they tend to be more diligent, but you can find statistics that will prove the opposite in that boys are better at doing exams. Regarding the evidence about gender bias, one could argue that boys tend to be much more practically based. There are definitely some elements where boys perform better with a practical element to it. If we are talking about the general spread of ability and the age range that we have, I do not think there are any real differences. You get some very good practical work done by girls and, equally, you do by boys. Academically, girls can be

measured at the same kind of level as boys. I do not think there is a gender element to it.

Q29 Pamela Nash: I appreciate that both of you teach older teenagers. Can I ask the rest of you if you have any experience of, or have noticed any difference in, the impact that practical work has on younger students and whether it has an impact on who takes up science subjects to A-level and beyond?

Darren Northcott: With very young pupils, I am not sure you can spot a gender difference readily in the classroom. Maybe it becomes more established later on. One thing that is very clear is that, when you provide those practical opportunities for very young children, both boys and girls really engage with it. They have to be maximised as much as possible. I do not think, again, at that younger level there is any kind of identifiable difference in gender as far as I am aware.

Professor King: An important element of this, again, is the quality of the practical work or the fieldwork that you provide. If you work in single-gender groups in your classroom, that tends to reinforce the way in which the single gender works. If you manage the learning more effectively and have mixed-gender groups, it will have a broader impact and the gender difference just is not there.

Darren Northcott: The main issue in relation to gender in science is around subject choice and in the disproportionate number of girls who do biology and the disproportionate number of boys who do chemistry and physics. There are deep-rooted reasons why that is the case. That is clear not only in the UK but across the industrialised world. It is a really entrenched issue about perceptions of science between boys and girls. They are significant, particularly amongst older students.

Q30 Pamela Nash: I guess what I am trying to get to is whether this has an impact on what you have just said and whether we could change that.

Darren Northcott: I think we are asking very profound questions about the nature of our society, the differences between boys and girls and the way in which they are socialised. Schools do take their responsibilities seriously when those issues arise to challenge those stereotypes. Schools understand that they are one of the few institutions in our society that can do that. They can encourage girls, too, if they are reluctant, to take part in practical activities, to see the value of it, to see the fun in it and to explore subjects in which they are under-represented like chemistry and physics. There has been a lot of work that has been done on women in science and engineering and that needs to be supported very strongly. Clearly, there is a lot of talent out there in terms of earth sciences, chemistry and physics that is just not being exploited, because girls, for whatever reason, are not taking it up in the same numbers as boys.

Kevin Courtney: I agree with Darren. I think there is a very strong good news story to tell about schools and girls' education in particular. We have moved from the girl/boy split in domestic science versus metalwork to the present situation, but we have not finished the job. The bias between biology, chemistry and physics is still there, but there has been a lot of movement. It sometimes requires active involvement and active training at teacher training colleges so that teachers can focus on the question of gender in their classrooms to make sure that they engage in bringing girls towards certain things and boys are not ruling themselves out of them. It is a question of active involvement and continuing to focus on training. It is good that the question should continue to be asked, but I think there is a good news story there too.

Darren Northcott: If I can make one brief point, it is one argument for a National Curriculum because it provides a common entitlement for all learners. Boys and girls can access practical learning. The world before the National Curriculum was perhaps the world that Kevin has described where girls did domestic science and boys did metalwork. No one wants to return to that. There were pros and cons to the National Curriculum, but one plus was that it said that, regardless of gender, you should get access to these learning experiences. That is the really positive thing about the common learning entitlement that the National Curriculum represents.

Q31 Stephen Mosley: Mr Jones, you were talking about teaching science in the 1980s. I did chemistry and went on to do chemistry at university in the early 1990s. It was either sitting in a classroom being taught or it was doing experiments. If you go to university now, where they used to have all the glassware, different liquids and compounds, they have row after row of computers. I guess that now the way you teach is practical with computers where you do the interactive stuff. It might be formal teaching or watching a DVD, but it might also be doing something interactive, for example, peeling layers of skin off an interactive body. It is in between formal teaching and practical work. Has the amount of IT and technology eaten into the amount of time in which you might do practical work, while delivering the same result at the end of the day?

Greg Jones: IT is a tool that scientists use in schools. It is used to different extents, depending upon the support that there is. I know one particular science department has only one computer at the back of the lab that is used for data logging, which is pretty inadequate when data loggers need to be used. Thermometers were the old game, if you like, and data loggers do a similar kind of thing, but it is a much more interesting way of looking at temperature over time experiments, for example. How individual institutions respond to the IT requirements does vary. If you think about the kind of high-spec equipment that you have in universities, schools cannot afford that. It is a matter of what schools can and cannot support financially, and that comes out of school budgets. It is how much a science department is supported by an IT budget and what experience science staff have in doing these much more IT-related experiments. There is more of that happening. I do not think that there is anything like the same amount that happens at university level because there is not the same amount of funding that is there for schools.

Q32 Stephen Mosley: I was trying to get on to the fact that there is a perception of fewer practicals being done because people are not chucking things into test tubes, but it is because there is more computer work going on instead, which is slightly different. As technology has changed, the way that you teach has changed as well.

Dr Hitch: I am following up on that in terms of geology. At the moment, students at A-level are able to do things that I was not able to do when I was doing a degree and post-grad. They are able to use the IT. The software is there and available for them. Some of it is free and easy. They can download pieces of software that can be used. They are becoming more skilled for when they go on to university. I take the point about IT taking away from the experiments, but it is developing research skills. Within my field of geology, their researching ability, and then professionalising their report-writing and things like that, is incredibly important. Those are skills that they are taking with them and when coming back from university, they say they are set up very well for the next stage.

Q33 Stephen Mosley: I have one final question for each of you. What one thing would you each suggest would improve the level of science teaching, the practical teaching or the student experience when doing practicals in schools?

Kevin Courtney: One thing that was just touched on was science technicians. They are a really important part of science teaching. We should have high-quality science technicians. Teachers have a defined pay scale. Science technicians need to get some support. There was going to be the SSSNB that was going to develop job descriptions and pay grades for different grades of support staff, but at the moment it is just generic. There are teachers and support staff. You need to have something defined within the category of support staff. Some focus on science technicians as a career would be an important thing to look at.

Dr Hitch: I think you would be looking for a requirement for it from the specification so that there is a genuine reason for it to be done within the schools. Then, people can fight their corner.

Q34 Stephen Mosley: Should Ofqual give some sort of guidance as to how much there should be?

Dr Hitch: I would think that would be the way forward, yes. Some of the specifications have it and some of them have not.

Greg Jones: Reducing the amount of content in the exam courses so that time is freed up in the curriculum to be able to do more experimentation, whether it is using IT tool skills or whatever. It is just freeing up that opportunity for students to investigate and to become practical—in the broadest sense—scientists.

Professor King: As far as fieldwork is concerned, an accredited course in fieldwork that is safe and effective.

Darren Northcott: Kevin cruelly stole the first point that I was going to make and Chris has just stolen the second. The wider school work force is very important and investing in CPD is also critical. I would just re-emphasise those two points.

Chair: This was your fieldwork. The questions that you were not able to answer count as your homework. Any additional comments from you would be welcome and thank you very much for your attendance.

Wednesday 29 June 2011

Members present:

Andrew Miller (Chair)

Stephen McPartland
Stephen Metcalfe
David Morris
Stephen Mosley
Pamela Nash
Graham Stringer
Roger Williams

Examination of Witnesses

Witnesses: **Paul Cohen**, Director, Initial Teacher Training Recruitment, Training and Development Agency, **Annette Smith**, Chief Executive Officer, Association for Science Education, **Dr Phil Smith MBE**, Co-ordinator, Teacher Scientist Network, and **Dr Steve Tilling**, Field Studies Council, gave evidence.

Q35 Chair: I welcome you all here this morning. Can I start by asking you all briefly to introduce yourselves?

Paul Cohen: Good morning. My name is Paul Cohen. I am the Director of Initial Teacher Training Recruitment at the Training and Development Agency for Schools. That means I am responsible for ensuring that the Government achieves its annual national targets for the recruitment of trainee teachers. I also have oversight of science matters in the agency.

Annette Smith: I am Annette Smith. I am Chief Executive at the Association for Science Education, which is the membership organisation for science teachers.

Dr Smith: I am Dr Phil Smith. I am Co-ordinator of the Teacher Scientist Network, a science education charity based in Norwich.

Dr Tilling: I am Steve Tilling. I am a scientist by training. I am Director of Communications for the Field Studies Council, which runs 18 field centres and produces scientific publications.

Q36 Chair: Thank you all for coming. I am going to quote directly from the Teacher Scientist Network. They told us that "good teachers are those who are confident teachers, up to date in their subject knowledge and practically adept themselves. These teachers will be those most able to inspire future scientists." Can you provide us with a picture of what is needed to make a good science teacher? Is teaching a practical class a different skill set from other forms of teaching?

Dr Smith: It definitely is a different skill set, but the two skill sets are combined by very able teachers because they have a commitment to teach both the practical and the theory. The theory on its own is very dry and is really uninspiring unless you are of that mindset. However, I believe passionately that when the theory is combined with the practical that is when the young people start to realise, "Yes, this is the value of doing the science. This is why I do science. This is why I want to do more science." The two skill sets are complementary. Therefore, teachers need two different skill sets themselves to be able to teach those pupils adeptly.

Dr Tilling: We would agree with that. We would suggest that a teacher would have, or should have, that full skill set to be able to offer the full range of teaching and learning approaches, which would include classroom as well as outdoor and beyond the classroom teaching.

Annette Smith: We hear a lot about inspirational teachers, but actually every teacher needs all of those skills. It is a difficult skill set, which is why perhaps we concentrate on science teachers a lot more than others. I would also add the linkage between practical science and the theoretical as being a very important part of science teaching. Teachers need to be able to make those links so that they are not doing practical work or outdoor work in isolation from the theoretical work that they will do back in the classroom.

Paul Cohen: I agree. The way that we approach Initial Teacher Training is to combine the theory and the practical, as you will be aware. In science, it is particularly important and there are a number of reports that no doubt we will come on to which reinforce the importance of the practical and the theory being integrated. There is one other point as well, which is that in terms of what makes a confident teacher in sciences particularly, but generally, they need to be comfortable in their specialism. They need to be able to apply that specialism while being aware of other specialisms. A lot of our work is designed to get a broad equilibrium of specialisms within science in the new teacher work force.

Q37 Chair: Can I just push you on that particular point because, of course, that is clearly very true of the secondary sector, but in the primary sector one sees few people with science qualifications? How, in the training process, do you address the needs to give all teachers the right skill sets to inspire younger children about science?

Paul Cohen: It is true that our focus has been on secondary because that is where the pressure has been around GCSE and A-levels. Primaries are a slightly different situation because you are largely looking at a model where a teacher will teach a year group for all their subjects. We have been offering some continuing professional development to teachers in primary schools to encourage them to improve their specialist science knowledge. I know that a number of providers do offer a science specialism alongside their primary teacher training courses. We are pushing that agenda as well as at the secondary level.

Annette Smith: I think it is too much to hope that the Initial Teacher Training can cover primary science properly for all teachers. There is so much in the

PGCE year. It has to be complemented by professional development throughout the career. One of the things that we have been doing is something called Primary Science Quality Mark, which looks at science across a school and aims to give all of the teachers in the school confidence in their teaching of science. The confidence in primary education is key.

Dr Smith: I would support that. There is a need for extra staff development year-on-year, even for good teachers who are established after one or two years' training. It is very easily forgotten by senior management and the pressures within the school environment can easily take away that vital element of ongoing support for teachers. These days we see so many changes to the curriculum. It is not yearly, but certainly I would say every two to three years there is a new change to which teachers have to adapt, and they have to make that change straight away. When they make that change straight away, do they have time to focus on their subject knowledge? The chances are, no, they don't. Then you end up, two or three years down the line, slightly outdated, slightly less confident in your science teaching. There can be a real detrimental effect because of that. There is this combination of factors that we have interplaying together that is adversely affecting teachers' ability to do practical science both in the primary and secondary sector. But we feel very strongly that the primary sector is very neglected.

Dr Tilling: Obviously, I will talk mainly about fieldwork and outdoor science. Certainly within those areas, we also feel that that CPD, that progression in skills, is let down by the standards which underpin that progression. For example, one of the skills that a teacher is expected to develop over the course of becoming more specialised and also more experienced from a qualified teacher through to an advanced skills teacher is to build skills in terms of the learning environment. That obviously includes out-of-classroom learning. Yet the learning environment is the only part of that whole progression within standards which does not progress at all from the early stages of a career scientist. When you progress through threshold and through to an advanced skills teacher, there is no standard which underpins that development in terms of working outside the classroom.

Chair: That takes us seamlessly on to David Morris, who wants to ask you some specific questions about fieldwork.

Q38 David Morris: Good morning, everybody. Part of the question that I was going to ask has already been answered. Going on to the fieldwork, the Earth Science Teachers' Association recommends that there be "a nationally recognised and accredited fieldwork leadership course". Do you endorse this proposal?

Dr Tilling: Absolutely; yes. We run courses—and I say "we" in the general sense across the community—for NQTs and early career scientists, for example, at the National Science Learning Centre. There seems to be a demand for them. I come back to my earlier points just now. Unless there are standards to which professional scientists or professional teachers can aspire or be expected to attain by the time they become advanced skills teachers, then that demand might not be there in terms of the higher order development of skills.

Q39 David Morris: Mr Cohen, do you concur with Dr Tilling's observations?

Paul Cohen: Yes. As Dr Tilling said, if there is sufficient demand for such a qualification, I am sure the market will respond. Of course, there are requirements around understanding, planning and operating fieldwork which are built into the various standards that exist at the moment for newly qualified teachers, and then on, as Dr Tilling said, through the various levels. The standards as a suite are being reviewed at the moment. The Secretary of State for Education has set up an independent review. No doubt Dr Tilling and others will be feeding into that review and it will be interesting to see it when that comes out.

Q40 David Morris: Do you think the provision of school fieldwork and field trips would be affected? Do you think it would go more in the line of quality and not quantity? Is that how you would see it going eventually?

Dr Tilling: I see both. Within science, in contrast to geography, for example, whereas the geographers are now talking very much about the quality of their fieldwork because the quantity is there, science still needs to tackle both the quantity and the quality.

Q41 David Morris: Do you think that science teachers should generalise in neither classroom nor outdoor, or do you think there should be specific fieldwork specialists to take children out into the field and see it at first hand?

Dr Tilling: It is always useful to have specialists who can support teachers, but, as we said right at the beginning, I think it should be part of a suite of teaching skills that any science teacher should have. The confidence, the competence and also the commitment to go outside the classroom should be a general requirement of science teachers generally.

Q42 Stephen Metcalfe: When we started this inquiry, one of the issues we were concerned with was health and safety and whether or not that had adversely affected the way practical science was taught both inside and outside the classroom. We have received a bit of a mixed message. The witnesses that we have had in front of us have said, no, it is not the primary block, but some of our e-consultation has said that there are some serious issues. One particular practising teacher talked about the "health and safety issues linked with the blame culture", "a disincentive to do anything that might have a risk" and that senior management are "wary of science and are risk averse". We have some examples where someone quoted that they had had to wear goggles to do a soap and water experiment, which does seem quite extreme. What is your experience of health and safety assessments?

Annette Smith: We did some work, which is part of our written evidence, asking our membership which disincentives there were to doing practical work in the classroom and in field trips and whether health and

safety played a part in that. We found that it was not the major issue. It was not the major detractor from doing practical science or field trips. That could be because we took our data from our membership, and our membership is singularly well informed about health and safety matters because we write books for them and we provide them with lots of briefings. So they are extremely well informed and they know what hurdles there are that they have to cross. They know about risk assessment. So they would perhaps select themselves as being less worried. They were much more concerned about time for preparation, general resources and support in the classroom and such like. The issues they had were much more general. They feel they can deal with health and safety. That also might be because they are scientists and scientists have understandings of risk and analysis of that.

Q43 Stephen Metcalfe: Do you want to add to that?
Dr Tilling: I agree with Annette. Our evidence, of which we have a lot with different groups of teachers at different levels of experience, is that there is a relationship between experience and concerns to do with health and safety. Taking an average, health and safety is an issue. It is a barrier but it is by no means the most important barrier for most of the people that we work with, which includes PGCE students.

Q44 Chair: Has there not been a shift over time towards the teacher demonstrating rather than the student participating in experiments under the guise of health and safety? Do you think youngsters actually get the same hands-on experience in the lab, in particular, as they did when certainly I was at school?
Annette Smith: There is an important place for demonstration in a school teaching lab. There are some things that you either have in short supply or they are just a little bit too dangerous to let the children have themselves. There is a suitable place for it, but it cannot replace young people handling materials and other things, observing for themselves, and having the whole of the rest of the experience that practical science brings. So there is the discussion and the debate about what is going on and the interaction with peers and so forth. It cannot replace it but there is a place for it. There are some important things that you can do by demonstration that young people cannot do individually.

Q45 Stephen Metcalfe: Following on from what the Chair said, do you think there is as much of that as there was, say, 25 years ago? Do you think there is as much hands-on or, because the health and safety culture has become so embedded, we expect that to be part of what we do and that has actually detracted from the amount of time that is available for practical hands-on science?
Annette Smith: We cannot see firm evidence for that. What we can see is from the other end. There are pressures to do with lack of technical support, resources and time, and particularly in secondary education the school day itself mitigates against doing considered practical work. It makes it much more difficult. You would imagine that with those difficulties there would be less going on, but we do not have firm data to back that up.
Dr Tilling: Perhaps I could pitch in with fieldwork. We do have evidence. Obviously we take well over 20,000 scientists a year and have been for the last 70 years or so. I can tell you categorically that, over the last 20 years, there has been a decline in numbers of scientists going on not just our residential courses but also day courses. In terms of upper secondary groups, there has been a shortening of the experience. It is about half of what it was 15 years ago. Linked to that, because of transport costs and other things, they are also going more local than they were 15 years ago. I think there have been substantial shifts.

Q46 Stephen Metcalfe: CLEAPSS was concerned at the variation in consistency in the Initial Teacher Training advice on using their services, because they provide help with risk assessment, as I am sure you are aware. Where should the responsibility lie for making sure that teachers across the board—newly qualified all the way through to advanced skills teachers—understand what is and is not as much required to do a good assessment so that you can carry on doing practical science?
Paul Cohen: I will start with Initial Teacher Training. The responsibility in Initial Teacher Training legally and practically rests with the provider of the training. There are standards which relate to ensuring that a trainee understands both the curriculum and specifically the health and safety aspects that may relate to any practical work. As an agency, we share with others a commitment in trying to ensure that there is greater consistency between what happens on ITT and out-of-classroom experiences with others. We sponsor the Teaching Outside The Classroom Partnership. Essentially, it is a website with all the places that welcome trainees so that they can learn more about this stuff. We also promote and support agencies that offer health and safety advice. Ultimately, it rests with the provider, but we do what we can to point people in the right direction at that stage of their development.
Annette Smith: In school, obviously, it is the governance structure of the school that is responsible for making sure that that happens throughout the school and should be asking all of the questions about risk assessment on all fronts, including practical work.

Q47 Stephen Metcalfe: But if the responsibility lies with the school, the tone of how much assessment is required will lie very much with the senior management of the school and how risk averse they are. Should there not be some sort of blanket standard or standard that is applied equally across the whole education system? If that is the case, who should then look at that? Who should control that?
Paul Cohen: If I can just come back, there are two slightly different questions there. One is about who is responsible for taking the decisions. As Annette Smith has said, it is ultimately the teacher. But then there is the question of whether there should be some common guidance to which people are working. I am aware that the Department is in the process of responding to Lord Young's report on trying to remove some of the

bureaucracy and the burden out of health and safety. He is looking to issue revised guidance shortly, which is going to be around the principles of common sense and proportionality. There will be a guide then around which heads and teachers can work more consistently than they have in the past.

Q48 Stephen Metcalfe: Who will be responsible for making sure that that guidance gets not only into the school but then into the classroom?
Paul Cohen: It will rest with heads to make sure that the guidelines are followed as they consider appropriate.

Q49 Stephen Metcalfe: That is where I am coming from. It is where they see appropriate, so if it ends up on the corner of a desk stuffed under a pile of very important papers, the danger is that it will never get out of the classroom and we will have this variety of standards applied across the education system. I am trying to get to whether we think we need to take that away from the heads and apply it more even-handedly across the whole system.
Dr Tilling: If I can respond again in terms of outdoor science and fieldwork, there is a threat. If we were asking that question 10 years ago, we would say the local authorities and certainly the state sector would have a key role in influencing how schools applied health and safety. Originally, the 1998 documentation for health and safety came from HSE/DFE, which was then taken by local authorities and rehashed, which then went into schools. Latterly, it was taken by education visits co-ordinators, who then put another tier of bureaucracy on to this quite often. That of course is now changing. Local authorities will not have the same level of influence as they have had in the past. The question is a good one. How will health and safety be regulated in the future? I don't think anyone knows. The detail has not been worked through.
We would make, and have made, a recommendation, which is that whatever appears—particularly for science fieldwork or fieldwork generally—it needs to be fit for purpose. The temptation might be to apply a general overall approach to health and safety. For example, a group is suggesting the Adventuremark as the new approach to health and safety standards. We would argue strongly against that because we think it is over-egging the health and safety issue. We would point people more towards Learning Outside the Classroom Quality Badge which is fit for purpose. It has a much lighter touch. It is a more common-sense approach to health and safety and does that wonderful thing also of combining health and safety with the quality of teaching. That has always been a problem. The two have been seen separately. One of the things we have always said in the past is, "What a wonderful opportunity to involve students, for example, in health and safety and risk education." They have been treated entirely differently, which is a missed opportunity.

Q50 Stephen Metcalfe: Is there a classroom equivalent of that mark, training or qualification?
Dr Tilling: In terms of learning outside the classroom?
Stephen Metcalfe: Yes.
Dr Tilling: There is a classroom link because one of the main criteria is the link and what happens outside with what happens in the classroom.

Q51 Stephen Metcalfe: One of the other things that struck certainly me, and I think some of my colleagues, is that there do seem to be an awful lot of schemes and programmes and variety. Do you agree that there is perhaps too much variety and too many different sources of information that make it very difficult to access? Perhaps some of that should be rationalised and we should have one central resource that collates all this information, and then it is more easily accessible so that teachers can access it and make the most of it.
Annette Smith: Are you talking specifically about health and safety in science education?
Stephen Metcalfe: Yes.
Annette Smith: Steve refers to the local authority role, which was clear up until now. The local authorities, where they still have control, still sign up to CLEAPSS and get regular updates on specific hazards which are pertinent to the classroom in general. That is really a useful service and they can act upon that. Then the schools have responsibility to act upon that. That is fine but it is changing. It is difficult to know where that will end up. Obviously you will be able to speak to those witnesses later on.

Q52 Stephen Metcalfe: Does anyone else want to add anything to that?
Paul Cohen: Only to say that I think there is a genuine point there. In preparing for this session, I was rather overwhelmed by the number of different organisations and websites that are available. I am not in a position to say whether that is confusing for teachers, but clearly it is a bit of a challenge to navigate if you are not an expert, I would have thought. The Department has just finished sponsoring something called the Getting Practical programme, which was designed to bring a lot of this stuff together around a common website, a common series of activities and common guidance. It was not exclusively on health and safety but on the generality of practical work. I think that is the direction of travel. A clearer and simpler way of accessing information is important for consistency.
Dr Tilling: I don't want to overdo the comparisons between science and geography but I will do another one, and it is linked to the first comment about experience. It is interesting, for example, that, if you ask geography secondary teachers about the importance of health and safety as a barrier to them going out of the classroom, only 15% of them will say it is of significance. That is to do with integrality into the subject, their level of experience and the competence and confidence which they have. It is exactly the same in science. If you have a very experienced science teacher who has done this before, health and safety will not be an issue.

Q53 Stephen Metcalfe: I have just one final question. Mr Cohen, I expect this is an impossible question to answer, but in the Initial Teacher Training

what is your stance on the general health and safety issue? Is it that as a teacher you should be totally risk averse, or are you encouraging people to see through the risk, see the benefit and then work out how they can deliver the benefit with the minimum amount of administration?

Paul Cohen: It is explicitly the latter. Without quoting great chunks of our guidance, can I just quote one area? It is in supporting the standard in this area to do with the out-of-school education context particularly: "Does the trainee know how to plan out-of-school learning experiences that demonstrate knowledge and awareness of health, safety and safeguarding requirements?" There is a balance there between being aware of these but also being able then to go ahead and do it and not just to say, "It's all too difficult." That balance is very much at the heart of the standards.

Q54 Roger Williams: Good morning. A number of the members of the panel have touched upon continuing professional development. Perhaps we could tease out a few more issues. At the moment, some money is spent on recruiting and retaining teachers of science. On the basis that there probably won't be any more resources or a large increase in resources, would that money be better spent on promoting continuing professional development and providing education out of the classroom rather than what it is spent on at the moment?

Annette Smith: That is a difficult question. There is a question of supply and demand of science teachers. Obviously the supply is less than one would hope for. The bursary schemes are put in place in order to attract people into the profession. You cannot do anything if you do not have any teachers. You need the teachers first before you can do any professional development of them. We ought to have some data on how much that has to be in order to encourage the optimum number of teachers. I am not currently aware of it. Professional development is vitally important throughout a teaching career. We would say, coming from the position of the Association for Science Education, that we look at professionalism in science teachers very seriously. We think it is the responsibility of the individual science teacher as a professional to make sure that their development is continued. We charter science teachers in order to reflect that. There is a gold standard that we have and teachers aspire to that. Having said that, it costs money to provide. The science learning centres have been supported significantly by this Government as well as the previous Government in order to help with that. They cannot be the complete answer but they go a long way towards it.

Q55 Roger Williams: I don't know if anybody would like to add anything to that.

Dr Tilling: I can give you a number of anecdotes. I don't think the two are separate: retention and professional development. Again, the evidence we have from longstanding relationships with teachers is that involving those teachers in the wide range of teaching and learning approaches, including the practicals and the fieldwork, is a way of maintaining that inspiration for the teachers themselves. That is to do with the fact that they do work with the students in a different way and it helps to build the relationship between the students and teachers, which then translates back into the classroom setting. Giving teachers an opportunity to develop those skills will arrive at an end point which I assume you are also wanting, which is the retention of a greater number of teachers, particularly in their early careers.

Q56 Roger Williams: Some evidence that we have had points to the fact that, even when opportunities for professional development are made available to teachers on a fully-funded basis, quite often those are not taken up. Would you like to comment about that?

Annette Smith: There has been a difficulty with teachers being able to get out of school. The "rarely cover" directive was significant as far as that was concerned. It is not just the cost of the course, and it is not actually just the cost of cover. It is the disruption to schools, especially in secondary schools where one teacher missing for a day disrupts the whole timetable, and exam timing of course—that kind of thing. What we have seen is a real focus on teachers taking up the opportunity to do exam-related professional development, which, in our view, is a kind of bolt-on at the end rather than developmental of the teacher themselves. It is fixing a problem rather than developing the teacher. We would want to see professional development across the whole piece as far as teaching is concerned.

If I can refer briefly to the Getting Practical project because it has been referred to before and it was co-ordinated by ASE, that combined professional development with a particular aspect of science teaching, that is to say practical work, and based professional development on recent research. So it was an ongoing research project as well as helping teachers to understand why they were doing practical work and to bind it in with the rest of their teaching.

Paul Cohen: If I may comment specifically on your question of the cost benefit of intervening at the beginning or during, it has to be both, because the challenge is so great. You cannot simply rely on new people coming through to deal quickly with the problems we have. Therefore, you have to do the CPD as well, quite apart from any benefits that would accrue to individuals. As Annette Smith said, it is increasingly difficult to persuade heads to release people. If I can crystal ball gaze, with the pressures on budgets that exist and are likely to exist, that will not get any easier. In our case not only do we provide those incentives to which you referred to get people in, but in terms of those people that we do offer training to we are increasingly moving to online training as a way to try and give them the help without taking them out of the classroom. It is early days but that is proving more popular than the alternative traditional model.

Q57 Roger Williams: Do we gather from that, then, that it is not a lack of appetite for professional development amongst the teachers? It is constriction or lack of opportunity provided by the schools for them to take advantage of it.

Dr Smith: Yes, I would say that most definitely. What I would love to see is the opportunity for the schools who are given budgets for CPD to be able to ring-fence some of that towards science specifically. That is a much bigger and challenging question for the future but it is something to which we should be aspiring.

Q58 Roger Williams: Some of the evidence we have received shows that technicians are more likely to take up these opportunities than teachers. Is that your experience? Are schools able to release technicians for these purposes more easily?
Annette Smith: Yes. There are technicians among our members and, practically speaking, it is easier to release a technician than it is a teacher. So, yes, they are more able to take up opportunities.

Q59 Roger Williams: Moving on from that, is this an opportunity for allowing technicians to develop skills in terms of practical opportunities and perhaps outdoor education so that they can take a lead in that—under the supervision of a teacher, obviously? Is that a missed opportunity among schools and other organisations?
Annette Smith: I think schools undervalue their technicians at their peril. They are absolutely key to practical science and outdoor science and in the classroom. They are under a lot of pressure at the moment. When schools are cutting budgets, they cut technicians before they cut teachers. As they form the bedrock of science education, they are incredibly important and we ought to concentrate on them considerably.
Dr Smith: There are certain practicals that are now available to young people—certain bio-technology practicals which are relevant to the real laboratory world—but they require very able technicians to be able to set those up, which takes several hours before the class teacher and the pupils are engaged with this process. Once again you come back to the need for supporting technicians to enable this process to happen—this supply chain, if you like.

Q60 Roger Williams: The question is, though, if we are saying that teachers are constrained in professional development, is there more of an opportunity for technicians to take a greater lead and play a more active part in these practical activities and away from the classroom?
Annette Smith: Absolutely, and bring the learning back in and share that with the teacher as well. Yes, I think that is an interesting route.
Dr Tilling: I would say that there are also ways of reducing the constraints on the teachers to enable them to take up the opportunities more than they have done in the past. Obviously we deal mainly with secondary schools. I would support very much what the others have said. The main barriers that we see in secondary schools are inflexible timetabling and "rarely covers" these days. It is not funding. It is within the behest, for example, of principals and head teachers to be more imaginative in terms of timetabling and collapsing timetables to allow teachers to take better opportunities and more use of the CPD opportunities that do exist, and also perhaps to get across those problems of departments not working together. Again, that is another barrier to us. The science departments will not work alongside the geography departments, who will not work alongside the history departments when there are wonderful opportunities for them to work together, particularly in the sorts of things we are talking about.

Q61 Roger Williams: Just to pick you up on that point, Dr Tilling, my experience with primary schools, as far as taking pupils out of the classroom is concerned, is that the teachers seem to be more able to take a cross-curricular approach because they are used to teaching many subjects, whereas the opportunities for that real broad sense of education are not so often taken advantage of with secondary schools.
Dr Tilling: Certainly, the statistic which has been quoted in the past—I am not sure whether it is true; I suspect it is—is that, for example, in primary schools, 75% of the teaching is thematic, whereas only 25% in secondary schools, even in the early stages, will be thematic. It is much more subject-based in secondary schools, which obviously then brings you into those significant barriers in terms of how you arrange timetables and crossovers between subjects and get colleagues, who sometimes are only 50 yards apart but could be 50 years away, to talk to each other and work together.

Q62 Graham Stringer: You mentioned in your answer to Roger the "rarely cover" directive. Should the Government rethink and renegotiate that, or is it a question of schools not organising themselves very well?
Annette Smith: As a directive, it was probably overly taken at face value when it first came out and schools thought that they had to react to it more than they did. If it were gently removed so that schools took appropriate action about cover in their own individual cases, that would be much better. As a blanket directive it was unhelpful.

Q63 Graham Stringer: Does it directly impact on fieldwork? I understood it was introduced where teachers were ill or couldn't get in, but do schools apply it to covering when there is course work done as well?
Annette Smith: Schools were banking their cover so that they would have some availability when the unexpected happened. That had a detrimental effect on fieldwork and taking excursions out of the classroom.
Dr Tilling: Certainly our evidence again is that it does have a major impact on fieldwork and the numbers of groups that are able to go outside. Again, there is a contrast—and I will make it again—between geography and science because of the statutory requirements in geography to do fieldwork and, therefore, there is more leverage in being able to force the issue and go out to do field trips and fieldwork.

Q64 Graham Stringer: I will follow up on Stephen's questions about health and safety. Does health and

safety inevitably produce lots of extra paperwork or is that an urban myth?
Annette Smith: It doesn't have to, no.

Q65 Graham Stringer: In your experience, does it? Do teachers overindulge themselves in paperwork that is unnecessary?
Annette Smith: Dr Tilling has something to say. He is nodding furiously.
Dr Tilling: I was agreeing with everything you said until the very last bit about the teachers indulging themselves. I have just gone through this with my wife, who is a special needs teacher, for example, who takes children away on residential trips in a local authority that will remain nameless. If you chart back to the original guidance in 1998, it was quite short, sharp and succinct. It has been translated into a 189-page document in the local authority, which she has to read and apply. I don't think that is her choice as a practising teacher. That is the guidance that she has been given.

Q66 Graham Stringer: That is a really good example. Are there other occasions when teachers are too cautious and do unnecessary paperwork? The reason I ask is because there seems to be a variation in experience. Some of the evidence is that this is a huge burden and some of the evidence is, "Well, we get it done very quickly." I accept what you say about the 189-page document, but are there other occasions when teachers do look to the paperwork to cover themselves?
Dr Tilling: Again I will tackle that from the fieldwork point of view rather than practicals generally. Yes, I think it is true to say that, when we worked, for example, in inner London, health and safety was being used as an excuse not to do outdoor science and fieldwork.
Annette Smith: It also reflects teacher confidence. In your question you referred to this. If a teacher feels less confident in taking a practical or a fieldwork activity, then they will overly rely on the paperwork. They will spend too much time concerning themselves with the paperwork. A more confident teacher will have a clearer idea of what the risks are and be able to deal with them appropriately.

Q67 Graham Stringer: You have confidence in local authorities burdening teachers with paperwork. Are there any other drivers for the paperwork?
Dr Tilling: Education visits co-ordinators seem to have evolved in a significant number of schools from people who were originally set up to support these types of activities to ones who are there to very much implement health and safety to us. It varies from school to school, but certainly, as I say, since 1998 we have been creating tiers of bureaucracy. Despite the best intentions, I think certainly within schools and sometimes within EVCs there is that barrier. Quite often it is health and safety linked.

Q68 Graham Stringer: If I combine the last two answers into my last question, what then is the solution to these drivers for extra bureaucracy? How can individual teachers be better supported? That is specifically about field trips and practicals generally.
Dr Tilling: I would respond by saying, take what already exists, which is a very good and practical working model, which is the Learning Outside the Classroom Quality Badge. It is based on a very pragmatic and practical approach and would support science fieldwork to the extent that it needs to be supported. Because it is a relatively simple, straightforward and common-sense approach, it will give the teachers the confidence to embark on it.
Annette Smith: Yes. There are quantities of easily accessible advice available. I have referred to our publications before. They are easy to read and they are practical guides. It is a question of teachers engaging with those.

Q69 Stephen McPartland: We are running out of time so I will be quite brief. Do you believe that no practical would be better than a bad or a boring practical lesson?
Annette Smith: That is a very good question. There is an expectation with young people that science will include an element of practical, so no practical at all would be extraordinarily disappointing to young people who see science as having a component of practical work. There is no need for it to be boring or pointless. It can enhance the learning as nothing else can in science. Going back to where we were talking about Getting Practical, that bound in the learning in an extraordinary and wonderful way with the activity that was going on.
Paul Cohen: Obviously we want to avoid a situation where it is that choice. I don't think it is that choice in the vast majority of cases. Your point refers to the need to ensure there is a quality experience. There is plenty of evidence from Ofsted and bodies such as those represented here that poor-quality practical work is of very little, if any, educational value and can be off-putting. There was a question earlier about the degree of demonstration. Demonstration is an important aspect. If it is demonstration and no involvement by the young people, then that can be off-putting as well. We are very clear in the standards in the CPD that we support that quality has to be at the cutting edge.

Q70 Stephen McPartland: The reason why I ask is because we have had a submission, and one child was saying effectively, when they wrote in to us, that they had to do practical work with soap and water; it was very repetitive, and they had to wear safety goggles, so it was very dull and very boring.
Paul Cohen: They might be better off not doing that.

Q71 Stephen McPartland: Exactly. That switched them off from science. That leads me on to another point. Dr Smith, you said earlier on that the majority of children are not particularly interested in the theory side of it; they want to get hands-on and be involved in the practical and the exciting stuff. Do you feel that teacher and technician-led demonstrations are positive or negative?

Dr Smith: They can be very positive. In a way they are almost something the young people could aspire to be able to do themselves.

Q72 Stephen McPartland: Do you think they could replace practicals?
Dr Smith: If they are given a rational explanation as to why they are not able to do that particular practical themselves, whether it is a safety consideration or a lack of resources, then the young people can think, "Okay, that's fair enough. That is a reasonable explanation. What can I do that is related to that demonstration? How can I work with similar materials?", maybe.

Q73 Stephen McPartland: Do you think there has been a move towards these teacher and technician-led demonstrations because it is much faster and easier to do than it is to allow the children to do the practicals themselves?
Dr Smith: I would hope not. On whether or not that is directly true, I would reserve comment.

Q74 Stephen McPartland: Would anyone else like to comment, in your experience?
Annette Smith: I do not have any figures for it, but I think Dr Smith refers to a really important point, which is to set the practical, whether it be demonstration or hands-on, in the context of the learning. A lot of talk and discussion has to take place beforehand in order to fit the practical to what is being learned, to the learning objectives and to the theories that are being demonstrated, and then to look at what has happened and talk about that afterwards. That is a really important part of it. In the soap and water experiment that you are talking about, clearly the young person who responded had not got the reason why he or she was doing that. They had not got the understanding of what that was showing or caught up at the end with what happened and why that happened. That is a clear example of a missed opportunity.

Q75 Stephen McPartland: Do you think there should be a ratio set of the minimum proportion of practical to theory lessons?
Annette Smith: Not really, no. There ought to be an understanding that practical forms an important part of science, but to set criteria like that is a bit difficult.
Dr Smith: If you set a minimum amount, there is always the tendency, certainly, for some people to think, "Right, I only have to do 10 practicals this year", for example, when there is the potential to do 20 or 40 or however many your lessons allow. There is no reason why every single science lesson could not have a practical component within it.
Dr Tilling: A lot of the practicals and certainly fieldwork these days are driven in secondary schools by assessments and exams. The nature of the practicals is sometimes driven by the assessment methodology. Again, there are contrasts with other subjects that can be made. GCSE for science in terms of fieldwork, for example, is a black hole. It is a neuro-inhibitor. All the practicals tend to be there to deaden the nerve senses, in comparison to geography. For example, in controlled assessment in geography, the students will be asked to make a comparison of the upper and lower regions of a river. It is that broad. They will go away and study the river. The comparison that is made in science, for example, might be a choice chamber experiment over 30 or 40 minutes with woodlice or earthworms. There is a different level of intellectual investment and the type of hands-on work that is going on. That is a critical issue for the whole subject. That then comes back to how important this type of approach is in the curriculum generally.
Paul Cohen: I agree with Dr Tilling. The answer rests in the curriculum and the means of assessment. Getting that right and having the time available, whether it is for the preparation that we talked about or for the sort of open-ended type of experiment in practical work, is critical. That is probably the way to go rather than trying to prescribe set amounts of time, which is not only counter to the way in which the school system is moving generally but also runs the risk, as Dr Tilling said, of going down to the lowest level and then saying you have done what is necessary.
Dr Tilling: Can I come back to your very first question, which was "Is it worth doing if it is bad?" I would say if you have one in five GCSE scientists going outside the classroom, which appears to be the situation we are in at the moment, things would have to be very, very bad to not take the other four out of five out and try something.

Q76 Stephen McPartland: My final question is this. One of the themes we have had is that the curriculum is too full to make time for practicals. I could ask you what we should remove from the curriculum, and every single one of you would give me a different answer. If I slightly rephrase it, do you feel that there should be a higher weighting of marks for practicals within the science GCSE so that teachers can devote more time to them? At the moment I think only about 10% of the marks go towards practical lessons, which suggests that you would spend 90% of your time doing the theory to get the best marks.
Dr Smith: Again, it is the way in which it is delivered. If you have the criteria set like that, what you potentially end up with is very staged and very directed practicals that are not open-ended, that are not as engaging for the young people, and so you counter what you are trying to achieve by saying, "We will reward you more for doing practical work but we will give you a very dull practical to do." The two are very much a contrast with each other.
Annette Smith: I absolutely agree. It is to do with the quality of the assessment rather than the quantity. With practical work and what we have called in the past, and what we still call at the moment, "How Science Works" and "The Nature of Science", it is not a trivial task to assess that part of the science curriculum. A great deal more concentration needs to go on in that area in order to get it right and in order to drive interesting and engaging practicals that support the learning.
Dr Smith: It is about the learning that can be achieved by having a particularly good practical that maybe is

not assessed, and the learning that comes from it and the understanding and the turning that theory into life for the young people. That is a value you cannot put a number on and you cannot quantify.

Stephen McPartland: Thank you very much.

Chair: Stephen, you had a very quick final question.

Q77 Stephen Metcalfe: Yes; thank you for indulging me, Chair. Are we right to think there is great value in practical science, and therefore do you all individually agree that we need to do more of it in the classroom? If so, what are you individually in your organisations doing to promote that and cut through some of the barriers that we have come across in our evidence? Could I ask you to be brief? I know it is a broad question, but I have snuck in at the end there.

Paul Cohen: I do think it is very valuable. All the evidence suggests that it is valuable. I also think, as has been said consistently on the panel today, it is important that the quality is right. That matters more than the quantity. Therefore, I would advise that Ofsted focus even more than they are doing at the moment on looking at the quality and calling schools that are not up to scratch on the quality of what they provide.

Annette Smith: The reason for doing practical work is so that young people can relate the science theory that they learn in the classroom to the real world. They can do that significantly outside the classroom, but it can also be done inside the classroom. If we want young people to really engage with science, good-quality, thoughtful, well-planned and well-prepared practical work is the way to do it. It is absolutely vital to science education, I feel.

Q78 Stephen Metcalfe: What is your organisation doing to practically promote it and cut through some of the barriers?

Annette Smith: We have come to the end of the Getting Practical project, which was supported by Government. There is some legacy from that, which we are continuing. This is the idea that we are going to engage with research and professional development and present some solutions to some of the barriers that have been facing practical work in the past. We also support science laboratory technicians and all teachers, and have done for over 100 years now.

Dr Smith: Practical work needs to be engaging, inspiring and exciting; and it needs to be a fundamental part of the science curriculum, unquestionably. What are we doing about it? We have concern about the amount of resources available in the classroom to support practical science, whether from a cost or a storage point of view in small rural primary schools. We provide a Free-to-loan Resources Kit Club where schools from Norfolk, Suffolk and into Cambridgeshire come to us to borrow kit boxes which are free. It works like a lending library. This works, but it needs to be expanded. Obviously it is not going to work asking a teacher to travel 200 miles to borrow one kit box. We need more of those around the country. We provide masterclass programmes. In two weeks' time we have 26 teachers currently signed up to attend a day of high-quality talks and a practical session about reproductive technologies. This is a subject that teachers have said they would like to be updated in, and that is the basis of our masterclass programme, responding to what teachers ask for in terms of their science knowledge and development. We think that linking teachers with scientists, both in primary and in secondary, can support their confidence and the need to keep teachers up to date in modern times.

Dr Tilling: If I can give two quick responses, one is the obvious one. We are doing as much as we can to give practical support. We will continue to run field courses for 600-plus secondary schools. We have started a centre in east London to try and make fieldwork accessible to inner-city schools, where again there has been an issue. We continue to produce 150,000 publications a year to support those who cannot come to the centres. I think the most critical intervention the FSC is trying to make at the moment is a surprising one for an organisation which traditionally has not been involved in campaigning. We are spending an awful lot more time in trying to get the words into curricula and into places that matter. Again, I will come back to geography, although I promised not to. Those words matter because, once they are in there, everything else starts to flow from them. The Ofsted inspections, the senior support, the resources, the intellectual investments and how to do it better have all flown from those simple words in the curriculum documents saying, "You must do it." Without those we will continue, as we have done over the last 25 years, to look at a problem rather than a positive development.

Chair: Thank you very much to all four members of the panel. It has been extremely interesting.

Examination of Witnesses

Witnesses: **Beth Gardner**, Chief Executive, Council for Learning Outside the Classroom, **Professor Graham Hutchings FRS**, Chair, Science Community Representing Education (SCORE), **Sir Roland Jackson**, Chief Executive, British Science Association, and **Steve Jones**, Director, Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS), gave evidence.

Q79 Chair: I welcome the four of you here. For the record it would be helpful if you could introduce yourselves.

Beth Gardner: I am Beth Gardner, the Chief Executive of the Council for Learning Outside the Classroom, which is a national charity responsible for promoting learning outside the classroom.

Professor Hutchings: I am Graham Hutchings. I am Chair of SCORE, which is a collaboration of five organisations: the Association for Science Education,

the Society of Biology, the Royal Society, the Royal Society of Chemistry and the Institute of Physics.
Sir Roland Jackson: I am Roland Jackson. I am Chief Executive of the British Science Association.
Steve Jones: I am Steve Jones. I am a Director of CLEAPSS, the School Science Service.

Q80 Chair: Thank you very much. Some of you at least heard the previous witness session. Science departments tend to be considerably more expensive to run than an English department. Is there any way that schools can be encouraged to see more value in their science department? Don't fight over it.
Sir Roland Jackson: That is really interesting, because that is a question of what one values and a question of culture and how one thinks about science. Listening to the evidence just now, I was particularly struck by the final exchanges this morning and some of the evidence that has been put before you already. What I think we are missing in the science curriculum that gets very much to the heart of practical science is that science is a fundamentally creative activity. Scientists are creative people, and we absolutely need that creativity for social development and for economic growth. We need people, therefore, to be scientists and to understand what it is like to be creative as a scientist. We expect it with art. We expect it with geography, as we have just heard. We don't seem to expect it and value it with science. I would like to see schools, and maybe our society as a whole, valuing that creativity in science more and following through to the logical conclusion, which is that an essential part of education in science should be opportunities for young people to be creative in their science. That, for me, is an important aspect of the sort of practical work that we should be seeing in schools.
Professor Hutchings: I am going to make a joint point to that in the sense that what you are pointing to is a sort of tension that exists throughout education. In the higher education sector, you have exactly the same tension as to where resources go, because resources are not ring-fenced in any particular way. It is easier to think that you should not put financial resources into a particular subject because you can have less teachers in one subject and more resources put into practical work. That is always going to be a tension when you devolve budgets in a particular way. That is going to be a result that will go through for some time. We are all passionate about making sure, as Roland was saying, that children are enthused about science and they get that. Following on from a point that was made in the previous session as to whether there should be a minimum level, I do not think there should be a minimum level but there should be a requirement that this is in the National Curriculum and then it has to follow. The point I would make is that you are alluding to the tension and it is a real tension.
Beth Gardner: I do not think we are the best placed organisation to comment on the cost of different departments within schools. One key point I would like to make is that learning outside the classroom for science or any other subject does not have to be expensive. A lot of the time we forget about the vast resources we have in the school grounds and in the local community. We would really like to encourage schools to think about those as part of a frequent, continuous and progressive approach to learning outside the classroom which should be going right across the school and integrated into the curriculum. That stops the one-off, expensive end-of-term school trips that tend to happen in schools now.
Steve Jones: I was interested in the question at the outset because it implies that they perhaps don't see that they are getting value for money at the moment. I missed the earlier part; so perhaps that has come from there. It is not my experience that all senior leadership teams think their science department is very expensive and they are not getting value for money. Some see it as an asset and think that they do get value for money from it. I suspect that very much depends on what happens in the classrooms in those science departments and whether what you are getting is really value for money or not. We mentioned that we have a side issue. There are techniques—we are very fond of micro-scale chemistry, for example—that we refer to in the submission. There are ways of keeping a handle on the costs without reducing the practical activities done in school.

Q81 Chair: Do you think all schools understand that, in your experience?
Steve Jones: Understand?
Chair: That you can keep costs down.
Steve Jones: No, probably not. Probably an increasing proportion of science technicians understand the value of those activities. Particularly in chemistry we have a tradition of, dare I say it, bucket chemistry in this country where everything has to be done with very large volumes of substances all the time, which is not necessarily true in fact. CLEAPSS is on a mission at the moment to try and convince more people that there is value in smaller-scale activities.

Q82 Stephen Mosley: You are talking about bucket chemistry, and then you move on to me as a chemistry graduate. As you can probably imagine, a great many of the submissions we have received say that one of the key factors of successful science teaching is a good teacher.
Steve Jones: Yes.
Stephen Mosley: I guess you would all agree on that.
Steve Jones: Yes.

Q83 Stephen Mosley: The Royal Society reported in 2007 that, when there was a good match between the teacher skills and the curriculum that they were teaching, the quality of the teacher was more likely to be assessed as good, very good or excellent by Ofsted. Does that mean that one of the problems with practicals is that we do not have the right teachers in the right jobs?
Professor Hutchings: If you look at secondary education, there is a shortage of specialist teachers in a number of subjects. That leads to confidence issues. The answer to the question is, yes, we do not have enough specialist teachers to teach the subject in a particular way. It means that people do not have the confidence to deliver the level of practical. Consequently, if they do not have the confidence, they are not going to go through with it, to some extent. The Institute of Physics recognised that there is a shortage of 500 specialist physics teachers, for

example.[1] That is a huge resource deficit that takes some years to build up. Even if we started training lots of physics teachers now, it would take a long time for that to go through. There is a similar shortage, but not to the same extent, in chemistry. We have very good teachers. It is just that we need more specialist teachers in the right positions.

Sir Roland Jackson: There is another dimension. That is right, but there is an issue with the experience and qualifications of teachers with respect to what I have described as this real open-ended creative work, which I think is the essence of science and which we should be offering to our young people. That does require some experience of doing that research oneself. Throughout our education system—and I am including universities in this—I am not sure that our science students throughout that process get enough exposure unless they go on and do a PhD. I do think that is a concern. I think we have got the balance wrong on our emphasis between understanding the solid theory and facts, which is essential for any grounding, but then having that confidence and ability to recognise that at the frontiers everything is uncertain but actually you can explore this creatively. That is what being a scientist is about. As I said before, that is where our future economic growth and prospects are going to come from. We need people who can do that.

Steve Jones: I would second that. There is possibly an over-emphasis on the transmission of knowledge rather than the understanding of what science is like when you do it. Practical work is critical to that because it offers you an opportunity to experience what it is like to inquire about something. A lot of children learn about science but do not necessarily learn what it means to be a scientist. You mentioned creativity earlier on. If you haven't done that bit, that is the bit where the creativity takes place. So you end up with a rather flat view that it is about acquiring a lot of knowledge that we already have rather than creating new knowledge, which is what it is really all about.

Beth Gardner: There is a gap in how we support our teachers and how we train and develop them. We heard earlier from the TDA, and my colleague was talking about the indicators within the Initial Teacher Training curriculum. The indicator only expects Initial Teacher trainees to have planned something practical. It does not expect them to go and carry that out. This is a case of expecting learning outside the classroom to happen from planning inside the classroom, and that is just going all the way through their teaching career. If we looked at those indicators and supported Initial Teacher trainees to think about the practical elements of their teaching, how they can be very inspirational and how they can lead to increased attainment, that would go some way towards achieving the goals that we want.

Professor Hutchings: I would like to make an additional point. It is not just having sufficient teachers. There is a deficit of technicians. Without the technical support, the teachers will not have the time, the ability or resources to do the experiments and the demonstrations. It is critical that it is technical support and the teachers together. That is the key issue.

Steve Jones: We are very keen on supporting technical support. It is one of the major functions of CLEAPSS. I have brought the papers from committees from five years ago and from five years before. The story about school science technicians is depressingly repetitive in those. They are, generally speaking, rather undervalued and possibly seriously underpaid. They often work term time only. They do not have any opportunity to do any work inside the holidays to get on top of situations. Without that technician support, it really undermines the teacher's ability and willingness to do different, varied practical work. I would not say it is unique but it is a distinctive feature of science education in this country that there is proper technical support.

At the moment, one of the things that CLEAPSS is alarmed about is that technicians tend to get lumped in with support staff in general in schools. At the moment schools are under pressure to cut all sorts of things, including support staff. We have had an increased number of calls to the helpline from concerned technicians whose total technician support time in school is being cut quite significantly in some cases, which, against a backdrop of fighting to keep the practical component in the science, is quite concerning at the moment.

Q84 Stephen Mosley: You do raise quite an interesting point. One of the things that came out of the evidence we have seen is that there is a belief that teachers do not really have the time to do the professional development. We had one or two suggestions about whether we could use field trips to allow teachers to do CPD at the same time as the kids were doing the field trip, and using those sorts of opportunities. You have raised something that I do not think has been raised all that clearly in the evidence, which is that you also have the technicians. If they are only there in term time, they actually have a huge amount of time outside that which if the schools and education system moved to allow them to do some CPD during the holidays—

Steve Jones: The technicians?

Stephen Mosley: Yes; the technicians.

Steve Jones: We have tried that, and the turn-out was very poor. Generally speaking, technicians are only paid to work in term time. It is a way of cutting the costs in schools. They are not paid to work outside term time. That is not true across the piece but it is quite a common model. There is a possibility there. About three quarters of our training is taken up by technicians. The courses that we offer for teachers about "Exciting and Engaging" practicals, "Surely that's Banned" or "Safe and Exciting" demonstrations don't recruit an audience. They get cancelled all the time, because the teachers can't, or won't, come out of school on the courses. At the moment we are trying a twilight model to try and get round this, where we will deliver a two to two-and-a-half-hour session to an audience of teachers at the end of a day. That is not a great moment to be having your CPD session when you are exhausted after a day's teaching, but we tend to get away with it with ours because they are

[1] Note by witness: The Institute of Physics estimates that 500 **schools** are without a specialist physics teacher

very hands-on and practical. You come to a session and you do science for two and a half hours rather than sitting around talking about it. That does work. We can make that work functionally for us by tagging it on to whole-day training courses that are for technicians who can get out of school and come on them. We have only done that for the last six to eight months, but I think that might be an interesting avenue. It is not an ideal solution but it would produce more training for teachers on practical activities.

Q85 Stephen Mosley: Throughout the responses you have given, you are saying there is recruiting people in the right place and making sure that people going to university have the interest they can then pass on; but you also have the CPD side of things. Is there a balance between the two? I know if I say which is more important you are going to say both. I will ask that question and hopefully I will not get a "both" response.

Steve Jones: I don't think it is possible to say anything other than "both". The context in which the folks are working is changing, so to keep up to date CPD is very important. Queries to our helpline have gone up quite a lot in biology in the last couple of years because of increased use of unfamiliar areas, particularly in A-level biology specifications where teachers and technicians do not have the skills needed to deliver those new areas of the curriculum. You need CPD for that. You cannot build that in at the outset. Unfortunately, you do need both.

Professor Hutchings: Can I make a point? What enthuses children is enthusiastic teachers. Enthusiastic teachers come from people who have been continually challenged throughout their career development. It has to be an integral part, but you have to recruit the right teacher at the start. The right teacher has to be trained at the start. We addressed that in the previous submission of evidence.

Q86 Stephen Mosley: From experience, do you find that those enthusiastic teachers are people who have had an enthusiasm from a young age and gone through school and university looking at the subject, or is it the case that you can teach an old dog new tricks? Can you teach a 40-year old who has always specialised in English to suddenly become enthusiastic about chemistry?

Professor Hutchings: It would be an interesting experiment, and we are talking about an experimental subject so it would be worth doing. I don't know. If they have O-level chemistry—going back that far—it is always possible, but they have to have the drive to want to do it and the confidence to be able to pick up the chemicals and do it, or whatever aspect of science it is. I would not rule it out but it would be a very brave experiment to start.

Beth Gardner: We have done a lot of work looking at the barriers to learning outside the classroom. They are the typical barriers that are cited all the time: cost, time, health and safety, and bureaucracy. When you drill down beneath those barriers it is quite interesting. You can get two very similar schools with very similar catchments and similar resources. One will be very good at learning outside the classroom and one will not have embraced it at all. When you look at drilling down, it is purely down to the motivations of teachers. There has been some work done by King's College London looking at these motivations. It is whether teachers have been exposed to that, throughout their own experiences of the education curriculum and throughout their ITT—whatever they have done in the past—that tends to be when they are more motivated. But we also have experience of when you can really enthuse teachers and they really get it and change their practices.

Q87 Stephen McPartland: We all accept that enthusiastic teachers enthuse children. We all remember a good teacher. Maybe one of the barriers to outside learning is that there is this huge myriad of support groups and organisations that will help teachers do everything that they want to do when it comes to science. I wonder whether there are many teachers who are confused with the amount of information and support groups that want to help. It is almost as if there is too much out there. Would any of you agree?

Sir Roland Jackson: There are a lot of organisations, especially, I guess, third sector organisations, who feel very passionately about particular areas of science and want to make those opportunities available to young people. There can very much be a confusion, but there has been a growing recognition over a number of years that all the organisations—and we would be one of them—who seek to work with schools and offer these opportunities need to work much more effectively together. We have done a number of things over the past few years to try to do that and present a more coherent picture to schools, colleges and teachers.

Over the last few years, for example, the STEM Directories project has brought together in a very accessible way, both in printed form and online, a searchable directory of who is offering what and where. Also the various groups who support what you might call enrichment activity in science have got together in a big way to produce the Big Bang Fair that some of you may be aware of and work together to promote the National Science and Engineering Competition. The network of STEMPoints funded through STEMNET—and the contracts are just being re-awarded at the moment—are intended to be local centres for teachers and schools that essentially provide information and are there as a content form for information for schools and teachers. We are trying, and we recognise that there is potentially a complex picture.

Professor Hutchings: In the case of SCORE, the partner organisations—the Royal Society of Chemistry, the Institute of Physics and the Society of Biology—will offer specialist advice. I would have thought they would be a first port of call for specialist teachers or those teachers interested in a particular subject. Thus, if you were interested in chemistry, you would go to that website and see what there is. They are extremely effective in dissemination of information. I agree that if you put anything into Google you are going to get a whole range of things

coming up, so you have to be selective. I think teachers know where to go and get that information.

Sir Roland Jackson: I think the richness is a real strength in this country but it does require a bit of co-operation as well.

Beth Gardner: Could I answer by coming back to an earlier point that you raised? Looking at the different quality marks that are available, that was one of the reasons behind setting up the Learning Outside the Classroom Quality Badge. It is one badge across all of the sectors. It is very important for science, but it also stretches across cultural activities, expeditions, adventurous activities and natural environment work. It is one badge, making it easily recognisable for teachers looking at the quality of education as well as risk- effectiveness. That is one way we are really trying to work with all of the sectors to make things a lot simpler for teachers and others working with young people.

A second example is in the natural environment sector, where we are partnering on the Natural Connections project with Natural England, which is being supported by DEFRA. Again that is bringing together all sorts of different providers working within the natural environment sector, making offerings to schools to help them get young people out to do practical science experiments and other things. We are trying to have a coherent offer by the whole sector, because schools have told us that things are quite disparate out there, they are being approached by all sorts of different people and it is confusing. There are mechanisms afield to try and address that.

Q88 Stephen McPartland: It is fantastic that the science community wants to be so engaged in learning in our schools, which we all welcome. As you have mentioned, Sir Roland and Professor Hutchings, there does need to be a greater coherence. Do you feel that somebody should be responsible for pushing that coherence or should it just be up to the groups themselves to co-operate? In our experience as Members of Parliament, we have large numbers of interest groups who are very passionate about particular interests but they are often not too keen to co-operate with one another. They just want their view and their point heard.

Sir Roland Jackson: I don't think anyone could do that, because these groups are so individual, they are autonomous, and the funding comes from all sorts of different organisations. Some is from public money, but a lot is from charitable sector money or even from the private sector. So it has to be a collective effort, and I do think people are lining up behind things that will enable them to do so. If you take the CREST support programme which we run, supporting creative work in schools, we partner through that with a lot of other schemes like the Engineering Education scheme and the Nuffield Science bursaries to help to provide a common structure and offering to schools. I mentioned the Big Bang. That is a really huge national collaboration. Over the next few years that will have even more effect on the way that people work collectively together. I do think it is our responsibility. I don't think anyone can do it for us.

Professor Hutchings: SCORE is an example where five organisations have come together. You have the chemists, the physicists, the biologists, the schoolteachers and the Royal Society, which overarches the whole scientific community of the UK. We are pooling our expertise and speaking with one voice on education. We produce research reports and there is a website that is there. Maybe we have to get that message further into the community. We are certainly trying to do that. Yes, I think it is possible.

Steve Jones: There is a very concrete outcome from that. Over the last two years a small project was funded by Government called Getting Practical. Has that been mentioned so far? That focused on trying to sharpen up practical work. That was a very cost-effective way of having a focus for that area of work. In the light of some of the other things that have been said, I am often struck by the fact that there is a lot of co-ordination around enrichment, enhancement and additionality. It is a difficult thing for me to say—I don't know what my colleagues will say back in the office—but CLEAPSS deals with the day-to-day, what-you-do-in-the-classroom practical activities. Those do not get much of a press because it is assumed that everybody knows how to do that. My biggest concern is that those things that we take for granted are in danger of disappearing out of the system because people no longer know how to do them. There might be some call for co-ordination around a focus on getting good quality basic practical work going on.

The Getting Practical project had that possibility. It had a theoretical basis. It had an argument for a methodology for looking at the purpose of practical work, but it also acted as a focus for all sorts of organisations promoting practical activities in science. That made quite a difference for a relatively small investment.

Q89 Chair: Sir Roland, you mentioned the Big Bang. Why is it that the Big Bang is dominated by private schools?

Sir Roland Jackson: I am not sure it is dominated by private schools.

Q90 Chair: I had this discussion with Sir Anthony Cleaver a couple of years ago when it was in Manchester. The exhibition was overwhelmingly private schools. There was one very good grammar school or secondary school in Edinburgh, I think it was, that had a very good exhibit, but there were hardly any state schools.

Sir Roland Jackson: I hesitate to question that—and I can give the Committee the evidence if you like—but I don't think that is entirely correct. I would be fairly sure that private schools would be over-represented, but I don't think to the massive exclusion of the state sector. You are talking here about the young people who were demonstrating their projects as part of the National Science and Engineering Competition. The interesting thing is that in all the years so far, and it is three years now of the National Science and Engineering Competition, we have not had a winner from the private sector. They have all been from the state sector, which is interesting. Where

teachers in the state sector are able to do this work, and there are many very excellent ones—I point, for example, to Becky Parker, whom you will know at Simon Langton Grammar, who is an absolute model in the state sector—they do it very well. If some of them can do it, I do not see why all of them cannot do it in principle.

Q91 Chair: That is an important point. Comparatively, I suspect, there is still a shortage of entrants from the state sector.
Sir Roland Jackson: Comparatively, I think that is true, but I would not want you to think that there is a massive over-emphasis on the private sector. I really don't think there is, and we work very hard to encourage state schools to participate.

Q92 Stephen Metcalfe: We are looking at the barriers to practical teaching. One of the areas that my colleague Stephen McPartland picked up on was how crowded the curriculum has become. We have anecdotal evidence that between Years 7 to 9, which are the first three years of secondary school experience, people get a real thirst for science. There is plenty of practical work going on and they look forward to doing it towards the end of their secondary school career, and, yet, in Years 10 and 11 they find the stuff that really engages them, the practical side of things, has diminished somewhat. Is that an assessment that you recognise? Do you accept that the curriculum is very crowded and, therefore, time is one of the major barriers to practical teaching?
Steve Jones: That would match what people to whom I have spoken have said. In a previous incarnation I did a lot of pupil interviews. If you interview Year 10 and Year 11 pupils they would often say, "Yes, we did a lot of practical work in Years 7, 8 and 9, but we haven't done anywhere near as much now." I would say that is a fair assertion about what goes on in a lot of secondary schools. The more interesting question is why does that happen? You need to unpick the notion of a crowded curriculum and understand the features inside it. I suspect there is not a simple answer to that.

Q93 Stephen Metcalfe: Could we start unpicking it?
Steve Jones: If you halved the content, so you took out half the concepts, would that double the amount of practical work? I don't know; I am not convinced. It would be an interesting experiment to try, because there are other issues about the extent to which colleagues understand how to make effective use of the practical work. Even if they had the time to do it, they might do more practical work, but would that practical work be effective when they did it? We would have to look at a number of features adding up to that effect, but I think what you have described is a real reflection of what happens. There tends to be more practical work in the lower part of the school.
Professor Hutchings: Time is only one of the factors. You can say that is one of the most important factors, possibly, but there is also the availability and the quality of the labs. In the evidence that the Royal Society of Chemistry have put forward, some years ago they found that 25% of labs were substandard. In 2006, when they went back and looked again, it had got worse, so the quality of the labs is important.[2] As we mentioned before, the confidence of the teacher is important. Doing practicals at the initial level of science is easier to do than doing practicals at more senior levels of science. As you go up through A-level and into university, it gets more and more difficult. The experiments you need to do to enthuse the children require more confidence of the person and more ability of the person. Time is one of the factors, but it is all of those things coming together. It comes back to the confidence of the teacher, which comes back to specialism and having the right teachers there.

Q94 Stephen Metcalfe: One of the bits of evidence that we have had from some of the students who have communicated with us is that, for some, they do not find the practicals very engaging at all and feel that they could get the same amount of effect from watching a YouTube video or looking at it in a book. If we accept that there is a relatively crowded curriculum to get to GCSE, should practical work for those students be optional, or do you think there is a vital part for practical work to play?
Professor Hutchings: It is crucial. Science is an experimental subject. It is born out of experiment. Yes, you have to have the theory. You come up with a hypothesis and you test it experimentally. You cannot have people opting out mentally in that way. Even at the most senior end of the subject where one does computational experimentation—you can do a lot of things by computation that save you doing lots of experiments; industry will tell you about this, and this is very important—you still have to understand how the experiments work. You cannot model things unless you know how it works. It is not an option. It has to be.
Sir Roland Jackson: It is also important to be clear on what practical work is important and when. From your evidence as well and some of the earlier discussions, there are many different legitimate purposes of practical work. Different types of practical work are appropriate in different situations. It is the balance that matters. It is the balance between the way a teacher uses the practical work to deepen understanding of the theory; the way they will demonstrate something that could not be seen otherwise to give access to phenomena that cannot otherwise be described; and then the sort of more extended work I have been talking about of being a real scientist. They are all different. The way in which teachers in schools will value them will also depend to some extent on how they are assessed and what is assessed. Obviously, we come back to curriculum and assessment again because that, ultimately, drives what teachers do.

Q95 Stephen Metcalfe: Where should the responsibility lie for making sure that happens? Is that with the teacher or the senior management within a

[2] Note by witness: In 2006 the RSC found that despite Government initiatives, which aimed to improve laboratory facilities (lime Building Schools for the Future), there was no monitoring system in place to determine the extent to which or whether laboratory facilities improved.

school? How do we ensure that students are receiving enough good quality practical teaching?

Steve Jones: In a school context, the power of involving your senior leadership team in understanding what a quality outcome would look like in science is immeasurable. The deliverers might ultimately be the science teachers and they might work under the direction of the head of department, but, ultimately, if your school senior leadership team understands what a good practical would look like, and expects it to be delivered, then that is the lever that would work in a school. One of the challenges is that I am not convinced that enough school senior leadership teams are sufficiently aspirational about what you could get out of your science department. Going round as a person who gets badged as a person who knows something about science, if you go into any head teacher or deputy head teacher conference environment, at some point someone will come up to you and say, "Oh, you're a scientist, aren't you? I've got a bit of a problem with my science department." If I had a fiver for every time I was told that, I would be in the Bahamas at the moment. They see their science department as a problem and not an asset. Trying to get them to look at it as the asset that it should be is a very important thing and should not be underestimated.

Q96 Chair: That is an important observation. Can I just push you a little further on it? How is that going to be addressed as we give more independence to schools?

Steve Jones: I am not really qualified to comment on that. It will be more challenging to do that, because your mechanisms for engaging with senior leaders as a group are possibly not as clear-cut in a system consisting of a lot of independent schools.

Q97 Chair: In terms of any attempt by Ministers to further devolve responsibility directly to the schools, the only way to address that problem is to make it conditional on handing that responsibility to the school. Is that fair?

Steve Jones: Yes, and then you need a mechanism to do that as well.

Professor Hutchings: You would need to add clear guidance as to what was expected and what would be models of inspirational leadership at that level.[3]

Steve Jones: But it needs to be aspirational. The problem with those levers is that they end up being punitive, and the impact of measures that measure this does not necessarily give the result that we really wanted, which was better experiences for pupils in science classes. Some of the best-intentioned pieces of leverage have resulted in some of the most bizarre curriculum models that have not benefited children at all.

Beth Gardner: Freeing up time in the curriculum for teachers to do what they do best and to teach is absolutely great, and we are very supportive of the Government's move to do that. What we are concerned about is the focus on the "what" and not the "how". If you do not put some thought into the "how", then teachers will just teach how they have always taught, and if they have always taught in a non-practical way that is just going to get worse. To encourage more learning outside the classroom and more practical activity, we need to be putting some thought into that "how", and some guidance, some really good exemplars and some aspirations there would be helpful to support schools to be able to do that.

Sir Roland Jackson: We are quite interested at the moment in the Extended Project Qualification, which I know at the moment is optional and sits outside mainstream subjects and, in a sense, is non-subject specific, but it offers quite an opportunity for science. I understand that Edexcel are looking at the CREST framework that we use to support science projects through EPQs at Level 3. The danger of putting one's eggs in that basket is that, if you look at things that are outside mainstream curricula, I still think the message and the values coming through the science curriculum ought to be valuing this creative aspect of science more than they currently do.

Q98 Stephen Mosley: Talking about the curricula, one of the other issues that people have raised with us is that the examinations do not put much of an emphasis on practical skills either. There is a quote from a child here: "Exams don't test practical skills and any important procedure examined can be learnt from a book." Another one says: "The exams were all about jumping through hoops, and if I'd known how stupid and time-consuming the coursework was going to be, I might have chosen another subject altogether." Do you consider that practical work should be formally assessed?

Steve Jones: It depends what you mean by "practical work" in that. If you mean, "Can you use a thermometer to measure the temperature?", the history of science teaching is littered with attempts to assess science practical skills in different ways, some of which were monumentally formulaic and unsuccessful. Do I think there ought to be a component that assesses how science is done? The answer is yes, because I am rather cynical. If it is not assessed it will not happen. Years of working in the National Strategy focused on the fact that, if it is not going to be measured, it disincentivises people working on it. However, I would possibly observe that there is a limited range of techniques and approaches available at the moment to do this successfully. There was a conference—I wish I could remember when it was—when people got together to talk about how you might assess procedure: understanding how science is actually done. It is not easy and not obvious how to do that effectively.

Sir Roland Jackson: It may be that science teachers and curriculum developers need to look a little more

[3] Please note that SCORE has embarked on a research project which will determine a baseline for the resourcing requirements of practical work. Science is a practical subject and as a compulsory subject in the National Curriculum, it is essential schools resource science education appropriately. The baseline will be in terms of laboratory facilities, technician support, field work facilities and equipment and consumables for primary and secondary school science. This baseline will be used to measure the extent to which schools currently reach the baseline. It will provide national policy advice on the level of resourcing required for science education.+

outside science. Some of the techniques that we are talking about here are perfectly well understood by geography teachers that we have seen and perfectly well understood by, for example, art teachers. It ought not to be beyond the wit of assessors to think about rather more open-ended techniques that allow people to demonstrate their scientific abilities creatively and not just the way that they can understand the theory. I do think that should be a part of the assessment. It is different types.

Steve Jones: It is. As a concrete example of that, there is a very laudable attempt in the latest round of GCSEs to construct the assessment of "coursework" in such a way that it models a proper scientific inquiry process for pupils. They have an issue to inquire around. They get an opportunity to do some research beforehand to find out what has already been done and what is going on. Then they plan a mechanism, a way of going about gathering some evidence. In theory, they are then supposed to carry that out. In practice, there is an option at that point in the process for the school teacher to say, "That technique isn't safe", or more likely, "There are now 25 different techniques here; I can't support that", or, "We don't have the apparatus", and substitute a standard method either provided by the school or the examining body. Then the rest of the assessment process is based largely on the outcomes from that standard method.

In that system, the opportunity exists for a child to really experience what it is like to be given a context, find out some stuff, plan a bit of an inquiry, do it out, collect some evidence and think about how good the evidence is. But, in reality, I suspect that may not be how it turns out because of the practicality of allowing them to follow it through. If we were a bit more open about the way that assessment was run, there would be less of a demand to close it down to that standard method. There is a real tension between being able to nail down that they have definitely done this and it is worth the marks and the opportunity to really follow their own chain of thought.

In a meeting I was in recently, one person said that they might allow their top sets to follow through their own methods. If you think about that for a few minutes, the children who most need to follow through their own methods are not the top sets. The kids who find it slightly harder need to do what they plan so they can talk about how well it went and not do what somebody else told them to do instead, because they lose the whole sense of the inquiry in that. I am sorry, but it is a bit of a hobby-horse at the moment we are having.

Professor Hutchings: If I can—

Steve Jones:—get a word in edgeways.

Professor Hutchings: No, I am not going to get a word in edgeways; it is too difficult. If I can add something, what you have both been saying is that you need to embed experimental work in with theory. Part of the question was an assessment of it as though it is separate, and I do not think it is separate. It is something which is integral to the subject. You have mentioned the extended project in the A-level. Maybe at the GCSE level we need to think about using the extended project more or something that could be brought in, which would then bring together theory and experiments, maybe in the way you have been describing it but in a structured way which could be assessed. That would be a way of bringing in something which is accessible to students, and they can understand that they are not just doing an experiment and trying to get the right answer because that is not what science is about. Earlier you were asking whether a bad demonstration is worse than having no demonstration at all. Lots of experiments in reality do not work. It would be good for students to realise that things do not work and they do not work for a certain reason, but you need very good teachers to get that across.

Q99 Stephen Mosley: Following on from that, I know the British Psychological Society have suggested a viva-style examination whereby, over the course of a year or two years, the students put their practical work in a course book. Then, at the end of the time, they have an interview and basically describe the work they have done and what they have learnt from the practicals and so on. Can you see that sort of model being successful?

Professor Hutchings: It would certainly help their interpersonal skills, wouldn't it, which is not a bad thing? In terms of whether it would work, I do not know. I could see that working at the most senior level. If you think about the way we examine people throughout the entire level, it is at the PhD level where we do an extended oral exam where there are no prepared questions.

Sir Roland Jackson: But that is far too late. Again, if you look around the sort of things that young people have shown they can do through the National Science and Engineering Competition at school, if you give people a little bit of creative freedom, it is astonishing what they can do, and what many students can do. We just do not give them those opportunities. We wait until they start a PhD and that is too late.

Steve Jones: That would certainly encourage pupils and students to talk about their science. With all the work that has been done in schools, there are opportunities for kids to talk to each other and to talk to the teacher about their science to get the best out of them. You get a much better picture of their grasp of things and they talk at much greater length.

Beth Gardner: I have nothing further to add to that.

Q100 Pamela Nash: Most of us in this room agree that good practicals and fieldwork are very beneficial to the student and their understanding of the subject. How much do you think experiencing good practicals and fieldwork is a major factor in how many students decide to continue their study in the sciences?

Professor Hutchings: I think it is a major factor. Anecdotally, myself, if I had not seen a particular experiment at a certain time I would not have become a chemist. I think I can point to lots of people throughout. I have had over 200 PhD students that I have trained. If I talked to all of them, they would say much the same thing. If you talked to all the senior scientists around the country, they will say they were inspired by seeing something or knowing something could happen and then having the chance to go and do things at home, which is much more difficult now

than it was years ago. It is an essential part; it really does enthuse. Something at some point will switch somebody on to the subject. If you think we are going to be a knowledge-based economy in the future and STEM is going to be crucial to generating that, then putting science into the primary national curriculum is crucial in getting young children enthused by science. They do not realise they are doing science; it is not couched in that way, but it gets them using and looking at materials. We follow that on very well up until 13, as we have discussed, and then it starts to go off, and yet the most exciting experiments come in at that later stage.

Sir Roland Jackson: We had an external evaluation of our CREST programme a few years ago. There was certainly clear evidence from that that the experience of doing the science themselves and following their own interest made it more likely for those students to think that they wanted to continue to study and eventually work in science. There is evidence from quite a lot of studies of that type, but I am not sure that anyone has ever done a completely rigorous longitudinal evaluation of all the factors that do or do not predispose people. All of our own experience and experience with these individual evaluations would point very strongly to the motivational and inspirational effect of those sorts of activities.

Steve Jones: National Strategies did some work on progression from pre-16 to post-16 and why students chose to do science. They did some analysis of the grades that students got at GCSE and how many of those students then chose to do science. One of the most striking features of that is that, if you looked at an individual institution and the numbers of students or the percentage of kids with an A or an A* who chose to do physics or chemistry, it would go up and down from one year to the next by a factor of as much as 50%. That strongly pointed at nothing to do with the curriculum but everything to do with the way that that particular subject had been taught in that year, which, unfortunately, leads you straight back to the teacher and in this context, presumably, the effective use of practical activities.

Beth Gardner: Anecdotally, if I am doing training, I will often start off with an ice-breaker of getting people to think about memories from school. 95% of those memories all relate back to something outside the classroom that they have been doing. That relates then to the different industries that people have gone into. I can see really clearly that that has had a marked effect.

Q101 Pamela Nash: That is really interesting. One of the statistics that we have in front of us today is that only 28% of English students and 27% of Welsh students take on science subjects at A-level. As you might tell from my accent, I am not from these parts. In Scotland, we have achieved a rate of 50%. I suspect that the practicalities of the Scottish education system will have a lot to do with that. Most students do take four or five highers and they take a wider range of subjects. For those who take on advanced highers, it is not the same as A-levels. It is only for very competitive courses that they would be required to do that or for fun, to put it frankly, if they were staying on. Are any of you aware of any other differences between the Scottish and English education system? Even, culturally, are there any other reasons why you think we have achieved a higher uptake in Scotland?

Professor Hutchings: I am lost for words for once.

Pamela Nash: You can say no.

Professor Hutchings: As you say, in the Scottish system it is more broad-based. It used to be—I am not sure if it still is—when students progressed through to university they often did a common first year at Scottish universities. Those foundation years have largely gone from English and Welsh universities. They used to be quite common until about 15 years ago, I would say. Because of that broader base, yes, people will be doing science. Whether they are doing it to the required depth that will take them further is difficult to say. If you are alluding to the fact that we should have a E-baccalaureate-type approach at GCSE where everybody has to do everything up to a certain point, we would need to consider the unintended consequences. We can see students now thinking, "We have to do this and this", and science then gets squeezed further in the English and Welsh sectors at the present time. That is a problem, I would say.

We want to make sure that the students make an informed choice at the right level that science is where they want to explore. That level is before they choose their GCSEs. That is the crucial time. Having chosen their GCSEs, they can choose triple science or double science. Often you find that students make a choice at that time which precludes them from doing career opportunities later. We need to make sure that the support is there for the student to make the right decision at that point. That is the crucial period. Often you find that when students are faced with the choice of doing A-levels, they find they cannot take those A-levels because they have not had the right mix of subjects before. Certainly, with degree courses, it gets worse. There needs to be some joined-up thinking going on across that.

Steve Jones: I could not comment, but I know we have a sister organisation in Scotland called SSERC. I am minded to ask them and have a conversation around that. I cannot tell you at this point but it would be an interesting thing to see.

Q102 Pamela Nash: I am sure we would all appreciate it if you could do that and write to us. Just to take that a bit further then, what do you think England and Wales can do that they are not doing at the moment to try and get that level up to something closer to what they have achieved in Scotland?

Steve Jones: I would go for school senior leaders and promoting science and science careers and pathways through it, and to get school leadership teams to value their science department.

Professor Hutchings: Again, I do not know whether you have a shortage of specialist teachers in Scotland. We would need to get the evidence to be able to answer the question. What we could improve in England and Wales is provision of specialist teachers at the senior level. That would then ensure that the practical work would be being done well, being demonstrated well, enthusing the children and getting them to go through. As I said earlier, it is also the

technical base and the provision of the labs. Those things all come together. Maybe in Scotland it is all there; I don't know. Again, I think we shall have to find out and provide some additional information, if that is available.[4]

Sir Roland Jackson: There are so many factors; that is the problem. I would also point to the information available and awareness of young people of what the opportunities are of sticking with science. I still think there is a sense that you study science if you are going to go on and be a scientist. That opens up a huge number of doors. We are seeing some of the guidance to universities—certainly the Russell Group universities—being clear about what subjects they require for entry. It may be helpful to give young people a clearer picture that there are careers in science, but there are also many careers from science and that use science, and sticking with it for a long time, especially with a grounding in mathematics, opens up many more doors than people might think.

Beth Gardner: We are a relatively new organisation so most of our work has been focused on England. Now that we are free of constraints, we will be looking to work within Scotland. It will be interesting to look at the difference in and outside the classroom in Scotland as compared with England and Wales and see whether that has an effect.

Q103 Pamela Nash: I look forward to seeing what you do then. My final question is just to pick up on something that you said, Steve, about leadership and skills in science subjects. As a Committee we visited a school last week. We met a very impressive group of young people. When we asked them what jobs they saw themselves doing, and they were all studying science subjects, they came out with a wide variety of jobs. I was very impressed by that, but it was also notable that they were all science jobs. In your opinion, what are the transferrable skills from studying science subjects? How do we get that across to our students in schools?

Steve Jones: It is a strategy for solving problems, is it not? I have stood on many a platform and said, "If you're not a scientist, I don't really quite know what you do on a day-to-day basis when you have to solve a problem." You use that logical construct of breaking it down and thinking about it and looking for the factors and so on every day, don't you? That is a transferrable skill. But it is the one that you don't get to practise in science if your science is about acquiring knowledge rather than about being a scientist. I would go for that as my No. 1. You are numerate and have all the skills that usually enable you to access careers outside science, but your No. 1 life skill is your ability to solve problems.

[4] Note by witness: The Royal Society state of the nations report *Preparing for the transfer to STEM higher education* looks at the differences between the four UK nations in terms of A-level combinations taken by pupils. The report calls for England, Wales and Northern Ireland to aim to emulate the high levels of student participation in science and mathematics evident in Scotland. Scottish students study a broader range of subject's post-16 in comparison other UK nations. Data suggests that it is already established practice in Scotland to take post-16 combinations involving two core sciences and mathematics—a combination strongly desired for STEM HE.

Q104 Pamela Nash: Any other ideas?

Professor Hutchings: No; I think you have hit the nail on the head, basically.

Sir Roland Jackson: Organised scepticism is the root of what science is about. That sort of approach is helpful in all sorts of walks of life.

Steve Jones: It is an antidote to advertising, isn't it? It enables you to respond assertively to adverts. My wife's son is now trained to look at those little tiny words that come across the bottom of the screen when the adverts come up that say, "This was done on a sample of six people one Thursday on a rainy afternoon", and then he goes, "Hmm, yes, perhaps I won't believe what they are claiming about it." You are then in charge of your own destiny, aren't you? You are not going to get hoodwinked. That is what it is really all about.

Professor Hutchings: The scientific method is applicable in real life.

Steve Jones: Interestingly, I had not really thought just how different that way of thinking is. I did a session for technicians in a nearby local authority. We investigated whether water divining works or not, which was interesting as an activity. The idea obviously is that you had to collect some evidence to show one way or the other whether it worked. Everybody was very sceptical because they all had a background in science. The first person picked up the set of rods, held them over a bucket of water and it appeared to work. So there was consternation and they all said, "Give me the rods; give me the rods; give me the rods." What they did was they all grabbed these rods and tried it. "My God, she's right. It works for me; it works for me." Other people said, "Give it to me; give it to me." After about 20 minutes it was obvious that nothing else was going to happen apart from the fact that more people were going to try it with more water and rods. I had to stop and say, "This is all very interesting but what we are doing here is a sort of social sciences inquiry. Is anybody going to do any science?" There was a little bit of an awkward silence and then somebody said, "Oh, hang on a minute. I can see the water in that pot. Perhaps that is affecting it." Then, "All right, we have to cover up the rods and cover up the water so we don't know whether it is there or not." But it showed that the natural way of thinking about things is not necessarily a scientific process, and yet there is the power of it once you have all the science, because at the end of the scientific process you potentially could know whether it worked or not. It did not matter how many people came in the room, picked up the rods and tried them. At the end of it you still would not know whether it worked or not. That was very striking, so it showed a distinct way of thinking. Even people who had been trained in that needed to be prompted to use that approach to come up with an answer, which was fascinating to watch. I will probably get arrested for doing water divining.

Pamela Nash: Thank you very much. We certainly appreciate that.

Chair: We drifted a long way from Scotland in the responses to those questions. Thank you very much for your contributions this morning. It has been extremely helpful. We would be grateful to receive

any additional information on some of those interesting points, particularly any data you have that compares the Scottish system with England, Wales and Northern Ireland. That does seem to leave a question mark in the air in terms of the responses you were able to give us. Thank you very much indeed.

Monday 4 July 2011

Members present:

Andrew Miller (Chair)

Gavin Barwell
Stephen McPartland
Stephen Metcalfe
Pamela Nash
Roger Williams

Examination of Witnesses

Witnesses: **David Knighton**, HMI Principal Officer, Subject Surveys Integration, Ofsted, **Kevin Myers**, Deputy Chief Executive, HSE, **Dennis Opposs**, Director of Standards, Ofqual, and **Nigel Thomas**, Director of Education, Gatsby Charitable Foundation, gave evidence.

Q105 Chair: May I welcome you, gentlemen? Thank you for coming this afternoon. It would be very helpful if you would introduce yourselves for the record.

David Knighton: I am David Knighton, one of Her Majesty's Inspectors. I have responsibility for oversight of Ofsted's subject survey programme, which includes our specialist inspection of science.

Kevin Myers: I am Kevin Myers, Deputy Chief Executive of the Health and Safety Executive, which is the primary health and safety regulator in this country. For the purposes of today, I need to declare an interest. My wife is a head teacher of a primary school.

Dennis Opposs: I am Dennis Opposs, Director of Standards at Ofqual. Ofqual is the regulator of exams, tests and qualifications in England and vocational qualifications in Northern Ireland.

Nigel Thomas: I am Nigel Thomas, Director of Education at the Gatsby Foundation. We are a privately endowed charitable trust with an interest in science and science education.

Q106 Chair: Whether by coincidence or not, this weekend we had some interesting press exchanges with Judith Hackitt and discussions about things that happen in schools. This was the area that started our inquiry and led us to go down this route. We were hearing concerns about the way health and safety was being applied in schools. Since then, other issues have cropped up that have given us perhaps even greater concerns about science practicals. Mr Myers will be aware that I am serving on Professor Löfstedt's review of health and safety, although we have not yet got down to the detail of schools in that discussion. It would be helpful if all of you could set out your thoughts. First, is there a problem in terms of the way schools interpret the advice they are given on health and safety? Secondly, are our concerns warranted and are there broader issues we should worry about in terms of the conduct of science practicals?

David Knighton: I have to say that we have no evidence that health and safety issues are restricting the nature or quantity of practical work in schools. That is the simple answer to your question. There may be issues in individual schools, but the overall picture that we are picking up from our survey work is that this is not a significant matter in relation to practical work in schools. There may be other factors which are affecting it, but that is not a significant one.

Kevin Myers: There is a general issue in society about health and safety, which has effectively replaced mothers-in-law as something that comedians know will get a cheap laugh. Most of it is based on perception, myth, and inaccurate reporting or recording of things. There is that background in society; it is not just a "school" thing. In the context of schools in particular, from the evidence you have heard from others, as you have said, if there is an issue, health and safety is not the cause or at the top of the list, but there is definitely a perception about it being a problem. The health and safety legislation is quite straightforward and is designed to ensure that proportionate steps are taken to protect children and adults from risks to their health or safety from school activities. If we are not careful, there is a danger that it translates from that into a disproportionate approach which tries to protect schools rather than children in the first place. We need to get that balance right, and that was what a lot of the coverage over the weekend, which was entirely coincidental, was about.

Dennis Opposs: Our role is perhaps one step removed from the classrooms. We set the rules for exams, GCSEs and A-levels, and the exam boards produce their syllabuses against our regulations. We then accredit those and monitor what goes on. If there were serious concerns, we would probably have picked that up through some of our monitoring. I have to say that nothing has come through to us in recent years which would suggest there are particular concerns in that area.

Nigel Thomas: In terms of health and safety, I would firstly ask Ofsted something. They may not have picked up any evidence within the inspection of Ofsted that health and safety is preventing school science teachers undertaking practical work, but I would ask: do they ask the question? They may not. Anyone who has been involved in science education over the last 20 years has heard persistent anecdotal evidence that health and safety perceptions have an impact on the range and quality of practicals undertaken in school science lessons. You can debate whether teachers use it as an excuse or they genuinely have a misconception that something is banned or unsafe, but I think there is widespread anecdotal evidence to suggest that it has an effect.

Q107 Chair: If one were doing a risk assessment of the conduct of a particular experiment, is it not likely to be much easier to do a risk assessment ticking all

the boxes if the teacher has to demonstrate something rather than the student doing it himself or herself? Is that not likely to happen, Mr Knighton?
David Knighton: All I can say is that we do not find that happening. The main purpose of practical work in terms of learning is for the young people to do it. There will be occasions when a demonstration is appropriate, but all I can do is repeat the fact that, if when our inspectors are in schools they find there is relatively little practical work going on, they will want to know why; they will talk to the teachers and to the pupils. There is no strong evidence coming through from those specialist visits by our science colleagues that health and safety issues and risk assessments are significantly constraining the practical work going on in schools.

Q108 Chair: Does everyone agree with that?
Nigel Thomas: I would widen it slightly to say that to talk about practical work as a single concept is slightly problematic in this sense. There are at least four purposes of practical work in science: enhanced understanding of scientific concepts and knowledge; enhanced understanding of process; equipping young people with laboratory and manipulative skills and use of specialised apparatus; and the engagement and motivational aspects. If you are talking about a teacher demo, it is quite clear that a well-constructed teacher demonstration with awe and wonder can easily play to that engagement and motivational aspect, but, arguably, it is unlikely to be the best approach if you are trying to equip a young person with specific laboratory skills. A good teacher knows the various purposes of laboratory work and will adopt different approaches, whether it be demo or hands-on group work, accordingly.

Q109 Chair: Do you see anything in the emerging education policy that ought to give us confidence that, in those issues where there is a grey area, it is moving in the right direction? Mr Knighton, are you comfortable that science practicals are getting better?
David Knighton: There is certainly some evidence coming through that there are improvements.

Q110 Chair: What are they?
David Knighton: In terms of the amount of practical work, for example, key stage 2 and key stage 3 tests disappeared a couple of years ago. We are starting to see some impact in schools in terms of more practical work and a greater investigative approach, because teachers see their programmes being freed up by the absence of those tests. That would probably be the most significant factor on which we would home in.

Q111 Chair: That is about volume. Is there anything about absolute quality?
David Knighton: It is not necessarily just about volume; it is about an approach and also about quality. It means there is more investigative, practical work going on in some schools, not all, as a consequence of that policy.

Q112 Stephen McPartland: One of the messages running throughout the inquiry has been that having the right teachers in the right place is key. Mr Knighton, when newly qualified science teachers are appointed to a new school what type of induction do you think they should undertake?
David Knighton: It was not a question I was expecting in terms of practical science. I would have thought it is the same kind of induction as for any other teacher. If we are talking about scientists, they will have done a science degree and some initial training, which will have introduced them to practical work, as well as other approaches to teaching and learning. I would have thought their induction as for any other subject would be a fairly structured programme where they would be mentored by an experienced member of staff.

Q113 Stephen McPartland: What if they were not scientists but had a degree in a different subject?
David Knighton: But they were teaching science.
Stephen McPartland: Yes.
David Knighton: I would have thought it meant, therefore, that the amount of supervision they required in terms of science would be greater. They would probably be introduced to teaching in a more gradual way, but it would be exactly the same kinds of principles as would apply to a non-specialist in any subject. Clearly, you would need to monitor the practical side of it fairly carefully if the teacher came from a background that did not involve previous practical work.

Q114 Stephen McPartland: Whose job do you think it should be to identify whether or not teachers are updating their skills?
David Knighton: Initially, I would expect it to be a matter for the head of department, but the senior management would need to support that as well. The issue of specialist professional development is one that we raise regularly in all of our subject reports. Almost invariably, that is an area that we think needs to be improved with greater focus on the subject-specific professional development of teachers.

Q115 Stephen McPartland: How does Ofsted facilitate and identify the quality of continuous professional development of science teachers in particular?
David Knighton: It is not our job to facilitate it. We report on what actually happens. For example, when we carry out a specialist science visit to a school, at the end of it we make judgments which go into the formal letter that is sent to the school and is then published on our website. In quite a large proportion of those there could well be an area for improvement which relates to professional development for the staff in the school. That is quite a common area which we identify.

Q116 Stephen McPartland: Do you think science teachers need something more than other teachers because of the practical applications?
David Knighton: I suspect that our science colleagues might say that, but our maths colleagues would say the same about mathematics and historians about history.

Q117 Stephen McPartland: Do you believe that an accredited course for science practicals would help?
David Knighton: I do not think I am in a position to be able to answer that.

Q118 Stephen McPartland: Would any of the other witnesses like to answer that?
Nigel Thomas: I think that, if you are looking at initial teacher training, including the NQT year, there would be real value in having additional access to practical work. If you talk to trainee teachers, what they will tell you about practicals is that they just need more time to practise them in a safe environment. The trouble is that with science, particularly the PGCE route, which is still the biggest one, it is just 36 weeks. There are lots of things that should be in a PGCE that are not, including some subject knowledge, so that if you have biologists who are going to teach physics it would be helpful for them to learn some physics during their training. But you cannot keep loading in more and more content; you would need to look maybe at a summer school idea either before the PGCE or immediately after it. To have that kind of lab summer school would be a great idea.

Q119 Chair: If Mr Myers is right, a bit of myth-busting about health and safety and practical understanding of how to do a proper risk assessment would not be a bad idea.
Nigel Thomas: Absolutely. You could even imagine it being a residential course at the National Science Learning Centre, for example, where you can explore all these kinds of things.
Kevin Myers: I cannot answer your final question, nor am I competent to talk about quality of teacher learning. In terms of health and safety, if you are talking about carrying out experiments that have intrinsic hazards associated with them, which can be properly and safely managed, we would expect people to be competent to do that. To do that requires them to be trained to do that specifically.

Q120 Chair: Have the Health and Safety Executive ever discussed that with the Department for Education and suggested that teacher training level might be a good place to do it?
Kevin Myers: We have had lots of discussions over time from nursery all the way up about the opportunities to imbue a positive health and safety culture. I am not sighted on the detail of that, but I could send you a note if there is something.

Q121 Pamela Nash: In recent weeks from a variety of witnesses in this inquiry we have heard much about the qualities of science technicians in schools. There has been lots of praise of them but also continuing concern about the pay and conditions under which they work. I want to ask each of you whether you feel more emphasis should be placed on the role of the skilled technician. Conversely, should teachers have greater practical expertise?
Nigel Thomas: Yes. Undoubtedly, technicians are vital in school science.
They continue to be under threat. There is some early evidence to suggest that, as budgets begin to get squeezed, technician numbers get cut before teachers, as you might expect. You still see a large number of technicians on term time only contracts. They are poorly paid and do not have a very clear career structure. Eight or nine years ago there was a study by the Royal Society that suggested we might be 4,000 technicians short. I cannot see any reason why that number has reduced since then.
Dennis Opposs: For us, I think the key thing in terms of these skills is that teachers are able to carry out accurate assessments of their pupils' practical experimental work, but technicians are probably one step further removed from that. I am not sure there is much I can add about technicians.
Kevin Myers: I do not think I have anything to add about the particular question you ask there, I am afraid.
David Knighton: The roles of technicians are absolutely key in science as they are in technology and other areas in schools. Essentially, what they do is free up teachers to do the teaching, so they are using their expertise in the most effective and efficient way. In those terms, therefore, the role of the technician is really important. They are doing what they are good at and it enables the teachers to do what they are good at.

Q122 Pamela Nash: Mr Knighton, does Ofsted currently assess how closely technicians are working with science teachers in schools?
David Knighton: We do not do that formally. The only occasions when we might pick that up are if we feel that the practical work was not being done particularly efficiently in a school. We might follow that up and look at the particular circumstances. It would tend to arise if there was an issue about technician support. We would not normally monitor it unless there was a reason to do so.

Q123 Stephen Metcalfe: Much of the evidence we have heard, or certainly the e-consultation we have conducted, has said that the practical teaching of science is not fundamental to the teaching of science in our schools and that the course is taught very much to pass the exam rather than to create, or perhaps as well as to create, a thirst for science. We have some evidence that the practicals are done because the course requires it, and if the results do not match what the textbook says you throw away your notes and write down what the textbook says the results should have been. Does Ofqual consider that the current science courses incentivise teachers to carry out really good quality practical science in classes, or is there no value in this?
Dennis Opposs: The control we have on this is in the criteria set. For example, in the A-level science subject criteria and in the content there is a requirement that says, "Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts", and there is further detail beyond that. There is an objective in all the A-level specifications. That means students will have to carry out practical work. They will be assessed on their skills in that; it has a particular weighting. There is something similar in the GCSEs,

so it is an essential part of all the courses and forms part of the assessment weighting.

Q124 Stephen Metcalfe: But you are not dictating to schools or the courses what should be taught. Is that because you do not think they will have similar set-ups and equipment and are just allowing them to make their own decisions on that?
Dennis Opposs: There is a step between what our criteria say and what goes on in schools, which is that each of the exam boards produces its syllabus to match these. They may vary in the specificity with which they say you ought to do this or that experiment. Sometimes they can be quite prescriptive; others may not be. Schools then have a choice as to which of those syllabuses they teach.

Q125 Stephen Metcalfe: Do you think that such a wide range of courses is a good thing? We would often say that choice is good, but does that mean there is quite a discrepancy in the way science practicals are handled and taught?
Dennis Opposs: The system in this country is that we have different exam boards offering the same titles but with their own particular syllabuses. There is a requirement that we have some kind of comparability of standards across those, but it does provide some variety so different schools in different contexts can make a choice of what best suits them.

Q126 Stephen Metcalfe: How do you check that the quality of those courses is equal so that, whichever board you have done, you have the same level of skills?
Dennis Opposs: Before the syllabuses go to schools they will have to be accredited by us, so we have to check that they match our criteria. That is our opportunity to make sure they are all of equivalent standard. We will then have, to a small extent, a monitoring programme that follows up some of these afterwards, so we will get some evidence. But I have to say that the kind of monitoring we do would not include going into classrooms and watching students carry out their work; it would be one step removed from that.

Q127 Stephen Metcalfe: Just for clarity, how do you monitor it?
Dennis Opposs: How do we monitor the practical experimental side?
Stephen Metcalfe: No, just generally. How do you monitor that the courses being taught are of equal quality?
Dennis Opposs: The way we check they are of equal quality is that from time to time we will choose a subject and look across the different syllabuses that the exam boards offer. We will check again what the requirements are in the syllabuses and collect examples of the candidates' work. We will get experts to look at that and make some comparisons. It will be one step removed. We will base it on the evidence of what the candidates have produced; we will not be seeing what they are doing in the classroom.

Q128 Stephen Metcalfe: That is my point. They could or could not have done a practical and written down the results from the textbook to say they have done it. Do you think that the practical teaching of science is valuable? Does it add to the overall experience? What should be the purpose of those practical experiments? I put that question to all of you.
Dennis Opposs: To come back to your first point, the idea that students would not be carrying out these practicals and the teachers would just be getting them to copy it from textbooks would be a serious malpractice. The requirement is that they carry out these practicals, and what is assessed is the students carrying out their practicals. I am not certain of the details, but there may be points where, if you are being assessed on planning and it is completely inappropriate for what you are doing, you might be provided with something that would be taken into account during the assessment. In terms of your main question, as I have said, all our criteria insist that practical work is taking place, so from that point of view we are saying that yes, it is an important and essential part of all these courses.

Q129 Stephen Metcalfe: But what should the purpose of it be?
What are the students trying to gain from it?
Dennis Opposs: There is a mixture of things. There will be the particular skills that you gain from manipulating equipment; there will be something about the kinds of analysis in intellectual terms that you have to go through to make some sense of your data; and I guess there is also something in there about it being a way of teaching science. That will not be very explicit in our criteria but I would have thought that would be part of the expectation.
Kevin Myers: I would approach it from the other end of the telescope. In terms of UK plc, when we regulate industry we emphasise the importance of competence. There is a dearth of competent scientists and engineers coming through the system. I do not know the cause of that, but all I would say is that one of the purposes at that level should be to stimulate and encourage people to be engaged and want to follow that profession for their own career development and the good of our society.

Q130 Stephen Metcalfe: Does anyone want to add to that?
Nigel Thomas: I go back to what I said at the beginning. There are several purposes besides embedding knowledge, one of which is laboratory skills. Our assessment is that laboratory skills are not assessed within the current system. If a young person conducts a controlled assessment within a practical lab and breaks all the test tubes, as long as he or she knows what should have happened and writes down, "I conducted the experiment like this. I did my research and planned it, and this is how I undertook it", that individual can get maximum marks. The actual carrying out of the experiment is not assessed but the process they go through is.
David Knighton: Going back to your basic question as to why practical work is important, the simple answer is that it is in the nature of science. To be a

scientist you do practical work. Scientific learning is about experimentation. You cannot, therefore, learn science without actually doing it. There may be some occasions when practical work is in the form of a demonstration. It all depends on what the learning objectives are, but the actual process of doing the science is key to the subject.

Q131 Stephen Metcalfe: We call them experiments because occasionally they do not come out the way you think they will, and a lot of learning comes out of that.
David Knighton: That is absolutely right.

Q132 Stephen Metcalfe: But it seems to me there is absolutely no recognition in any part of the assessment that getting the wrong result from an experiment can be equally as interesting and important as getting the right result, because then you can explore why it came out differently from the way it said it would in the textbook.
David Knighton: Absolutely. In the schools where good science is taught, that happens. It is built into the national curriculum, because if you look at the skills of inquiry the evaluation at the end of it is a key part of it. What we tend to find is that the first stage of scientific practical work, which is the planning, and the evaluation at the end of it, where you look at what you have learnt from it, tend to be the weaker elements, relatively, whereas the actual implementation and recording of results tend to be stronger; but in the best schools all of those elements are there very strongly.

Q133 Roger Williams: Mr Knighton, in your inspection framework there is practical science as a discrete element. When an inspector is planning an inspection of a school, will that school be required to demonstrate some practical activity, or will it be a chance thing and there may be some practical activity going on when the inspector is there?
David Knighton: What we would want to see is what normally goes on, so we would not specify that we want to see practical work. However, we have now published our descriptors for various grades that we give. It is quite clear in those that, if we are seeing outstanding science, we will expect to see practical work. It may not be occurring in a particular lesson, but the inspector will be talking to the students, looking at their notebooks and finding out whether they have done science in the past and it is an integral part of their programme, rather than just an add-on where perhaps you have just one practical lesson a week and it does not necessarily connect to the rest of the learning. The practical work and investigative approach is the key to outstanding and good teaching and learning in science.

Q134 Roger Williams: I think you published an assessment of science teaching recently.
David Knighton: Our science report was published in January.

Q135 Roger Williams: What did you say about practical subjects?
David Knighton: Our first key finding was about practical investigative science, and that finding was that that was the key to good learning. The highest standards are in schools where the most effective practical work takes place. We are saying that the schools that have made the most progress in developing the quality of their science are the ones where the amount of practical work has increased. We are quite unequivocal about the relationship between practical investigative science and standards and progress in the subject.

Q136 Chair: Mr Opposs, following on the answer by Mr Knighton, if you were designing a new syllabus for an exam board that I am putting you in charge of now, what proportion of science would be conducted as a practical in the laboratory?
Dennis Opposs: What proportion of the teaching?
Chair: Yes.
Dennis Opposs: I am not sure I can fully answer that. The kind of weighting for the assessment in the syllabuses tends to be typically about 20%. I guess there ought to be some link between that proportion and how much teaching time is spent on it, although that might well be an underestimate because you might be doing other practical work which certainly does not relate to the assessment.
Chair: The logic of Mr Knighton's answer is that that should be nudged upwards.

Q137 Stephen Metcalfe: What do you believe are the main barriers to getting better practical science taught in schools?
Nigel Thomas: If you have to go for one thing, it has to be assessment. I am sure you have heard this from many of the witnesses. High-stakes assessment prohibits a range of innovative practical work. You end up going down to the lowest common denominator where all children do the same set experiments that they have been drilled on for many weeks. They know what is going to happen; it is not inspiring and surprising, and it is not science.

Q138 Stephen Metcalfe: Does anyone else want to come in?
Kevin Myers: If there is a myth that health and safety is getting in the way of it, we should do all that we can to deconstruct and break down that myth and talk to people about the reality.
David Knighton: My answer would be different for primary and secondary. I think that in primary schools the barrier is probably the confidence and expertise of teachers. That is perfectly understandable.

Q139 Stephen Metcalfe: If that is the case, how do we get more pure science teachers perhaps to think of primary school as a destination for them?
David Knighton: I am not sure I can answer that. We will always be in a position where probably a fairly small minority of primary teachers are trained scientists. I think that is inevitable however we go about encouraging more to come in. The key to this is developing the teachers we have and making sure there is sufficient high-quality professional development. There are some really good initiatives

out there, and it is a matter of encouraging schools to get their staff into them. Possibly in the last few years, particularly in primary and to a lesser extent in secondary, the emphasis in teachers' professional development has been on generic issues: assessment for learning and also, understandably, literacy and numeracy. I think we need to be encouraging a greater involvement in subject-specific, science-specific, professional development. That is on the primary side. In secondary, it is a matter of perceptions about the time you have available and preparing people for examinations. That is not an issue in the majority of secondary schools. We are finding good quality science teaching and learning in secondary and primary schools, for that matter. In the majority of schools it is not an issue, but there is a minority, probably about 30%, where it is no better than satisfactory. In that case there is a narrow view of science and the perception that you have a limited amount of time, and possibly the practical work is an extra which you might be able to do away with. The most effective science occurs where you have practical science underpinning the knowledge and understanding.

Q140 Gavin Barwell: I apologise for my voice; I am not at my best today. I want to ask a more wide-ranging question. You touched on the lack of people coming forward with competency in science, technology and engineering-related issues. If we want more people studying those subjects at undergraduate level, clearly we need more people to study them at school as well. What would you change to attract more pupils to study science at school, especially at A-level or an equivalent stage in the curriculum?
David Knighton: One of the clear messages coming through from sixth-formers in schools is that the reason they chose to do AS and A-level science is that they found it interesting and enjoyed it. The most important features were the practical investigative aspects of science. That is the simple answer. You get the practical work embedded in the science in key stage 4 and that encourages people to do it post-16. There have been a number of other factors as well. Certainly, some evidence is starting to emerge that the growing number of students doing triple science in key stage 4 is increasing the numbers who are opting to go on to do science post-16 as well.
Dennis Opposs: Clearly, there are a lot of factors. Just focusing on my side of things, so to speak, it seems to me critical that, when we are producing particularly the GCSE syllabuses, they are as interesting, motivating and as good as they can be, and in particular perhaps offer the right kind of challenge to those who might want to go on and take it at A-level. It is the quality of syllabuses apart from anything else.
Nigel Thomas: Clearly, there is a wide range of things that could help with the pipeline of STEM into the economy. Careers advice comes up very frequently. Labour market information is very poorly communicated to young people and their parents. Experience of meeting scientists and engineers in the real world is clearly motivational, hence STEM clubs and ambassadors. In the context of this inquiry and practical science, if you talk to scientists, you are often struck by the fact they say they can go back in their memory to a time at school when they had a really engaging and inspiring demonstration by a teacher or they were doing something surprising within practical science. I do not think I have ever heard a scientist say, "I got into science because of osmosis in a potato experiment I did five weeks running just so that I could pass the exam." It comes back to assessment.

Q141 Gavin Barwell: In 2006 the House of Lords Science and Technology Committee concluded that there was a perception among students that science was hard. We picked that up a little ourselves when we visited a school. It was clear that triple science was an option only for the brightest pupils. Do you think practical science can have a role in encouraging less able children to take on science qualifications and, potentially, go into a STEM-related career?
David Knighton: Yes. It applies equally well to all students. Whatever your ability and aptitude in science, the more engaging the course the more likely you are to follow it through. I mentioned triple science, but the fact that we now have quite a wide range of courses, which are suited to a range of different abilities in key stage 4, seems to be a positive way forward and is meeting the needs of a greater range of young people. There are a number of vocational courses now operating as well. We have raised one or two issues about some of those, but for some young people that is the most effective form of learning in key stage 4. I think the range of provision is an important factor in encouraging more people to do more science for longer.

Q142 Gavin Barwell: What has led to that range of provision? What has happened in the last few years? You said there was a broader diversity of courses at key stage 4 now and that has led to more people taking triple science.
David Knighton: I think it has been a gradual process and a realisation that we want more young people to do science, and therefore we need to meet their particular needs.

Q143 Gavin Barwell: When Ofsted is inspecting schools, is one of the things you look at whether they are offering access to a full range of science qualifications? Is the range of qualifications that they offer something that you consider?
David Knighton: Are we talking here about our school inspections which tend to be fairly general ones, as opposed to our specialist science visits?
Gavin Barwell: By all means comments on both.
David Knighton: Certainly, on the science visits we would do that. You may be aware that under the proposed Ofsted framework that is going through at the present there is less emphasis on formally looking at curriculum provision. So, with a limited amount of time, it would not necessarily be the case that the inspectors would be able to look in detail at the total curriculum provision in all the subjects. I do not think I am able to speak about our general section 5 inspections, as they are referred to now. Certainly, on our subject-specific science visits, the inspectors will

be looking at the range of provision and matching it to the young people in the school. In different schools the range of provision might be different because it matches a different group of young people. We certainly would not go with a particular template where we looked for a certain range and variety of courses in every school. It depends on the particular circumstances and the young people there.

Q144 Gavin Barwell: Looking at the section 5 inspections for a second and making sure I have understood correctly what you have just said, the Government are changing that at the moment.
David Knighton: Yes.

Q145 Gavin Barwell: You are saying that under the new regime the focus is very much, as I understand it, on teaching alone.
David Knighton: That is right.

Q146 Gavin Barwell: There would not necessarily be the time to look at that issue, but did that happen under the old section 5 inspections?
David Knighton: Under the current section 5 we talk about the curriculum. We will not be focusing on that in the same way, but even under the current arrangements you cannot guarantee that there will be a scientist on the team. The approach is a general one. You are looking at the general feature of the school, and you would not necessarily have the time or capacity to be able to pick up on very specific issues relating to science or any other subject, for that matter.

Q147 Gavin Barwell: On the science-specific ones where you would look at the curriculum offer, you said you would not go in with a template in mind; you would tailor it to a degree to the particular students for whom that school was catering. I know that one of the things Government Ministers flag up is the number of schools in this country where, essentially, nobody is taking a triple science option. You would not look at whether students who wished to do so had the opportunity to study triple science.
David Knighton: We would certainly look at that. If it was felt that that was an important gap in their provision, we would report on that.

Q148 Stephen Metcalfe: I would like to examine the health and safety issue a bit more, if I may. We started this inquiry because we believed there had been a decline in the way practical science was taught in schools over the last 25 to 30 years or so. There is no doubt that in that period of time the prominence of health and safety has risen a great deal. Is it possible that health and safety has become so ingrained in our culture that we do not recognise that that is the cause of some of the decline in the teaching of practical science, and the way it is taught has managed to take some of the excitement out of it because of the assessments that have taken place? If that is not the case, how do we redress the balance so that people can see that a reasonable amount of risk assessment can take place and then we can just carry on with doing some exciting practical work in classrooms?
Kevin Myers: The evidence suggests that the problem is not health and safety, but, as I said, there is a perception that this is a problem. Perceptions are sometimes more difficult to challenge than the reality. We have been trying for a number of years to debunk some of these health and safety myths. We used to produce cartoons to try to shoot them down but they persist. That is why we are trying to up the game in terms of being clearer about what is and what is not required under health and safety law, trying to work with colleagues about what is a sensible and proportionate approach to risk assessment, and trying to work with other organisations, like some of those from which you have heard evidence, that can de-mystify science experiments and give people a method statement. Instead of every science teacher in the country doing his or her own individual risk assessment, if CLEAPSS or SSREC in Scotland can do it for you, that will help take it forward. We need to keep emphasising that it is about a sensible and proportionate approach.

Q149 Stephen Metcalfe: Are you working with all these organisations to make this happen?
Kevin Myers: Yes, we are.

Q150 Stephen Metcalfe: How long has that piece of work been going on?
Kevin Myers: It has been going on for ages. We first worked with CLEAPSS when the Health and Safety at Work etc. Act 1974 was introduced.

Q151 Stephen Metcalfe: Do you accept that it has been a long process?
Kevin Myers: It has been a long process, but we did not reach the tipping point and get all of these problems in 1974. It first became prevalent about 10 years ago. We will work with anybody to try to debunk these things and give people sensible assistance in developing it. We think it is best if that is developed from within the education sector by the people who actually know what they are doing rather than us suddenly seeking to become experts on education. We prefer to work with the bodies themselves because then there is more likelihood of them buying into it.

Q152 Stephen Metcalfe: So those discussions are ongoing.
Kevin Myers: Yes.

Q153 Stephen Metcalfe: What will be the next development from which we will see some practical outcome?
Kevin Myers: We published some stuff over the weekend about schools trips and outdoor learning activities. The Department for Education also revised some of its guidance. Clearly, we need to take stock to see whether that is having any impact. Obviously, we will be interested in any recommendations that might flow from your study. As the Chairman said, there are other studies going on about whether there are any legislative issues at the heart of this, although the legislation that applies to schools is relatively narrow and clear.

Q154 Stephen Metcalfe: Once you had made your announcements over the weekend, straight away some of the organisations representing the teachers came out and said they were concerned about this. That is why I get the sense that it has almost become ingrained in people to think about health and safety as a barrier to doing these things. It is a question of how we break that down. Perhaps you yourselves need to take a more active role in doing that if, as a culture, we have become so risk-averse that we are worried about doing things. Because we hear the health and safety excuse all the time, perhaps you need to take a more active role in that. I am pleased to hear that you are starting to do that, but I think it needs to be more.
Kevin Myers: We are not starting to do it; we have been doing it over a period of time. We will continue to do more of it. Frankly, I would like us to spend more of our time talking to people who are managing significant risks that are killing and maiming people. Senior management spend more time responding to spurious and inaccurate articles in the press, frankly, than ideally we would like. Our chairman, Judith Hackitt, visited the Institution of Chemical Engineers. She can be seen on YouTube setting fire to herself, which is probably above and beyond the call of duty, to demonstrate impactful science and how, if you properly manage the risks, you can achieve awe and wonder without harming people.
Chair: You will be pleased to know that for the launch of the International Year of Chemistry we conducted similar experiments in the House of Commons and we did not burn down the building.

Q155 Gavin Barwell: I have a general question on which to end, which follows your point about health and safety not being the main barrier. The evidence we have had from teachers and others has shown very clearly that time is the number one barrier to doing more practical work in the classroom. What bureaucracy do you think could be cut out to provide teachers with time to do more practical work in the classroom?
Kevin Myers: From my perspective, any paperwork that is generated to cover people's backs rather than proportionately address health and safety risks in a simple and straightforward way is wasting everybody's time.
David Knighton: What you are talking about is a perception among a large number of teachers, not the majority. The majority manage to teach effective, high-quality practical science without considering time to be an issue. It is a matter of providing the support for teachers and sharing good practice so they can see that when they get down to it time is not necessarily going to be such a problem.

Q156 Gavin Barwell: When we visited a particular school, a number of the science teachers we spoke to referred to changes in the curriculum. They felt it was not that the curriculum did not value practical work but that the volume of material covered by it crowded out the opportunity for practical work. Are there specific areas in the curriculum that could be slimmed down?
Dennis Opposs: I would say only that a review of the national curriculum is going on at the moment and science is one of the subjects in the front line. I guess that is the place where it will be addressed.

Q157 Gavin Barwell: Do you wish to venture an opinion on the subject?
Dennis Opposs: I am sorry; no.
Chair: Gentlemen, thank you very much. It is five o'clock. The Minister is sitting behind you filling in the tick box to check up on you. Thank you very much for your attendance this afternoon.

Examination of Witness

Witness: **Mr Nick Gibb, MP,** Minister of State, Department for Education, gave evidence.

Q158 Chair: Minister, welcome and thank you for coming this afternoon. As you know from what you have heard in the last few minutes and the briefing on the inquiry that we are conducting, we are concerned about the perceived decline of science practicals and field trips. The core question from the evidence provided to us would seem to be: from your perspective what value do practicals and field trips have in science education?
Mr Gibb: They are very valuable indeed, first, in terms of helping with understanding. I do not know how you can understand the potency of hydrochloric or sulphuric acid without ever having held a bottle of it and poured it on something, preferably into a beaker in a safe way. It is also very important in terms of accuracy. Being able to measure accurately is an important skill that children need to acquire during their school career. Conducting experiments is an important way of ensuring that they have those skills. It also motivates children.

Q159 Chair: We have just heard that there is a review of the curriculum. What is your view about how we could radically improve science education particularly from the point of view of practicals? We all know that there is a national problem in terms of not producing enough people with STEM skills. What is your formula?
Mr Gibb: We are reviewing the curriculum from five to 16 across all the national subjects, and science is one of the priority subjects. English, maths, science and PE are in the first phase of that curriculum review. We want to slim down the curriculum. I heard in the previous session a question about the volume in the curriculum. We want to slim it down and focus on the core knowledge and concepts that we believe all children at school should acquire during that period. The review will also recognise the importance of the practical application of scientific skills, particularly things like measuring, and seeing experiments happen in real life will also be included in the curriculum.

Q160 Chair: Virtually all the evidence we have had has in some way or another expressed the importance of science practicals and field trips in terms of teaching science. What levers do the Government have? If the review says that that has to increase substantially and you have to free up the curriculum, what levers do the Government have to make that happen?
Mr Gibb: It is a difficult question, because we do not want to exercise too many levers, particularly when it comes to pedagogy. The whole direction of travel for the Government is to trust professionals and let them decide on the basis of their professions how they want to teach. There will be some aspects of practical scientific education that need to be in the curriculum. There will be a recognition of some of the important skills, such as being able to measure and record results accurately. Being able to know the diagrammatic formula for how you depict a test tube and how you draw diagrams for an experiment are all matters, subject to the conclusions of the review, that I believe should be in the curriculum, but how you deliver that should be a matter for professionals. But there are none the less levers that you can exercise. One thing in which I believe very strongly is that, if you have teachers who know their subject extremely well, they will be better equipped to provide good practical experiments and lessons in chemistry and physics than a teacher who is grappling with the subject content.

Q161 Chair: I very much agree that the drivers should be the professionals, but some benchmarks must be applied nationally, must they not, to have consistency across the country so that we can measure the success of good schools?
Mr Gibb: Yes. The question you are asking, therefore, is: should we be assessing these issues? That will depend on what the review recommends should be in the curriculum. We will have to see what that comes up with. But you also have to distinguish the national from the school curriculum. We want to have a slimmed-down but content-full national curriculum in science. The school curriculum is what the school decides to do beyond the national curriculum, and we want to free up teachers and professionals to provide an inspiring, rigorous and very broad-based approach to education that will include things like field trips and practical experiments in science lessons.

Q162 Stephen Metcalfe: I was looking at a remarkable statistic that in England only 28% of students study one or more science at A-level. The Royal Society is keen that that proportion is increased. Would the Government support that? Do they have an aspiration to increase the number of students studying science at A-level?
Mr Gibb: We do not have targets but we certainly want more students to be studying scientific subjects, both at GCSE and A-level. It has been of concern to us that the numbers taking A-level chemistry and physics dropped from 1996 onwards. There has been a gradual reverse in that trend in recent years, which is welcome. One of the drivers behind the English baccalaureate is to encourage more young people to take the three sciences to GCSE, and that will lead them to being comfortable about taking their subjects to A-level. We also want to make sure that young people are selecting the right subjects at A-level if they want to go on to progress to scientific subjects at degree level.

Q163 Chair: You do not have a target but you would like us to get up to the Scottish level.
Mr Gibb: It would be a target. We just want a higher proportion taking these important subjects that have progression.

Q164 Stephen Metcalfe: You mentioned the E-Bac. Science is already a core subject in schools at GSCE, is it not?
Mr Gibb: Yes.

Q165 Stephen Metcalfe: Why would the E-Bac increase the number of children who potentially take that on to A-level?
Mr Gibb: Although it is a compulsory subject, it does not mean that it is compulsory to take and pass the GSCE in it. Our concern is that there has been a focus on some of the softer subjects at GSCE to deliver the five or more GCSE figure. That can sometimes mean a focus on the softer subjects at the expense of what are perceived to be more rigorous science subjects.

Q166 Stephen Metcalfe: You are hoping that schools will teach more science at key stage 4 to get an exam passed, so they will focus more of their resources on science within schools because it forms part of the E-Bac.
Mr Gibb: Yes. To have more young people taking the GCSE right through and doing well in that exam is one of many factors.

Q167 Stephen Metcalfe: As opposed to just studying the course, the incentive will be to get those students up to the level at which they can take an exam in it.
Mr Gibb: Yes. There are all kinds of other issues about the league tables. For example, we are focusing on those who did not perform well at key stage 2 to see how the school is developing those youngsters so that there is not a focus just on the C-D border but on the D-E and A-B borders. We want another column for high achievers at key stage 2 and how they are achieving in GCSEs at key stage 4.

Q168 Stephen Metcalfe: The Chairman said that in Scotland the proportion studying sciences to A-level is almost double. I think that 50% study one or more science. That has a cost implication in that teaching science is more expensive than teaching some other subjects because of the resources and facilities required. Would the Government support that increased participation?
Mr Gibb: The Scottish system is slightly different in that the Higher has a broader range of subjects, so, statistically, you will have more 17-year-olds studying a science than a 17-year-old in Britain, who will specialise in taking only three A-levels, generally speaking. Having said that, we want to see the numbers taking chemistry and physics, in particular,

rising in future, and if that requires the school to allocate more resources so be it.

Q169 Stephen Metcalfe: But it is the infrastructure, the labs and that kind of thing, that supports it. Do you think resources would be made available?
Mr Gibb: Capital spending is a subject for another session. Schools will need to prioritise the limited amount of capital that they have as a result of the wider difficulties facing us.

Q170 Stephen Metcalfe: But the Government would be supportive of that aim.
Mr Gibb: Yes. Secondary schools should have good quality laboratories, fume cupboards, technicians and all the chemicals and equipment they need to enable them to conduct experiments and students to take part in them, but how schools allocate their capital is a matter for the schools and local authorities.

Q171 Stephen Metcalfe: You touched on technicians. Some of the evidence we have heard has highlighted the importance of technicians. SCORE told us that it is essential technicians are supported in their work and accorded the professional status they deserve. There should be substantial investment in technicians' continuing professional development. Is that something with which you agree?
Mr Gibb: Yes. I think technicians are important. It is not the role of central Government to employ technicians, but the science learning centres that we are continuing to fund, quite generously given the overall constraints on public spending, have courses for CPD for technicians, and obviously we would support that.

Q172 Gavin Barwell: The Department indicated to us in its evidence that, in reforming GCSEs, it will look to assess the ability to undertake practical experiments through formal examinations. What kind of assessments do you have in mind?
Mr Gibb: We will have to see what the curriculum review proposes. I think we will have to await the outcome of that before we decide how that manifests itself in terms of the GCSE specification and the assessment criteria. That is all I can say on that at the moment.

Q173 Gavin Barwell: Do you have any initial thoughts that you want to share with us? I think most people agree with the principle. Certainly, a number of people have expressed to us concerns about how easy it is to cheat on some of the current assessments that are used, but a lot of the evidence submitted to us is that it is not necessarily an easy thing to do.
Mr Gibb: It is not an easy thing to do but you can do it by asking a question about the conduct of an experiment. If a student has not had exposure to a considerable number of experiments, they may find such questions very difficult. You do not have to assess it live through a practical session, if you like; it could be a written exercise, with students writing up about experiments they have seen and taken part in.

Q174 Gavin Barwell: It might be paper-based.
Mr Gibb: It could be.

Q175 Gavin Barwell: Does that apply just to GCSEs, or does the Department have a similar view about other scientific qualifications?
Mr Gibb: In terms of A-levels, we want to re-link their development to the universities and the learned societies. Given their concern about these issues, I am sure that is something in which they would also be interested as they become more and more involved in the development of future A-levels in science.

Q176 Pamela Nash: During the last few weeks there seems to be a very broad consensus that laboratory work, fieldwork and field trips all contribute to encouraging students to take science subjects to a higher level. I want to move on to how the Government can incentivise both teachers and young people to take part in those trips and therefore take on science subjects. There has been quite a lot of evidence from students in an e-consultation we have been holding that it is definitely possible to enthuse and engage children by exposing them to high-quality science through laboratory work and field trips. Do you feel there is a place for the Government to provide more central funding if they are really serious about encouraging British schoolchildren to take up STEM subjects?
Mr Gibb: I am pleased that this Committee is conducting this inquiry. Anything in this building that can be effected to raise the profile of STEM subjects, and indeed field trips and practical experiments in science labs, is very welcome. But I do not think it is the direction of travel of this Government to continue the approach of central prescription and initiatives. That really was the approach of the last Administration and we have tried to get away from that by putting more and more funding that was held centrally to provide those initiatives and get that money down to the school level so that the school can decide how it wants to spend that money on its priorities. Having said all that, my view is that field trips are essential, particularly in subjects like geography and geology. I also think that practical experiments in science are very important. We would want to encourage it but not to do so through a plethora of central initiatives and ring-fenced funding streams.

Q177 Pamela Nash: If not funding, another idea that has come up is to produce a system of accreditation: a course for teachers to take in fieldwork and field trips. Is that something that the Government support?
Mr Gibb: Certainly, but again not necessarily from the centre. Part of what we want to do with teacher training and continuing professional development is to encourage, albeit from the centre, if you like, teaching schools to form clusters, relationships and alliances with other schools in an area so they become the focus of the development of teachers. That is an area where that kind of accreditation and professional development can take place.

Q178 Pamela Nash: There has been a foray into this from the Learning Outside the Classroom manifesto

which has developed a quality standards badge. They told us that there was a much bigger uptake of the fieldwork rather than the field trip aspect, which was separate, which led us to think that teachers were less inclined to take pupils out on field trips. We have seen evidence of that in the last few weeks. Is there anything else the Government can do specifically to encourage more fieldwork by school science departments?

Mr Gibb: Again, the whole thrust of our direction is to trust professionals to devolve these decisions down to the school level, encourage the growth of teaching schools and to have these developments coming from the bottom up rather than the top down. What we do want to do, however, is remove any obstacles. If teachers are telling us that health and safety rules and risk assessment hinder fieldwork and field trips, we want to try to do what we can to remove them. That was why, on Saturday, the Department launched a slimmed-down guidance about health and safety so that we can return to common sense and not have that as a hindrance to teachers in organising trips around the country.

Q179 Chair: However much you try to duck out of the responsibility of what happens from the centre, I think you were here earlier when the official from the HSE gave evidence. It is all very well to say that it is the responsibility of schools and clusters of schools, but what about at initial teacher training? Are there not responsibilities that central Government have there? First, when are you going to free up the curriculum for teacher training to ensure that these important subjects are covered? The first part of the question is much broader, but, secondly, given what has been said in the media over the weekend specifically about health and safety and schools, this cannot just be done on the initial training side; there must be continuing professional development. Surely, central Government must have a role in that.

Mr Gibb: Yes, but not in the old-fashioned sense that we want an initiative that we dream up, to which we give £20 million and launch in a great fanfare. Education policy has to be cleverer than that. If you look at what we are doing, you accuse us of trying to absolve ourselves of any responsibility. No. We want a rigorous curriculum, hence the national curriculum review. We want rigorous qualifications and exams, and we are reviewing GCSEs and A-levels and how they are configured. We are bringing A-levels back to the universities and learned societies. That is where you will get the input in terms of what children should be exposed to when they are studying science. I do not believe you can really understand science unless you have been on a field trip and chipped rock off a cliff or put some sodium into a beaker of water and so on.

Q180 Chair: Do you know how few kids do that these days? It is done behind a Plexiglas screen as a demonstration.

Mr Gibb: Again, how do you address that? Should we be passing a regulation to say that every child should take part in that experiment rather than just watch it from behind a screen? No.

Q181 Chair: But from the centre you need to make sure that technicians and people managing fieldwork and laboratory experiments are properly accredited.

Mr Gibb: Maybe. For example, only 14% of science teachers have a degree in physics. If we want to get teachers in our classrooms who are comfortable with practical scientific experiments, the way to do that is to have highly qualified, able teachers in the classroom. One of the thrusts of our policy is to have a bursary scheme to encourage the top graduates in the STEM sciences in particular to come into teaching. That is the thrust of delivering what you want without central prescription. In terms of ITT in particular, we are reviewing the Qualified Teacher Status standards under Sally Coates. Again, we are trying to simplify it and make it clearer and crisper, but one of the standards will be that we want teachers to be well qualified in their own subject areas. I think that is the way you deliver that rather than say, "We are going to have a special QTS for science teachers and one for geology teachers." Of course, we want CPD; it is terribly important, but the best CPD is provided from peer to peer and teacher to teacher so that teachers can observe high-quality teaching taking place. That is what the teaching schools, we hope, will deliver in due course.

Q182 Chair: The point of that question, coming back to the health and safety issue, was that clearly you cannot ensure that the necessary protections are there unless there is continuing professional development.

Mr Gibb: Yes.

Q183 Chair: Although you say you really want schools to determine that themselves, at the same time you recognise that to achieve your objectives you will have to have a certain amount of strong guidance from the centre.

Mr Gibb: Slimmed-down guidance that is readable and usable is what we have produced.

Chair: But strong.

Mr Gibb: Helpful, so that teachers know what the law is. When it comes to trips, there is this myth about a 100-page risk assessment form that teachers have to fill in. They do not have to fill in such things. We are making it very clear precisely what teachers have to do when they are arranging a field trip. They just have to go there and check it out rather than fill in a 100-page form. I am not sure that health and safety is an issue in terms of the science lab. Last year a survey by science learning centres showed that health and safety in terms of doing experiments in the science lab was a minority concern among teachers.

Q184 Chair: I think time is the big issue.

Mr Gibb: Time is a big factor.

Q185 Roger Williams: The Chairman has covered a lot of the ground that I was going to cover. The Department has said it wants to reform initial teacher training and will talk to schools, students, universities and other training providers. Do you think it would be a very good idea to talk to other people in the science world, for example, the Association for Science Education, SCORE and CLEAPSS? Surely, those are

critical people to be talking to as well as the education system itself.
Mr Gibb: All the reviews we undertake are conducted openly and with wide consultation. The same applies to the review of initial teacher training as well as the review of the curriculum. So yes, you are right. You could not possibly reform any of these institutions or issues without consulting those that are delivering this on the ground.

Q186 Roger Williams: And you are talking to them.
Mr Gibb: Yes, very widely. For example, in the national curriculum review we had a call for evidence and in three months we had nearly 6,000 responses, which I think is a record in the Department for any consultation. We are open and consulting widely in all our reviews.

Q187 Roger Williams: You mentioned a number of quality systems, such as the science learning centres and the peer-to-peer training process. I think the point the Chairman is making is that these are very good systems, but we have lots of evidence that teachers find it very hard to find the time to attend these centres. How are really skilled teachers going to find the time to train other teachers when they do not have enough time for their own continuing professional development?
Mr Gibb: I have heard many teachers say the same thing. On inset days, when there is time to develop CPD, there tend to be courses run by an exam body instructing them how to get their students from a D to a C grade, which really is not the best use of CPD time. We have said that we want our schools to become centres of academic excellence in this country. That is what they should be, not exam factories. That is why we have also introduced a scholarship where teachers can bid for time off to engage in deeper subject knowledge. I think that is very important. We want to change the culture in schools so that head teachers regard it as important that teachers enhance their subject knowledge by attending the excellent courses at the science learning centres, among others.

Q188 Roger Williams: Talking to a few teachers over the weekend, I got the impression that right at the heart of this was a feeling that at individual teacher level, even if a practical lesson or visit to the countryside was planned well, and the risk assessment and supervision were done well, a pupil could, through a particular action, get into trouble and damage themselves. The feeling of those individual teachers was that that perhaps put them at risk of a civil action against them. They felt that they should not put themselves and their families in that position. Could the Government table some legislation that there is an inherent danger in certain activities, and if pupils act inappropriately the teacher should not in any way be put in danger of prosecution?
Mr Gibb: That is right. Of course, the reality is that prosecutions are very rare.

Q189 Roger Williams: But civil action is not, is it?
Mr Gibb: No. That is what the guidance is designed to do. If schools are following the guidance, which is now readable, because it is not eight pages of waffle but very sensible precautions—I have it here—and teachers adhere to it, they should be in a strong position to defend any civil action.

Q190 Chair: How many teachers will be able to apply for the scholarships you mentioned?
Mr Gibb: It depends on how much is spent. It is £2 million a year. I think it can go up to about £3,500 per teacher. I do not think it is fixed at that, so it could be less. It depends on how much is spent per teacher.

Q191 Gavin Barwell: I want to develop the philosophical point about the balance between giving the schools more autonomy and not requiring each individual teacher to re-invent the wheel, essentially. From what you have said, you will slim down the curriculum to give schools more freedom, essentially more space, to decide exactly how they are going to educate their pupils. If you take a science teacher who is looking to organise field trips or practical work, without having lots of central initiatives that you say you do not want, how do we avoid a situation where there is a source of guidance they can go to in terms of the best opportunities in their area, rather than leaving each individual teacher to go out and find the relevant resources off their own bat?
Mr Gibb: This is what organisations like the science learning centres are about. There are lots of organisations out there that schools can buy into which have this expertise. That is what we want to see flourish and not have all that initiative coming from just the Department. I think that must be the right approach. People are professionals. They will develop their own approach and, hopefully, spread best practice through the teaching schools. Indeed, we will have on the website examples of best practice in all kinds of areas.

Q192 Gavin Barwell: Presumably, the teaching schools will have a responsibility for driving best practice in terms of how to teach science.
Mr Gibb: Yes.

Q193 Gavin Barwell: But in terms of opportunities of places to visit places for field trips and things like that, that is a matter for the national science learning centres.
Mr Gibb: Among others. I really do not know what the alternative is other than to say, "We think that on Thursday afternoon there should be a visit to the British Museum." I do not think that is the approach we want. We have to rely on professionals ultimately to know where it is best to go on a field trip. Those who are deeply immersed in their subject and attend seminars on their subject will know the places to take their pupils.

Q194 Gavin Barwell: I do not think anyone on the Committee will be looking to you to prescribe what people should do in individual sessions. I think it is more having a single resource which brings together all the opportunities so that there is one place to which

people can go and look for those opportunities. Certainly, from the school visit we made, that came up as an issue. Teachers thought there was not a single place to which they could go to see all the opportunities available. In relation to another inquiry, this Committee visited CERN. They were desperate to engage with schools in the UK, both at primary and secondary level, and were not really aware whether the mechanism to do that was in terms of providing opportunities for pupils to go out and visit or resources they could provide for use in the classroom. I entirely understand your political and philosophical point that you do not want the Department to prescribe all of this, but it seems to me there may be a gap between not having central prescription and making sure there is a vehicle out there which brings together all these opportunities in the same place.
Mr Gibb: I hear what you say and I will take it away and think about it further. As you say, it is not the direction of travel which we are headed towards. It is a wonderful idea for youngsters, if the opportunity arose, to visit CERN. It is also a good idea for them to have a trip round the Queen Mary, which I have also seen. Just a few weeks ago I saw a wonderful scheme at Imperial College called the Reach Out Lab. It is fantastic. Students from primary and secondary schools come in and see an experiment organised by Lord Winston at Imperial College. There are all kinds of initiatives like this. Once you start centrally suggesting that this or that is a good idea, it crowds out the potential for innovation.

Q195 Gavin Barwell: To ask the question in a slightly different way, do you think the Government have a role in providing a forum where teachers themselves can exchange thoughts about best practice? How should teachers in different schools swap thoughts and ideas about things they have done that have inspired their students to make sure that best practice is spread across our school system?
Mr Gibb: Again, that is what we want the teaching schools to do. That is the answer to that question. To provide a better answer to your earlier question, we also fund the Royal Institution to maintain a STEM directory. That is a directory of various STEM enhancement and enrichment opportunities open to people.

Q196 Gavin Barwell: Does the Department fund that?
Mr Gibb: It funds the Royal Institution to provide that.

Q197 Chair: Gavin referred to our previous inquiry into particle physics and astronomy. In that inquiry, students studying A-level physics were in front of us sitting in the very seats that you are in now. It was an enlightening session. I am not saying this is not. They talked about the things that you would expect: that an inspiring teacher makes a difference; obviously, support from parents makes a huge difference. But access to things that excited them also came out. One of the things we looked at in the case of astronomy was the role of the National Schools Observatory. Have you had any discussions yet with the STFC about that as a consequence of our report?
Mr Gibb: No, but if you suggest I do then I will.

Q198 Chair: We would very strongly encourage you to do so. You are quite right to talk about some of the exciting places such as the Reach Out Lab and so on, but clearly that is London-centric. There are facilities like those up and down the country. The NSO is a facility available online. The last figures I saw showed that a stunning number of schools had registered on that. Our concern was that it would disappear for want of a small sum of money, but we are not here to argue that. When we look across the country, some of those exciting places to which young people can go to experience science hands-on are under huge pressure. I have had some detailed discussions with David Willetts about that. I can see a very strong role for Ministers getting together and working with the private sector to try to enhance some of those and get serious support across the country. Don't you agree with that?
Mr Gibb: Yes.

Q199 Chair: So there are things the Government can do, you see.
Mr Gibb: Exhortation and facilitation, absolutely; we are very keen to do that. We are always talking to academics and universities, and encouraging a Reach Out Lab-type approach is the right one. Again, it is a bottom-up approach; it is about encouraging but not prescribing or organising from the centre.

Q200 Chair: One piece of evidence we had is: "We need more technicians in industry and less Stephen Hawkings. Maybe it is no surprise that the number of students attending HE science courses is declining and the number of those achieving certain grades is falling." Is that something the Government recognise?
Mr Gibb: I think the thrust of your quotation is the need for more people with those technical skills rather than pure ivory tower academics.
Chair: I guess that is the thrust of it.
Mr Gibb: We need both. We need to have top academics in our universities if we are to maintain British universities in the international tables where they are at the moment.

Q201 Chair: I would totally agree that we need both, but do you think that the current curriculum encourages the Stephen Hawkings at the expense of technicians?
Mr Gibb: No. I think we have problems right across the curriculum, which is why we are reviewing it. There are problems in mathematics; we need more youngsters to achieve higher levels of arithmetic and mathematics at school level; we need more youngsters taking the three separate sciences; we need them to be more knowledgeable in those three separate sciences by the age of 16. We need more youngsters taking A-levels. At every level I think we need to do better in this country, which is why we are reviewing the national curriculum.

Q202 Chair: Of all those possibilities, what do you see as the single most important improvement that could be made to improve science education?

Mr Gibb: I think we need to sort out maths, to be frank. I cannot remember which academic it was who said to me the other day that what they want for their physics undergraduates more than even physics A-level is maths and further maths at A-level. I worry about the level of arithmetic of youngsters leaving primary schools. We have to get that right and have a real boost in further maths at A-level. I think both of these things are important.

Chair: The Minister must have looked at the inside of my family and recognised that we have produced one higher level mathematician, so that is a good point on which to finish. Thank you very much for attending this afternoon.

Written evidence

Written evidence submitted by the Department for Education (Sch Sci 00)

Introduction

Science is a critically important subject for this country. The Schools White Paper: *The Importance of Teaching* acknowledged the importance of a "strong national base of scientific skills" providing a clear commitment to provide additional support to improve take up and achievement in the sciences in schools and colleges.

Practical science delivered with flair and knowledge can help pupils understand scientific concepts and ignite their interest in physics, chemistry and biology. Practical science is also an important part of scientific knowledge and teaches pupils about the empirical basis of scientific enquiry.

The key to making sure that good quality practical science contributes fully to effective science teaching is having high calibre science teachers and technicians in place. It is also important that existing teachers have access to good quality professional development opportunities and that they teach to a curriculum that provides them with the freedom they need to teach science in a way that best suits the needs and aspiration of their pupils.

International Comparisons

PISA 2009 showed that the UK performance in science continues to fall down the international rankings. England is now only marginally above the OECD average and so clearly there is much to be done to improve the general standard of science education if we are going to compete with the best in the world.

PISA 2006 (the most recent survey where science was the main focus) provides mixed results on the prevalence of practical science and field trips in England. We compared well internationally on the amount of time students spent doing practical experiments. This was supported by analysis[1] undertaken by SCORE[2] which found that in the UK more practical work takes place in science lessons than in most other countries. However, PISA 2006 data also showed that students in England tended to take part in slightly fewer excursions or field trips when compared to other countries.

DATA FROM THE PISA 2006 STUDENT QUESTIONNAIRE

When learning science topics at school, how often do the following activities occur?

Students spend time in the laboratory doing practical experiments

	England	*Wales*	*Northern Ireland*	*Finland*	*New Zealand*	*Japan*	*OECD Average*
In all lessons	–	3%	2%	2%	3%	3%	4%
In most lessons	24%	17%	16%	20%	18%	7%	16%
In some lessons	62%	67%	66%	52%	57%	44%	43%
Never or hardly ever	11%	13%	16%	25%	12%	45%	30%

The Way Forward

The latest Ofsted report on science education[3] found that more practical science lessons and scientific enquiry were key factors in schools which showed clear improvements in promoting students' engagement, understanding and progress. The report recommended that secondary schools and colleges ensure they use practical work and scientific enquiry as the key stimulus to develop scientific knowledge, understanding and skills. Crucial to achieving this will be to make sure we have enough good teachers in place and that existing teachers have good access to professional development opportunities so that they can readily update their subject-knowledge and skills. This is supported by SCORE who emphasised in their report the importance of effective teaching for improving the quality of practical work in science.

Recruiting More Science Teachers

We remain concerned that we are not drawing enough teachers from our top graduates, and find it challenging to attract the necessary number of graduates into some subjects such as science. Latest evidence[4] shows that only 14% of science teachers have a physics degree, 22% have a chemistry degree and 44% have a biology

[1] Practical work in science: a report and proposal for a strategic framework, December 2008

[2] Science Community Representing Education. Members comprise the Institute of Physics, Royal Society of Chemistry, Society of Biology, Association for Science Education, Royal Society and the Science Council.

[3] Successful science: an evaluation of science education in England 2007–2010, published January 2011.

[4] School Workforce Census, November 2010.

degree. *The Importance of Teaching* White Paper states the Government's intention to provide stronger incentives to attract the best graduates to come into teaching, including science.

Changes to higher education and student finance have been announced by the Department for Business Innovation and Skills. The Department for Education will publish later this year further details of proposals for the reform of initial teacher training. These will be discussed with schools, students, universities and other teacher training providers, before confirming plans in the summer, in time for the recruitment of teachers who start their training in September 2012. The White Paper also reaffirms our commitment to more than double the number of participants in the Teach First scheme so that more schools are able to benefit from the talents of the country's best graduates. The majority of Teach First participants teach the most demanding shortage subjects. In addition, teacher training bursaries are continuing to be paid to graduates in the sciences.

Improving the Skills of Existing Teachers

It is important that teachers and technicians have access to good quality professional development so that they can update and improve their subject-knowledge and skills. This is crucial to good quality practical work, enriching teaching and improving engagement in science subjects. The network of science learning centres (jointly funded by the DfE and the Wellcome Trust) will continue to play an important role in providing teachers and technicians with access to such opportunities.

Science learning centres will complement our more general approach to teachers' continuing professional development (CPD) and leadership training. This will focus on schools taking the lead for the training and development of teachers and creating more practical opportunities for peer to peer training. Giving schools greater autonomy in what they do and encouraging greater collaboration between schools will help ensure improvements in science education. This is consistent with our philosophy that teaching professionals know how best to teach.

At the heart of this approach will be the network of teaching schools.[5] These schools will work with strategic partners, including science learning centres and others who can contribute to improving the quality of science teaching, to offer a range of CPD opportunities for teachers and support staff including technicians. Teaching schools will also need to identify other schools and individuals that have the skills, capacity and willingness to work outside their own school to deliver programmes as well as coaching and peer to peer support. The expectation is that the scale and range of provision will grow as teaching school partnerships evolve.

We will continue to develop the relationship between science learning centres and teaching schools to ensure teachers have access to the highest quality development opportunities.

Curriculum Reform

The Government set out in the Schools White Paper its commitment to give schools greater freedom over the curriculum. As part of that commitment, Ministers launched a comprehensive review of the National Curriculum in England for 5–16 year olds.

Science is one of four subjects—along with English, mathematics and physical education—that have been confirmed will remain part of the National Curriculum at all four Key Stages; and in the first phase of the review we are drawing up drafts of new Programmes of Study for these subjects.

The review will consider the National Curriculum at both primary and secondary levels with the aim of setting out the essential knowledge that all pupils should acquire in key subjects such as science. The review will be informed by the best available evidence, including evidence about what works in the most successful education jurisdictions in the world. The new Programmes of Study for science will be prepared and available to schools by September 2012, to be taught in maintained schools from September 2013.

The Government is committed to wide-ranging and open consultation on the new National Curriculum. The review was launched on 20 January, together with a Call for Evidence which ran until 14 April. We received over 5,800 responses, including detailed responses from the Royal Society, the Association for Science Education and SCORE. We have also been consulting directly with the science education community to seek their views on the content of the science curriculum. This includes the Institute of Physics, the Royal Society of Chemistry, the Society of Biology, the Association for Science Education, the Royal Society and SCORE. This provided them with the opportunity to stress the importance of scientific enquiry and practical work in science education. The Department led a seminar with a wide range of key stakeholders on 31 March, and SCORE organised a one-off conference on the review on 21 March. Further consultation is planned including events to seek the more detailed views of practising teachers.

Qualifications Reform

The Schools White Paper set out the Government's intentions for qualifications reform. New GCSEs will be developed to reflect the outcomes of the National Curriculum review, and specifically to reflect the new

[5] The teaching schools prospectus can be found at: http://www.nationalcollege.org.uk/index/professional-development/teachingschools.htm?WT.ad=TK015

Programmes of Study for science. In reforming GCSEs, we will also assess the extent to which the ability to undertake effectively practical experiments in laboratory, field and other environments should be specifically assessed through formal examinations.

The Department is working with Ofqual on a new process for developing A levels which gives universities and learned societies a much stronger say in their design and development. A levels should match the best qualifications in the world and assess candidates on the knowledge which universities require them to have. We will look to universities to advise on the extent to which practical experiments and field study should be part of A level specifications in science subjects in future.

DfE Support to Promote Practical Science

Some work has been undertaken and is in place to promote greater use of good quality practical work in science lessons at all levels of education. This includes specific projects and programmes supported by the Department for Education to raise the profile of practical science.

The Getting Practical Programme: Improving Practical Work in Science (IPWiS) project was a two year project delivered on behalf of the Department for Education by the Association for Science Education in partnership with the science learning centres, the Centre for Science Education and CLEAPSS. This was in response to concerns raised by the science education community about the quality of practical work being carried out in schools. Its aim was to raise the awareness of the importance of practical work and to improve the quality of practical work in primary and secondary schools. The programme, which ended in March 2011, provided professional development for teachers, technicians and high level teaching assistants. The evaluation of this programme found that it brought about a substantial change in both the use and effectiveness of practical science.

As part of a drive to promote practical work, the Department also contracted with SCORE to produce the *Practical Work in Science* booklets that were sent to all primary and secondary schools in England in 2009. The booklets were designed to help teachers recognise and plan for a wide variety of high quality practical work, including opportunities for pupils to practise specific scientific techniques and procedures.

The network of science learning centres provide science teachers and technicians with a good range of professional development opportunities including courses and events on practical work. The Science Learning Centre website provides access to a whole range of support for teachers including, for instance, the Practical Chemistry webpage which provides teachers of chemistry with a range of experiments from which to choose. The National STEM Centre, funded by the Gatsby Charitable Foundation, is based at the National Science Learning Centre in York. It houses a large collection of resources that science teachers can draw on to support teaching in the classroom.

The DfE-funded online directories of STEM enhancement and enrichment activities provide yet another source of rich high quality programmes and activities that teachers can use.

Health and Safety

Although health and safety risks need to be managed, the safety measures adopted should be proportionate, and in most instances will enable rather than hinder activities, thus enabling pupils to benefit from a wide range of experiences.

All schools must adhere to the *Health and Safety at Work Act etc.* 1974 which places a duty on employers to ensure that all staff and pupils are safe; and *The Management of Health and Safety at Work Regulations 1999,* which requires employers to assess the risks of activities such as science lessons and field trips and to put into place measures to control those risks. Currently in relation to some field trip activities (eg caving, trekking etc) schools should check that the provider holds a licence from the Adventure Activities Licensing Authority, which manages the statutory inspection and licensing scheme as set up in 1996. Parental consent is advisable for visits that involve any element of the outdoors and, in general, for visits that take place outside the normal school day. Information (without consent) should suffice for less adventurous visits that fall within the school day. In the case of science lessons as well as the HSWA duties school should also look at advice from CLEAPSS, which has a website of information on practical safety measures.

The SCORE *Practical Work in Science* booklets also contained general health and safety guidance; and there are professional development courses on health and safety available through the network of science learning centres.

The Government wants schools to adopt a more common sense approach towards health and safety by reducing the level of bureaucracy involved. We are concerned that too great a focus on health and safety can often stifle school activities, particularly off site educational visits. The Government wishes to encourage teachers to take pupils off-site by making it simpler to do so safely.

The Department for Education published, on its website in February, its response to Lord Young's report *Common Sense, Common Safety* (published in October 2010) following his review of health and safety law and the compensation culture. We are working with the Health and Safety Executive (HSE) on the recommendations that apply to schools.

The Department leads on facilitating school trips in general. This includes new succinct guidance to convey the message that consent is not advisable for most off-site activities that occur during the school day, and to offer a generic consent form for each pupil which can be used, with an opt-out, for the comparatively few visits on which parental consent is advisable. These, and other measures on which we are assisting the HSE, are designed to make risk assessment more realistic for schools, making it easier for science field trips, amongst other off-site excursions, to be undertaken.

Department for Education

10 May 2011

Written evidence submitted by the British Science Association (Sch Sci 05)

INTRODUCTION

1. The British Science Association is a registered charity that exists to advance the public understanding, accessibility and accountability of the sciences and engineering in the UK.

We seek to achieve that by connecting science with people: promoting openness about science in society and affirming science as a prime cultural force through engaging and inspiring adults and young people directly with science and technology, and their implications.

Established in 1831, the British Science Association organises major initiatives across the UK, including the annual British Science Festival, National Science and Engineering Week, programmes of regional and local events, and an extensive programme for young people in schools and colleges.

The British Science Association is established under Royal Charter and governed by a Council which forms the Board of Trustees. It is registered with the Charity Commission (number 212479) and with the Office of the Scottish Charity Regulator (number SCO39236).

How important are practical experiments and field trips in science education?

2. The benefits of practical work are well documented and were summarised in the SCORE (2008) report[6] which stated "practical work promotes the engagement and interest of pupils as well as developing a range of skills, science knowledge and conceptual understanding".

3. The OECD-wide PISA studies provide compelling evidence of the value of practically-based activities.[7] They show that involvement by students in enrichment activities such as science fairs, competitions and visits is one of only three "educational resource factors" correlated with increased performance in science after allowing for socio-economic background.

4. Practical activities and field trips offer particular opportunities for young people to develop creativity. Creative activities, according to the report of the National Advisory Commission for Creative and Cultural Education (the Robinson report),[8] have four characteristics (which are used by Ofsted inspectors to report on creativity in schools), namely: being imaginative and purposeful, and developing something original and of value in relation to the purposeful objective. That implies the need for contexts that offer opportunities for exploration, for taking risks and making mistakes, provide exciting or unusual stimuli, sharing and reflecting openly on ideas, respecting difference and offering choice and control to students.

5. We believe strongly that young people should experience science and technology by engaging in exploratory and open-ended scientific and technological activities themselves. Project work allows students to gain experience of some of the technical skills associated with doing science as well as benefiting from team working and problem solving.

6. Our CREST Awards scheme was externally evaluated recently by Liverpool University[9]. The findings from the impact study showed that:

- CREST has a strong positive impact on its primary target audience.
- Students gained knowledge and developed transferable skills.
- Students' attitudes towards STEM and aspirations for STEM careers were improved.
- A large number of teachers commented that CREST enthuses and motivates students and many commented on the skills and confidence that students develop.
- Many teachers felt that the scheme helped inform their teaching and gives students a broader experience of STEM than school alone can offer.
- Teachers felt that CREST raised the profile of STEM in the school.

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6 Science Community Representing Education (2008) Practical Work in Science: A Report and Proposal for a Strategic Framework, Royal Society, London

7 PISA 2006: Science Competencies for Tomorrow's World, Vol. 1, pp258–264 and Executive Summary pp43–44

8 http://sirkenrobinson.com/skr/pdf/allourfutures.pdf

9 Grant, L (2006). *CREST Awards Evaluation Impact Study*, University of Liverpool

— Mentors highlighted the impact on students' decision-making at Gold level, and described the impact on young people's subject choices at university.

7. The British Science Festival (organised by the British Science Association) also provides inspirational hands-on practical experiences for young people outside the classroom, reinforcing our organisation's dedication to these principles.

8. The Association manages the National Science and Engineering Competition and is a major partner and instigator of the Big Bang (UK Young Scientists' and Engineers' Fair).

Are practical experiments in science lessons and science field trips in decline? If they are, what are the reasons for the decline?

9. The British Science Association is particularly interested in the level of opportunities for project-based practical work in schools and colleges. We believe this is in decline despite on-going curriculum developments encouraging this approach. Based on ad hoc feedback, possible reasons contributing to a potential decline include:

— Discrete STEM experiences are easier to implement initially whereas project-based approaches may be more time consuming and problematic.

— Investigative project work is used mainly for assessment purposes (as shown by Millar and Abrahams (2009),[10] who observed 25 practical situations in schools as part of their study, none of which came under the category of supporting the processes of scientific enquiry).

— Teachers sometimes feel that the benefits of project work regarding attainment are not proven or not always recognised.

— Teachers have prioritised implementing new curriculum changes and have not yet had the time to incorporate project-based approaches that effectively support these changes.

— Teachers may be less motivated to implement project-based practical experiments since they feel it can be difficult to find experiments that are both exciting and achievable, as reported in an independent evaluation of the CREST Awards carried out by Grant (2006).[11]

— Today's teachers have developed through a structured curriculum and are not as experienced in implementing project-based approaches.

10. Reports such as NESTA's Real Science[12] have investigated the status of science enquiry in UK schools, but given this was produced in 2005 and that educational policy now further encourages schools to offer project-based and cross-curricula approaches to practical work, it's crucial that we find out whether genuine experimentation by pupils is actually getting less common, not more, in schools and colleges.

Do examination boards adequately recognise practical experiments and trips?

11. As an organisation focusing primarily on informal learning opportunities we are not best placed to comment on this in detail. However, we do recognise the difficulties in employing fair models that uniformly assess practical work as part of exams. A variety of techniques have been used by examining bodies (eg ISAs, IAA tasks) but anecdotal comments from teachers suggest that some may look for the easiest way for students to safely score the best marks (rather than choosing the assessment approach that may provide the best opportunities for students to develop a broad range of practical skills) given the emphasis on league tables and results. We are very interested in the development of new qualifications recognising the importance and value of longer term project work (which is often practically based) such as the Extended Project Qualification, which echoes the ethos of CREST and the principles of the British Science Association.

If the quality or number of practical experiments and field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in Higher Education?

12. Our own small scale research with admissions tutors in HE has suggested that students often arrive at the start of their course without the skills set to persevere and problem solve in longer term project-based work. This could directly relate to the lack of opportunities for such practically-based project work that students undertake in schools/colleges and this reinforces our belief in the value of the CREST Awards.

13. Generally there is a low awareness of the breadth of careers that may result from science/maths routes. Similarly there is a low awareness of the rewards and opportunities that may be available through STEM careers.

14. High quality enhancement and enrichment is very important to improve engagement with role models and scientists helping to remove stereotypes and playing a key part in enthusing young people. Learning does not just take place in lesson time and young people can benefit from having a wide range of learning

[10] Abrahams, I and Millar, R (2009). Practical Work: making it more effective. *School Science Review*, 91 (334), 59–64.
[11] Grant, L (2006). *CREST Awards Evaluation Impact Study*, University of Liverpool
[12] http://www.nesta.org.uk/library/documents/RealScienceFullReport1.pdf

experiences in different environments outside of the classroom and through field trips. These principles are firmly supported through the CREST Awards scheme.

What changes should be made?

15. A radical change is not required since it feels as though teachers (and students) have had to deal with an ever-changing curriculum. We would suggest there should be more of a change of emphasis, to be gradually implemented which will take time if it is to be effective.

16. New curriculum developments should not just focus on "what" is included, but more of a consideration should be given to "how", providing space for creativity and the development of broader skills. However, if teachers are to be encouraged to broaden their approaches through a more open curriculum then it needs to be recognised that appropriate support will be required and it will take time (and resources) to effectively implement any change of emphasis in a new curriculum.

17. There is a wide range of organisations that are well-placed to help teachers provide their students with opportunities to do practical work and take part in field trips and visits. These organisations range from national bodies like the British Science Association, the Association for Science Education, the various professional bodies and STEMNET through to small local organisations that work with a small number of schools more intensively. These organisations are facing considerable turbulence at the moment as a result of reductions or disruptions in their funding streams. While this may be an inevitable consequence of the Government's current spending priorities, we need to ensure we don't inadvertently lose a swathe of experienced activity providers who can help to safeguard the future health of the UK's R&D base.

One of the key themes that emerged from the most recent meeting of our CREST Quality Assurance Group was that primary schools continue to request intensive support from our partner organisations (those who provide activities for schools). Primary teachers tend to recognise the value of hands-on, practical activities in stimulating interest in the sciences—but because so few primary teachers have science backgrounds, they often lack confidence, which is why they value the support from us and our partners. We need to ensure that, despite the challenging funding situation, teachers in primary and secondary schools continue to have access to providers of high quality practical activities and field trips that encourage children's interest in the sciences.

18. Finally, one of our activity provider partners has commented that with the loss of the STEM Advisory Forum from April 2011, there is no longer a channel through which providers of practical activities, field trips, etc. can voice their opinions.

Is the experience of schools in England in line with schools in the devolved administrations and other countries?

19. We can use the numbers of CREST Awards achieved by secondary students as a proxy for the amount of practical work going on in schools across the UK. In 2008, Northern Ireland students achieved 5,461 Awards which was 21% of the total number achieved in the UK, despite only having 3% of the UK's population of 10 to 19-year-olds.[13] A similar phenomenon, though less exaggerated, can be observed in the figures for Wales and Scotland which may suggest that schools in devolved administrations are able to offer more practical work opportunities to their students. Any such conclusion would require further research though, since perhaps students in England are being offered practical work opportunities outside our programmes.

Declaration of Interests

The British Science Association is in receipt of grant funding from the Department for Business, Innovation & Skills and the Department for Education towards the CREST Awards programme and from the Department for Business, Innovation & Skills for the National Science and Engineering Competition.

British Science Association

6 May 2011

Supplementary written evidence from the British Science Association (Sch Sci 05a)

At the evidence session this morning, the Chairman raised the question of independent school participation in the National Science and Engineering Competition at the Big Bang, and I gently disagreed with his picture of overwhelming private school participation.

Here are the figures from this year, which show majority state school participation, though some over-representation from the private sector (as one might expect given their larger resources), and from selective schools (including state grammar schools).

71% of finalists came from state schools with 29% from the independent sector. The state schools included comprehensive schools, 60 form colleges, academies and maintained schools.

[13] Figures taken from Office for National Statistics http://www.statistics.gov.uk/statbase/Product.asp?vlnk=15106

55% of finalists came from non-selective schools, compared to 45% from selective schools.

The tables below show breakdown by country and selectivity.

	Total	*Total %*
England—Maintained	69	45
England—Academies	13	8
England—Independent	36	23
England—Colleges	3	2
Northern Ireland	9	6
Scotland	14	9
Wales	9	6
Home Educated	1	1
	Total	**Total %**
Total Selective	69	45
Total Non-Selective	84	55

Sir Roland Jackson
Chief Executive
British Science Association

29 June 2011

Written evidence submitted by the Earth Science Teachers' Association (Sch Sci 06)

The Earth Science Teachers' Association is a UK-wide teaching association with some 500 members, most of whom are engaged in teaching A-level or GCSE geology but are mostly also involved in secondary science education. ESTA members also teach in primary schools and in geography departments as well as in teacher education and Higher Education. ESTA was formed as the Association of Teachers of Geology in 1967 and since then has been supporting teachers of Earth science and geology, the Earth science/geology curriculum and the wider teaching of Earth science across the nation.

1. *How important are practical experiments and field trips in science education?*

ESTA has worked for many years in collaboration with the Earth Science Education Unit which brings practically-based Earth science workshops to trainee teachers and practising science teachers across the UK, through a team of regionally-based facilitators in England, Scotland and Wales. The wide range of practical activities has proved very popular with both practising and trainee science teachers at primary and secondary level, and research carried out by the ESEU has shown that the activities are widely used in schools following ESEU visits (King and Lydon, 2009). Teachers who have used the activities have responded that they have "brought the lesson to life" and made the lessons much more engaging and understandable to students.

Fieldwork is and always has been an underpinning part of geology education as evidenced by the fact that the GCSE geology specification and the two A-level geology specifications all strongly recommend fieldwork. ESTA members argue that students can not gain a proper understanding of Earth science without engaging with rock exposures in the field, and applying the methodology of geology to understanding the geological settings of the rocks they examine. This not only involves a number of skills unique to geology fieldwork, but also develops wider thinking and investigational skills as well as all the social skills associated with working in the field. Many geology teachers of all levels would argue that it is impossible to gain a proper understanding of how geology is studied, and what geologists do and find out, without experiencing fieldwork. Many also note that their own interest in geology was sparked by a fieldwork experience during their own education, and that we should continue to offer these experiences to spark and maintain interest in the geologists of the future, as well as in the wider population. The emphasis on the fieldwork may underpin the recent increase in geology exam entries at all levels, recorded by King and Jones (2011).

2. *Are practical experiments in science lessons and science field trips in decline? If they are, what are the reasons for the decline?*

ESTA members have anecdotally reported increasing difficulty in being able to undertake fieldwork, for the following reasons:

- — the "rarely cover" regulations which mean that schools find it more difficult and expensive to cover the lessons of teachers taking fieldwork during school time;
- — increased emphasis on health and safety regulations, meaning the arranging of fieldwork has become much more time-consuming and paper-intensive than previously;
- — specifications in science that are very time consuming, particularly those with some forms of practical assessment, leaving little time for fieldwork;

— the need to argue for fieldwork to be supported within all the other broader curriculum constraints that operate in schools and colleges; and
— increasing expense.

3. *What part do health and safety concerns play in preventing school pupils from performing practical experiments in science lessons and going on field trips? What rules and regulations apply to science experiments and field trips and how are they being interpreted?*

Anecdotal evidence over many years has shown that authorities respond to increasing health and safety concerns by increasing paperwork, when a much more effective method might have been to invest in professional development that would train the teaching workforce to anticipate and cope with potentially hazardous fieldwork. This would have had the effect of releasing teachers to lead more effective fieldwork, rather than being a disincentive to leading fieldwork. Further anecdotal evidence indicates that some schools and colleges have much more effective policies and procedures for facilitating and supporting fieldwork than others.

Had there been recognised certificated courses for leading fieldwork and funding for teachers to attend these courses, the effect would have been more effective and probably less hazardous fieldwork, and a much wider understanding of the benefits of fieldwork coupled with many more fieldwork experiences being available to pupils. Such courses would have been of real benefit to trainee and practising science teachers alike. The lack of such courses over many years, despite efforts by ESTA and other teaching organisations interested in fieldwork, has been a continuing disappointment. It represents a failure of our education system to engage and inspire students in ways that could have transformed their lives, and which would have had impact far beyond the confines of science.

4. *Do examination boards adequately recognise practical experiments and trips?*

As noted above, both GCSE Geology and the A-level Awarding Bodies all strongly recommend fieldwork. However, this is not the case with GCSE science examinations. The case for outdoor science would be much stronger if GCSE science awarding bodies supported outdoor science activities more strongly.

5. *If the quality or number of practical experiments and field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in Higher Education?*

Recent evidence has shown that 45% of the applicants for UCAS undergraduate courses in geology have studied A-level geology or Scottish Higher geology at school. Many of these will have been inspired to take up geology in the first place, and then to continue studying geology through Higher Education, by fieldwork.

6. *What changes should be made?*

A nationally recognised and accredited fieldwork leadership course should be devised that would focus on the leadership of effective investigational fieldwork and how this should be implemented most successfully and in the safest and most healthy ways. Such a course should be well supported and funded as well as being broadly applicable to all school-level fieldwork. By the investment of relatively small amounts of funding to such an initiative, the fieldwork experiences of students across the country could be much more widespread and even more effective than they are today.

Meanwhile the Science and Technology Committee should encourage further developments in school level fieldwork through:

— highlighting to all those involved in education the benefits of fieldwork shown by research;
— reducing the hurdles to the implementation of fieldwork in schools and colleges;
— encouraging Awarding Bodies to raise the profile of fieldwork in their science specifications and their assessments;
— encouraging the development of fieldwork education in teacher education institutions and CPD courses for practising teachers;
— encouraging further research into the impact of fieldwork on student learning, motivation and career aspirations, and into the initiatives outlined above; and
— instigating cross-school subject support for fieldwork, involving, science, geography, history, etc.

7. *Is the experience of schools in England in line with schools in the devolved administrations and other countries?*

Feedback from ESTA members in Scotland, Northern Ireland and Wales gives a very similar perspective to that described above, with the same issues and constraints. This is not surprising as in England, Wales and Northern Ireland at least, teaching is to the same specifications (in science and geology) so it is not surprising that the issues are similar.

References

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Earth Science Teachers' Association

8 May 2011

Written evidence submitted by the Field Studies Council (Sch Sci 07)

Introduction

The Field Studies Council (FSC) is delighted that the Science and Technology Committee have chosen to undertake an inquiry into the practical experiments in school science lessons and science field trips. The FSC is the UK's only education charity that specializes in field studies, working every year with over 3,000 school groups and 125,000 visitors to its national network of 18 Field Centres.

The FSC's science related provision includes:

- Fieldwork courses for 550 groups and 23,000 students studying mainly secondary science;
- PGCE fieldwork training courses for students from over 30 colleges;
- Hosting bioscience courses for universities;
- Delivering outreach projects such as *London Outdoor Science* and *Schools in the Parks*, to support secondary schools in Inner London to carry out fieldwork in local parks and open spaces;
- Providing 240 natural history courses for adult professional and leisure learners in field skills such as habitat assessment, field surveying and identification;
- Employing 140 teaching staff and over 200 Associate Tutors, many with bioscience and environmental science degrees;
- Publishing over 140,000 guides and resources to support fieldwork;
- Campaigning with partners such as Association for Science Education (ASE) to support science fieldwork;
- Being a founder member of the ASE's Outdoor Science Working Group; and
- Managing the Learning outside the Classroom Council's Quality badge for the fieldwork sector.

The FSC believes that this experience gained over nearly 70 years in the UK gives it a unique insight into trends and influences in science fieldwork and field trips. All of the following evidence is based on FSC's own experience and data sources. Published references are quoted, but all other observations are supported by FSC unpublished but attributable data.

Are science field trips in decline? If they are, what are the reasons for the decline?

General

1. A review of 13 published surveys—including FSC published data—highlights a decline in fieldwork provision in the UK between 1963 and 2009 (ref. 8).

2. FSC's view (derived from long-term membership of organizations such as Institute for Outdoor Learning, English Outdoor Council, Association of Field Studies Officers, Association of Heads of Outdoor Education Centres) is that there has been a reduction over 40 years in the capacity in residential centres to offer taught upper secondary science fieldwork, mainly due to a shift in capacity from field centres (with a secondary fieldwork focus) to outdoor education centres (often with a primary adventure focus).

3. Current national capacity to teach high quality science fieldwork (remote residential and local day) is under continuing threat. In 2011, over 72 field and outdoor education centres are either closing or are "threatened" by current funding reviews, 66% being Local Authority Centres. Together, these have a combined visitor base of 310,000 primary and secondary pupils.

Field Studies Council

Trends in residential fieldwork

4. Science field courses in FSC residential Centres have been in decline for 30 years, both in terms of number and in duration.

5. Secondary science groups in have been replaced in FSC Field Centres by geography groups (54% of FSC groups in 1970 were science; 36% in 2003) (ref. 14).

6. Post Curriculum 2000, the "modular" teaching of science A level has sharply constrained the months in which science A level fieldwork is taught, often squeezing fieldwork and field trips into three months of the academic year (July, September, October).

7. The average FSC A level science residential field course has halved in length in 15 years, from just under seven days to 3.4 days (ref. 9). This trend is continuing today.

8. Shortening of courses leads to schools travelling shorter distances to carry out fieldwork, reducing the opportunity to visit contrasting and potentially inspiring locations such as seashore, moorlands and montane habitats. The dramatic decline in opportunities to visit such locations has also been published elsewhere (ref. 7).

9. The decline in FSC residential A level biology courses has accelerated recently, with a fall of 18% recorded between 2008–10. The reasons given for this decline by FSC Heads of Centres are:

(a) Lost groups (36 lost) not being replaced by new ones (22 gained) in 2008–09;

(b) New groups staying for shorter periods (3.3 nights compared to 4.5 nights);

(c) Existing groups dropping one or two nights of their stay.

The reasons given by visiting teachers for these changes (in declining importance) are:

(d) Loss of coursework at A level;

(e) Declining support for science teachers wanting to do fieldwork from school colleagues, including Head of Departments and senior managers—often linked to the demise of coursework and consequent "devaluing" of fieldwork's importance;

(f) Schools moving fieldwork from remote residential to local day activity OR a total loss of fieldwork (sometimes replaced by laboratory practicals);

(g) Percieved overall cost of fieldwork (particularly increasing transport costs and supply cover costs (see h below));

(h) A narrow interpretation of the "rarely covers" guidance in the teachers workforce agreement which has resulted in increasingly complex timetabling and planning, and increasing cost for supply cover.

10. The decline in UK residential fieldwork, including FSC hosted, is also being replicated in universities, where a general decline in whole-organism biology, modular teaching and the growth of subject content in molecular and cellular biology are often cited as causal factors (ref.13)

Trends in non-residential fieldwork

11. Surveys carried out during the FSC's *London Outdoor Science* and *Schools In The Parks* projects, which aimed to develop use of inner London parks and open spaces by science teachers in local secondary schools, show that a minority of secondary science departments in inner London schools use local parks and open spaces for science fieldwork, with fewer than 20% of schools carrying out GCSE science fieldwork locally (ref.4).

12. The main barriers and issues raised by 47 secondary teachers in the FSC's *London Outdoor Science* and *Schools In The Parks* projects were (in diminishing order): 1) Disruption to classes and other teachers; 2) Staff cover; 3) Health and Safety; 4) Lack of access to suitable site; 5) Perceived lack of usefulness re. curriculum (refs. 4 & 5).

13. An FSC survey of 36 Secondary Science PGCE students from two leading university initial teacher education courses (working with the FSC *Schools In The Parks* project) have also cited similar barriers, as shown in the table below. Nearly a third cited "School Systems" as being the main prevention to completing outdoor activities with their classes in the future. This included lack of support from mentors, administration, bureaucracy, permissions, and attitudes of the school to outdoor learning.

Response	*Total number of responses*
School systems*	22
Pupil behaviour	14
Timetable issues	8
Location of park near to school	7
Health and Safety**	7
Weather	6
Confidence	6
Other***	2

14. FSC's work in urban areas throughout the UK has consistently shown that primary schools are much more likely to use local parks, open spaces and resource centres for fieldwork compared to secondary schools. There is a precipitous decline between upper primary (KS2) and lower secondary (KS3). Inflexible timetabling is often cited as a major barrier to secondary provision (see paragraph 13 and 14).

The role of teacher training

15. FSC work with partners, including through the ASE's Outdoor Science Working Group (ASE OSWG), has consistently identified that there is a shortage of secondary science teachers with the confidence, competence and commitment to lead fieldwork. In response, the ASE OSWG has released two reports which have made recommendations to remedy this shortage (refs 10 & 11).

16. Any reversal in the decline in science fieldwork will have to be led by teachers. The capacity and enthusiasm to teach science in the field will need to be increased and ensuring a high status for fieldwork in Initial Teacher Training and the standards which underpin it will be the most effective way of equipping future teachers of science with the skills to take their students into the "outdoor classroom".

How important are field trips in science education?

17. A review of Outdoor Learning commissioned by the FSC shows that science fieldwork which is well planned and effectively delivered will have positive impacts on cognitive development, personal/social skills and physical development (ref. 12).

18. Another review by the Institute of Education of residential fieldwork courses (combined with adventure activity) at FSC centres undertaken by inner-London secondary schools showed that pupils had increased positive impacts in the following developmental areas: cognitive; interpersonal and social; physical and behavioural (ref. 1).

19. Teachers working with the FSC also note that the experience of using "messy" primary data outside the classroom (ie less easily sanitised, managed and orderly than its indoor or virtual equivalent) is very powerful in demonstrating the real strength of scientific methodology (How Science Works).

What part do health and safety concerns play in preventing school pupils from going on field trips? What rules and regulations apply to field trips and how are they being interpreted?

20. Health and safety concerns are cited as important by science teachers and PGCE students, but often less important than other barriers such as inflexible timetabling, lack of cover, lack of training etc (see paragraphs 12 & 13).

21. Not surprisingly, there is a contrast between importance attributed to health and safety between teachers who are leading their own fieldwork and those who are using "external" experts such as FSC. Over half of teachers using FSC Centres report that Health and Safety has no negative influence on their decision to offer fieldwork (ref. 14).

22. The ways in which rules and regulations are applied vary considerably between Local Authorities, between schools in the same Local Authority, and even between departments in the same school. Science departments in London secondary schools will cite H&S as a barrier even when history and geography teachers are content to lead residential trips, even overseas.

23. The FSC welcomes many of the findings of Lord Young's Review and his proposals to simplify the process that schools and other organisations undertake before taking children on outdoor learning experiences.

Do examination boards adequately recognise science field trips?

24. The status and nature of field trips in secondary schools are very much determined by national curricula and specifications: this affects the views of teachers, examiners and inspectors.

The influence on teachers

Levels of fieldwork

25. Fieldwork has not been compulsory in the national curriculum for science, unlike geography. As a result, geography numbers have grown within the FSC over 20 years, replacing science as the major contributing subject to FSC visitor numbers (ref. 14).

26. Geography teachers are twice as likely to do residential fieldwork at Key Stage 3, and ten times more likely at GCSE level; they were also twice as likely to do local fieldwork at both levels (ref. 14).

27. In some years FSC sells more plant and animal identification charts to geography teachers than to science teachers—probably because geographers are doing more habitat related (environmental geography) fieldwork than their science counterparts.

28. The heightened profile in specifications such as Edexcel SNAB A level biology can increase the take up of fieldwork by biologists. In a 2001 telephone survey carried out by FSC of secondary teachers in 75 state schools who did not use FSC centres the proportion doing A level biology fieldwork ranged from 62.5% in one specification to 100% using the Edexcel specification (ref.14).

29. Another recent FSC example of curriculum having an immediate impact on levels of fieldwork provision is provided by GCSE Geography where the introduction of Controlled Assessments has led to a sharp rise in GCSE Geography groups.

30. However, compulsion is not the only reason for differences in level of fieldwork provision across subjects. Fieldwork seems to be embedded more strongly in the culture of some subjects. For example, the Key Stage 3 history curriculum does not include compulsory fieldwork and yet a 2004 FSC survey of London secondary schools showed that three times as many history groups embark on residential fieldwork compared to science groups from the same schools.

Nature of fieldwork

31. Whereas secondary geography teachers see fieldwork as being integral to the whole course (the most important reason they cite for continuing to do fieldwork), many science teachers have a much narrower view of its purpose—seeing it as an activity which delivers a discrete part of the curriculum (usually ecology related, and often with a very tight focus on data collecting, handling and analysis, and associated skills and techniques) (ref. 14).

32. These differences in perception result largely from curriculum design which assigns fieldwork to a particular unit in the science curriculum (particularly when it became very closely linked to A level coursework after *Curriculum 2000*) whereas it reoccurs throughout the whole geography curriculum.

The influence on inspectors

33. The statutory requirement for fieldwork in geography also raises the profile of fieldwork in Ofsted subject inspections in schools. Previous FSC research has shown that geography subject inspections have been eight times more likely to comment on fieldwork than science subject inspections. This will influence the importance attributed to fieldwork by teachers and managers (see paragraph 34 below) (ref.14).

The influence on senior managers

34. At a meeting of A level Biology Chief Examiners hosted by FSC the group strongly supported the view that the profile of fieldwork in schools is driven very strongly by external inspection... "if it's not inspected, it's not important" (ref. 3).

35. Teachers who have cancelled FSC field courses have cited the perceived lowering of fieldwork's importance in the eyes of senior managers and departmental colleagues—the fact that it is no longer essential (because coursework was no longer a requirement for example)—as one of the main reasons to cancel (see paragraph 10e).

Influences on socio-economic accessibility

36. Compulsion also support attendance by a broader socio-economic grouping of students. In some FSC projects, for example working with KS3 and GCSE groups from disadvantaged urban City Challenge schools (2009–10) up to 80% of the 14–16 year olds had never been on a residential in their school careers (and neither had their parents).

37. The probability that a stronger curriculum requirement can lead to a more inclusive take up of fieldwork is supported by FSC data: 75% of geography groups come from State funded schools, compared to 68% of Science groups.

If the quality or number of field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in Higher Education

General

38. Fieldwork trends are being replicated in undergraduate bioscience degrees (see paragraph 11 above (ref. 13).

39. This is reducing the number of bioscience graduates available (to FSC and others—see paragraph 38 below) to pursue professional vocational careers in ecology throughout the UK (ref. 6).

40. The reduction in fieldwork will also lead to a decrease in exposure to a range of data handling scenarios and the development of associated skills which are highly valued by employers (and identified as a current weakness) including the FSC. See also paragraph 15 above.

41. The low level of fieldwork training in Initial Teacher Education and CPD is failing to sufficient numbers of science teachers with the confidence, competence and commitment to lead fieldwork. See also paragraphs 12 & 13 above (refs. 10 & 11).

Field Studies Council

42. The decline in fieldwork experience is reducing the number of bioscience graduates with practical fieldwork skills, thus reducing the pool of potential tutors recruited by the FSC.

43. One area in which the demise of practical fieldwork has had a noticeable effect on A level students and trainee teachers is in field surveying and identification skills (ref 2) (research carried out in FSC centres).

What changes should be made?

44. The FSC recommends that the following changes are needed to ensure that the full potential of fieldwork is developed in the science curriculum:

(a) Fieldwork should be a **statutory or strongly stated requirement** in the science (particularly upper secondary) curriculum;

(b) **School inspections** by Ofsted should comment on the level and quality of fieldwork being taught in schools, and it should be a requirement for school science departments to achieve good or outstanding status;

(c) Any reversal in the decline in science fieldwork will have to be led by teachers and we feel that the **Qualified Teacher Standards** (which are currently the subject of Sally Coates' Independent review) should include a requirement for all trainee science teachers (including chemists and physicists, as well as biologists and earth scientists) to have prepared and taught at least one fieldwork lesson as part of their training;

(d) **Career progression** in science teaching should recognize the value of fieldwork experience, including the role of teachers in training colleagues to build school capacity;

(e) Awarding Bodies should adopt **assessment methods** which are appropriate for fieldwork, rather than formulaic summative tasks which diminish its potential; and

(f) Guidance to schools should clearly state that the **pupil premium** can be used for fieldwork to proved equitable access by all students to the full range of effective science teaching and learning approaches.

Is the experience of schools in England in line with schools in the devolved administrations and other countries?

45. FSC has Field Centres in Northern Ireland (one centre), Scotland (one centre) and Wales (four centres) as well as England (12 centres). Our very strong evidence is that the trends described above are happening throughout the UK. For example, in 2002 FSC took over Kindrogan Field Centre in Scotland following many years of continuing decline in school and HE visits.

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Field Studies Council

9 May 2011

Supplementary written evidence submitted by Field Studies Council (Sch Sci 07a)

The Field Studies Council (FSC) was delighted to have the opportunity to give oral evidence to the Science and Technology Committee on 29 June2011. Due to the time constraints of the session I felt that there were a number of issues which I was unable to fully bring to members attention. We have, therefore, pulled together this short document to expand on our oral evidence and would be most grateful if members of the committee would take a moment to read its contents.

Professional Standards for Teachers

I raised the point about the weakness in the professional standards for teachers in relation to outdoor science but didn't have time to fill in the detail. The current standards are presented at five levels:

1. Qualified Teacher Status
2. Core
3. Post Threshold
4. Excellent Teacher
5. Advanced Skills Teacher

Standards for out-of-school learning fall within the section labelled Teaching Skills—the Learning Environment. There are standards for The Learning Environment at QTS and Core levels, but no further professional development after that. In other words an AST is only expected to achieve the same standard as a QTS or C Teacher. The Learning Environment is the only teaching skill that isn't developed (unlike Planning, Assessment, Teamwork etc.) above Core level.

Without an obvious professional development underpinned by explicit standards, prospective PTs, ETs and ASTs won't value CPD courses associated with Teaching Skills—the Learning Environment as highly as the other areas. It sends the wrong message about this area of competency being valued.

The FSC supports a main recommendations in the Outdoor Science report recently published by the ASE's Outdoor Science Working Group which calls for "more experienced teachers to demonstrate their own role in providing fieldwork training for colleagues in other departments and schools (including across age phases and transitions)."

Initial Teacher Training

Another recent development (since the committee's call for evidence closed) is very worrying. Paul Cohen of the TDA referred to the current review into Professional Standards. The first drafts to emerge from this review show that any reference to learning in out-of-school contexts has disappeared completely from the teaching skills section (even at QTS level). This will represent a big setback for those of us who would like science teachers to develop skills which will enable them to employ the full range of teaching and learning approaches available, both inside and outside the classroom.

It is almost impossible to imagine how the current levels of professional development in teaching in out-of-school contexts will be improved when the standards are weakened, allied to the fact that a growth in number of initial teacher training locations could make inspection and monitoring even more difficult.

The FSC strongly recommends that the reference to learning in an out-of-school context should be retained in the QTS standards, and further developed through subsequent standards to ATS level.

Pupil Premium

The Chairman raised the issue of equitability, with uneven access by State and Independent schools. Published evidence (eg Power, 2007) clearly shows that schools with higher proportions of Free School Meals have fewer field trips, and these experiences tend to be narrower and less inspiring. Since the call for evidence closed the government has published its natural Environment White Paper (The Natural Choice). This states

that "we have created a Pupil Premium, intended to raise the attainment of low-income families. This could be used to give fairer access to nature for pupils from deprived backgrounds, for example funding school trips to experience the natural environment". The Schools Minister, Nick Gibb MP, has repeated this in response to parliamentary questions. We feel that that the use of the Pupil Premium for this purpose is unlikely to happen without very clear and strong guidance from the government.

The FSC recommends that explicit guidance should be given to head teachers and governors, clearly stating that the pupil premium can, and should (when appropriate), be used to support science practicals and field trips.

The demise of science fieldwork for some inner city schools is likely to be exacerbated by a continuing (and possibly accelerating) closure of Local Authority run field centres upon which many secondary schools currently rely for science fieldwork. Recent surveys, including one broadcast by the BBC, show that 33% of such centres think that they are in imminent danger of closing.

Dr Stephen Tilling
Director of Communications
Field Studies Council

30 June 2011

Written evidence submitted by the Council for Learning Outside the Classroom (Sch Sci 10)

I enclose evidence on behalf of the Council for Learning Outside the Classroom as to the importance of practical science lessons and field trips for improving individual and school attainment and improving the personal, social and emotional development of young people.

The Council for Learning Outside the Classroom (CLOtC) is an independent, national charity which champions learning outside the classroom (LOtC) and encourages young people to get out and about, because research shows that children learn best through real life experiences. We believe that EVERY child should be given the opportunity to experience life and lessons beyond the classroom walls as a regular part of growing up.

We ensure that more young people have access to these life changing educational experiences by providing support on the ground, facilitating the sharing of best practice and promoting the benefits of LOtC in raising attainment and aspirations, reducing truancy and re-motivating those who are disengaged from their education.

The Council for Learning Outside the Classroom is the awarding body for the LOtC Quality Badge, which recognises providers offering good quality LOtC provision and managing risk effectively. The Council also offers free online guidance to help teachers and youth leaders plan, run and implement effective LOtC experiences.

1.0 *Introduction*

The Council's response answers the questions most appropriate to its knowledge and expertise, highlighting key points within each section, and following this with supporting evidence.

2.0 *How important are practical experiments and field trips in science education?*

2.1 Key points:

2.1.1 Regular learning outside the classroom (LOtC), including practical learning and experiments in the school grounds or field trips in the local community and beyond, raises attainment, improves behaviour and re-motivates children who do not respond well in the classroom environment.

2.1.2 LOtC appeals to different learning styles. It makes learning more memorable, enabling pupils to apply what they have learnt inside the classroom to real life situations and giving them hands on skills that equip them for real life and employment.

2.1.3 LOtC is extremely effective in helping to develop scientific skills. LOtC has been demonstrated to move pupils beyond simple knowledge recall to a point where they can apply knowledge, hypothesise and think critically through inspiring real life experiences. It effectively supports learning back inside the classroom.

2.1.4 In order to be most effective, frequent, continuous and progressive opportunities for LOtC should be integrated into the curriculum. It should not be about once a year field trips. The outdoors represents the real world laboratory and quality fieldwork can take place in the school grounds, local community, environmental centres, on residentials and field trips abroad.

2.2 Evidence:

2.2.1 Nundy, S (2001) *Raising achievement through the environment: the case for fieldwork and field centres*.

Reinforcement between the affective and cognitive outcomes which resulted in students being able to access higher levels of learning was reported.

Positive impact on long-term memory was identified, due to the memorable nature of the fieldwork setting as well as affective benefits of the residential experience (eg improvements in social skills). There was reinforcement between affective and cognitive outcomes which resulted in students being able to access higher levels of learning.

"Residential fieldwork is capable not only of generating positive cognitive and affective learning amongst students, but this may be enhanced significantly compared to that achievable within a classroom environment."

"Fieldwork in new and unfamiliar surroundings creates events and images that significantly enhance long term memory recall, knowledge and understanding."

2.2.2 *Opinion Matters survey on behalf of TUI Travel PLC*, 2010. 99% teachers agreed that children are more animated and engaged when learning outside the classroom.

2.2.3 *NFER TeacherVoice survey 2010*. 70% teachers said LOtC is more effective than classroom teaching in engaging different learning styles. 77% teachers said LOtC is more effective than classroom teaching in motivating and enthusing children with regard to learning.

2.2.4 Malone, K (2008) *Every Experience Matters*. Children engaged in LOtC achieve higher scores in class tests, have greater levels of physical fitness and motor skills development, increased confidence, self esteem, show leadership qualities, are socially competent and more environmentally responsible.

2.2.5 Ofsted (2008) *Learning Outside of the Classroom—How far should you go?* "Learning outside the classroom contributed significantly to raising standards and improving pupils' personal, social and emotional development and also contributed to the quality and depth of learning. Even when it was not delivered particularly well LOtC still resulted in major learning gains for the young people taking part."

2.2.6 Passy, R, Morris, M, and Reed, F (2010). *Impact of School Gardening on Learning*. Outcomes from involving pupils in school gardening: "Greater scientific knowledge and understanding; enhanced literacy and numeracy, including the use of a wider vocabulary and greater oracy skills; increased awareness of the seasons and understanding of food production."

2.2.7 Rickinson, M et al (2004). *A review of research on outdoor learning*. "Substantial evidence exists to indicate that fieldwork, properly conceived, adequately planned, well taught and effectively followed up, offers learners opportunities to develop their knowledge and skills in ways that add value to their everyday experiences in the classroom."

2.2.8 Cowell, D & Watkins, R (2007), *Get out of the classroom to study climate change—the "Spring Bulbs for Schools" project*. The museum outreach programme involved setting up 160 monitoring sites. Students became "aware of the world around them and the idea that human activity can have noticeable effects, even on a local scale in the school garden". "The project enabled [students] to undertake pattern-seeking and observational activities—aspects of scientific enquiry that are often underdeveloped throughout the science curriculum".

3.0 *Are practical experiments in science lessons and science field trips in decline? What are the reasons for the decline?*

3.1 Key points:

3.1.1 There is evidence of a decline in opportunities for children to learn outside the classroom over recent years.

3.1.2 Increasing pressure on teachers' time and an increasing bureaucratic burden associated with planning LOtC appears to have contributed to this decline.

3.1.3 Cotton wool culture, fear of litigation and concerns over health and safety have also played a part.

3.1.4 The perceived barriers that teachers say prevent them from taking children outside the classroom include funding, health and safety, red tape, lack of confidence, teacher cover issues and concerns over behaviour.

3.2 Evidence:

3.2.1 Education Select Committee Report, 2009–10. *Transforming Education Outside the Classroom*. "School trips and visits were not seen to have flourished, especially day or residential visits to natural environments. Our evidence suggested that, in subsequent years, pupils' access to school trips and visits had, at best, remained static".

"A recent survey by the Countryside Alliance showed that, in any year, only around half of 6–15 year-olds go on a trip to the countryside with their school."

"Anthony Thomas, Chair of the Council for Learning Outside the Classroom, having reviewed a series of Ofsted reports, found that even in geography, where fieldwork is a requirement, not all pupils are spending time outside the classroom. He also found that only around 10% of pupils experience learning outside the classroom, broadly defined, as part of their science lessons."

"Fear of litigation remains an important factor in deterring teachers from organising trips and visits. In a separate survey, the Countryside Alliance found that health and safety concerns were still the main barrier to learning outside the classroom for 76% teachers. It was suggested to us that, among school leaders, health and safety is sometimes used as an excuse rather than a reason for not offering trips or practical work."

"Our witnesses stated that there was evidence of learning outside the classroom being cancelled due to the 'rarely cover' provisions—even where bookings had been made well in advance and cover could therefore have been arranged. The Field Studies Council has 17 centres in the UK. It reported that all of them have experienced a significant reduction in bookings and an increase in cancellations, which it attributed to 'rarely cover'."

"Attendance at training run by the National Science Learning Centre is reported to be down 25% since September, enquiries about specialist courses promoted by the National Centre for Excellence in the Teaching of Mathematics to have dropped by half."

3.2.2 Association for Science Education Outdoor Science Working Group. (2011), *Outdoor Science*. "Despite the strengths and advantages that fieldwork can bring to teaching at all ages, there has been a long-term and continuing decline in the provision and condition of outdoor education in science."

"Some research points to a decline in the provision and condition of fieldwork at primary and secondary levels, and that this is a long term trend in GCSE and A-level science." Sources: Fisher, A. (2001) The demise of fieldwork as an integral part of science education in UK schools and Tilling, S (2004). Fieldwork in UK secondary schools: influences and provision.

"Issues of health and safety, risk management and cost are the most significant factors reported as limiting fieldwork...Rickinson et al. also highlighted teachers' confidence and expertise in teaching and learning outdoors; requirements of school and university curricula and timetables; difficulties due to shortages of time; resources and support; and more generally the susceptibility of fieldwork to the wider changes in the education sector and beyond." Source: Rickinson et al. (2004), A review of research on outdoor learning.

3.2.3 Power, S et al. (2009), *Out of school learning: variations in provision and participation in secondary schools*. The higher the levels of pupils eligible for Free School Meals, the lower the number of trips and visits offered (at Key Stage 3). The same study also found that the opportunities for LOtC offered by schools serving less affluent areas tended to be narrower in scope than those run by other schools—restricted to the local area, and linked into vocational provision.

"Despite the potential of out of school learning to open up new learning horizons to disadvantaged students, our research suggests that it is the most disadvantaged pupils who will be offered the least inspiring experiences".

3.2.4 *Opinion matters survey on behalf of TUI Travel PLC*, 2010. Teachers surveyed identified the top five barriers to LOtC as:

57%—Cost.

46%—H&S issues (including risk assessments, paperwork, fear of litigation).

41%—Stress of organising.

38%—Lack of time.

26%—Lack of staff availability to accompany students.

4.0 *What part do H&S concerns play in preventing school pupils from performing practical experiments in science lessons and going on field trips? What rules and regulations apply to science experiments and field trips and how are they being interpreted?*

4.1 Key points:

4.1.1 The role of health and safety concerns in preventing more learning outside the classroom opportunities are well established (see 3.0). Teachers say they are worried about litigation, and hindered by the bureaucracy associated with planning trips.

4.1.2 Many barriers associated with the health and safety requirements are perceived rather than real, as teachers are confused about the legal requirements around risk assessments, ratios etc.

4.1.3 The free online guidance on the Council for Learning Outside the Classroom website www.lotc.org.uk was initially developed for the Department for Education in 2008 (then DCSF) in order to help teachers plan, run and evaluate effective LOtC experiences and overcome the perceived barriers. However, more support is needed in letting teachers know that this free guidance is available to them.

4.1.4 The LOtC Quality Badge is the national accreditation scheme which recognises organisations offering good quality educational provision and managing risk effectively. It was initially developed for the Department for Education (then DCSF) to provide assurance to teachers and reduce paperwork when planning educational visits and is the only industry-led scheme recognised across all ten sectors involved in LOtC provision (including Adventurous Activities, Farming and

Countryside, Natural Environment, and Expeditions Overseas). The Outdoor Education Advisers' Panel has endorsed the award and ask that their Local Authority members request that teachers look for the LOtC Quality Badge when planning educational visits. Support is needed in getting the message out to teachers to look for the LOtC Quality Badge when planning educational visits.

4.2 Evidence:

See 3.2.

5.0 *If the quality or number of practical experiments and field trips is declining, what are the consequences for science education and career choices?*

5.1 Key points:

5.1.1 Attainment in science education will be compromised. LOtC has been demonstrated to move pupils beyond simple knowledge recall to a point where they can apply knowledge, hypothesise and think critically through inspiring real life experiences.

5.1.2 Children who are not given access to regular opportunities to learn outside the classroom as part of science education will be disadvantaged. LOtC significantly improves the development of scientific skills and enhances scientific understanding compared to that achievable within the classroom environment.

5.1.3 The skill and attainment levels of young people entering the workforce or higher education will be compromised. LOtC provides young people with real life experiences and help them to develop hands on skills that equip them for real life and employment.

5.1.4 Fewer children will enjoy and engage in scientific education, impacting on the number of quality students entering science and engineering degree level and vocational courses post-16.

5.2 Evidence:

5.2.1 Education Select Committee Report, 2009–10, *Transforming Education Outside the Classroom*. Anthony Thomas, Chair of the Council for Learning Outside the Classroom, having reviewed a series of Ofsted reports, found that even in geography, where fieldwork is a requirement, not all pupils are spending time outside the classroom. He also found that only around 10% pupils experience LOtC, broadly defined, as part of their science lessons. Declining access to laboratory based practical work in science is a related problem. Science can be taught rigorously through LOtC. The relative absence of these opportunities, as well as practical work, undermines the whole basis of science as an experimental learning experience, and leaves pupils ill-equipped to study science at university level.

5.2.2 Nundy, S (2001), *Raising achievement through the environment: the case for fieldwork and field centres*. (See 2.2.1)

5.2.3 *NFER TeacherVoice survey*, 2010 (See 2.2.3)

5.2.4 Malone, K (2008), *Every Experience Matters* (See 2.2.4)

5.2.5 Ofsted (2008), *Learning Outside of the Classroom—How far should you go?* (See 2.2.5)

6.0 *What changes should be made?*

6.1 Key points:

6.1.1 As part of the National Curriculum programme of study for science, provide schools with accompanying guidelines and exemplar materials on how integrating LOtC into the curriculum can be achieved. We have strong evidence which indicates schools require guidelines and information in order to have the freedom to integrate frequent, continuous and progressive LOtC into the curriculum.

6.1.2 Include guidelines for the amount of time to be spent outside the classroom at each key stage (defining what is meant by frequent, continuous and progressive LOtC) within the National Curriculum programme of study for science and/or accompanying guidance notes. These guidelines should highlight the opportunities for LOtC that exist in the school grounds and local community at very low cost as well as opportunities for visits further afield.

6.1.3 Promote the support and guidance available to help science teachers embrace methods of teaching that can bring the curriculum to life. Signpost the free guidance on planning, running and evaluating LOtC on the Council for Learning Outside the Classroom website, www.lotc.org.uk (which the DfE initially helped to support so it already has Departmental endorsement) within the National Curriculum programme of study for science.

6.1.4 LOtC is not a subject area but a method of delivering the curriculum across all subject areas and we hope that the new National Curriculum will include accompanying guidelines highlighting the value of LOtC and how teachers may integrate frequent, continuous and progressive LOtC across the full breadth of the curriculum.

6.1.5 Ensure teachers learn the tools to deliver LOtC through its inclusion in the ITT curriculum. Currently, the ITT requirement is that teachers have to plan an LOtC activity, but they do not have to deliver it. This means that the requirement may be little more than a paper exercise, with no real life experience gained of actually taking children out and about.

6.1.6 Recognise the LOtC Quality Badge as an industry-led, non-statutory scheme to decrease bureaucracy for schools when planning field trips and other educational visits (as recommended in the Lord Young report Common Sense: Common Safety) and promote the scheme to schools within the National Curriculum and accompanying guidance notes.

6.1.7 Reduce bureaucracy for schools when planning school trips in line with Lord Young's recommendations within Common Sense: Common Safety.

6.1.8 The Council for Learning Outside the Classroom has a vital role to play in helping educational establishments incorporate learning outside the classroom across the curriculum and overcome the perceived barriers such as lack of funds, concerns over health and safety and red tape. The Council must be given more support from Government in achieving these aims (including financial support).

6.2 Evidence:

6.2.1 *Opinion matters survey on behalf of Education Travel Group*, 2009. Teachers responded with the following top five answers when asked what the Government can do to encourage school trips:

79%—more funding.

63%—minimise bureaucracy.

43%—offering well accredited organisations and providers.

33%—offering more guidance.

20%—offering advice and consultancy on school trips.

6.2.2 Education Select Committee Report, 2009–10, *Transforming Education Outside the Classroom*. "Fear of litigation remains an important factor in deterring teachers from organising trips and visits. The Countryside Alliance found that health and safety concerns were still the main barrier to learning outside the classroom for 76% teachers. It was suggested to us that, among school leaders, health and safety is sometimes used as an excuse rather than a reason for not offering trips or practical work."

"Teachers need to be exposed to learning outside the curriculum from early on in their career, and this should not be left to chance. We expect to see a clearer and more consistent presence for learning outside the classroom across initial teacher training and early career and ongoing professional development for teachers."

"Learning outside the classroom is important, and the Department must provide adequate funding to achieve maximum impact...We believe that the allocation of a comparatively small sum would make an enormous difference to learning outside the classroom, and call on the Department to look again at the resources it has provided for the Council for Learning Outside the Classroom and the Quality Badge scheme".

Beth Gardner
Chief Executive
Council for Learning Outside the Classroom

10 May 2011

Supplementary written evidence submitted by the Council for Learning Outside the Classroom (Sch Sci 10a)

Many thanks for inviting me along to give evidence to the Select Committee last week. I hope that the Committee felt that they got what they needed from us!

From our point of view, the Council for Learning Outside the Classroom may have been better placed giving evidence as part of the first session, as that's where most of our experience lies. However, in view of our conversation after the hearing when you invited me to submit additional evidence directly to you, I thought it would be worth getting in touch with you to answer a couple of questions posed by MPs during the first session which were not answered by the panel.

1. Alternatives to the LOtC Quality Badge to Recognise Learning in Schools

Q35 Stephen Metcalfe: Is there a classroom equivalent of that mark, training or qualification?

Dr Tilling: In terms of learning outside the classroom?

Stephen Metcalfe: Yes.

Dr Tilling: There is a classroom link because one of the main criteria is the link and what happens outside with what happens in the classroom.

Colleagues on the first panel would not have been aware that the Council for Learning Outside the Classroom is currently developing an LOtC Mark for schools, which we hope will be launched in September. This is an alternative to the LOtC Quality Badge (which accredits providers of LOtC offering good quality teaching and learning and managing risks effectively, thereby assisting schools to reduce bureaucracy relating to health and safety and fieldwork). The School LOtC Mark will recognise those schools offering frequent, continuous and progressive LOtC experiences as an integrated part of the curriculum, to all their young people. There are three levels: bronze, silver and gold, signifying a school's continuous commitment to the quality of their LOtC (which includes science fieldwork within the school grounds, in the local community and further afield).

2. One Central Resource to Collate all of the Information Available for Teachers

Q36 Stephen Metcalfe: One of the other things that struck certainly me, and I think some of my colleagues, is that there do seem to be an awful lot of schemes and programmes and variety. Do you agree that there is perhaps too much variety and too many different sources of information that make it very difficult to access? Perhaps some of that should be rationalised and we should have one central resource that collates all this information, and then it is more easily accessible so that teachers can access it and make the most of it.

Annette Smith: Are you talking specifically about health and safety in science education?

Q37 Stephen Metcalfe: Yes.

Annette Smith: Steve refers to the local authority role, which was clear up until now. The local authorities, where they still have control, still sign up to CLEAPSS and get regular updates on specific hazards which are pertinent to the classroom in general. That is really a useful service and they can act upon that. Then the schools have responsibility to act upon that. That is fine but it is changing. It is difficult to know where that will end up. Obviously you will be able to speak to those witnesses later on.

Q38 Stephen Metcalfe: Does anyone else want to add anything to that?

This was one of the primary aims of the Council for Learning Outside the Classroom and its website (www.lotc.org.uk). Set up with the financial support of the then DCSF in 2009 to take forward the aims of the LOtC Manifesto, CLOtC works not just to bring organisations and resources together from a science fieldwork perspective, but takes up the challenge even further, broadening out its partnerships to span 10 sectors, comprising:

- Natural environment
- Arts and creativity
- Heritage
- Built environment
- Sacred spaces
- School grounds
- Farming and countryside
- Adventurous activities
- Study, sports and cultural tours
- Overseas expeditions

The CLOtC website was designed as THE place to find information about all learning outside the classroom, ranging from advice and guidance on planning, running and evaluating LOtC to specific resources relating to different sectors. The website continues to develop, and we would be very happy to rise to the challenge of the Select Committee and act as a portal to signpost all teachers and others working with young people to relevant resources and support.

I hope that this additional information proves useful. Good luck with concluding the work, and I look forward to seeing the report. If I can be of any further assistance, please do not hesitate to contact me.

Beth Gardner
Chief Executive
Council for Learning Outside the Classroom

6 July 2011

Written evidence submitted by Office of Qualifications and Examination Regulation (Ofqual) (Sch Sci 20)

1. Ofqual's role is to regulate qualifications and assessments in England and vocational qualifications in Northern Ireland. To regulate the quality and standard of qualifications, Ofqual and its fellow regulators set requirements which must be met by recognised awarding organisations and the qualifications they award.

2. GCSE science qualifications have had a high profile in recent years, following the serious cause for concern we found when monitoring the version of the qualifications used in 2007 and 2008. Ofqual has now set new criteria for GCSE science, and has accredited new GCSEs for first teaching in September.

3. This submission to the Science and Technology Committee inquiry into practical experiments in school science lessons and science field trips covers the following issue: Do examination boards adequately recognise practical experiments and trips?

Background

4. On 1 April 2010, the Apprenticeships, Skills, Children and Learning (ASCL) Act 2009 formally established Ofqual as a non-ministerial government department which reports directly to Parliament and the Northern Ireland Assembly. Ofqual had existed in interim form since 2008. The current Education Bill proposes changes to Ofqual's objectives and governance.

5. Ofqual regulates and maintains standards by recognising awarding organisations. Only recognised awarding organisations can offer regulated qualifications. All organisations registered can be found at the Register of Regulated Awarding Orqanisation and Qualifications: http://register.ofqual.gov.uk/

Do examination boards adequately recognise practical experiments and trips?

6. Regulated qualifications must meet the relevant criteria produced by Ofqual. The current criteria for GCSE and GCE sciences both emphasise the skills requirements that are gained through practical investigations and the need for them to be included in the course of study and assessment. For example, in GCSE Science the following are included:

Aims and Learning Outcomes:

- *develop their awareness of risk and the ability to assess potential risk in the context of potential benefits; and*
- *develop and apply their observational, practical, enquiry and problem-solving skills and understanding in laboratory, field and other learning environments.*

Assessment Objective 2

- *Apply skills, knowledge and understanding of science in practical and other contexts.*

7. Likewise, in GCE (A level) criteria for science subjects the following are included:

Specification content

- *Carry out experimental and investigative activities, including appropriate risk management, in a range of contexts.*

Assessment Objective 3

Candidates should be able to:

(a) *demonstrate and describe ethical, safe and skilful practical techniques and processes, selecting appropriate qualitative and quantitative methods;*

(b) *make, record and communicate reliable and valid observations and measurements with appropriate precision and accuracy; and*

(c) *analyse, interpret, explain and evaluate the methodology, results and impact of their own and others' experimental and investigative activities in a variety of ways.*

8. The criteria do not specify what experiments must be carried out. Nor do the criteria specify that there must be field trips or, indeed, what constitutes a field trip. We are aware that some schools and colleges use their local surroundings to carry out investigations; others take planned (but perhaps costly) trips to field centres.

9. In summary, the criteria make clear the expectation that learners will experience and acquire experimental skills. But the details of what should be required is left to the awarding organisations responsible. They, in turn, write their specifications to embody sufficient flexibility to enable each school and college to meet the requirements within their constraints of their resources, geographical location and expertise.

Office of Qualifications and Examination Regulation

11 May 2011

Written evidence submitted by The Gatsby Charitable Foundation (Sch Sci 23)

About Gatsby

1. Gatsby is a Charitable Trust set up in 1967 by David Sainsbury (now Lord Sainsbury of Turville) to realise his charitable objectives. We focus our support—which in 2010–11 exceeded £68 million—on the following charitable areas:

- Plant science research.
- Neuroscience research.
- Science and engineering education.
- Economic development in selected African countries.
- Strengthening public policy.
- The fabric and programming of selected arts institutions.

Introduction

2. The Committee will no doubt receive considerable evidence regarding the importance of and possible barriers to practical work in school science. The Committee also has previous Select Committee reports to draw upon. We note in particular the 2006 House of Lords Science and Technology Committee report on "Science Teaching in Schools" and the 2002 House of Commons Science and Technology Committee report on "Science Education from 14 to 19", both of which address the issue of practical science.

3. Given the significant amount of evidence about the issues with practical work in school science, why do substantial concerns persist about its decline? Has there been an adequate response from the government and, where action has been taken, has it been successful? Perhaps most crucially, to what extent have government interventions specifically targeted practical work in school science rather than assume that general policies to support teaching and learning will somehow address the issues specific to laboratory-based science?

4. We sincerely hope that this current Inquiry—while almost certainly needing to reiterate the conclusions of previous Select Committee reports—will result in more significant and sustained action being taken to address the longstanding issues associated with practical science than has hitherto been the case. With schools facing significant constraints in the resources and support available to them, we believe there is only a small window of opportunity—perhaps the next three years—to put in place the necessary measures to protect the place of practical science in schools before irreversible decline occurs.

5. The Committee's Inquiry is timely therefore. Indeed, against the backdrop of Gatsby's longstanding support for practical work and concerns for its future health, we have recently embarked on a significant piece of work that, over the next 12–18 months, will seek to:

- establish an accurate picture of the current health of practical science in UK secondary schools and make international comparisons where feasible;
- unpick the current enablers and barriers to effective practical work that affect schools at a local level;
- identify the likely impact on practical work of the upcoming education policy changes, including the changes to the National Curriculum, funding mechanisms, Local Authority involvement and initial teacher education; and
- make pragmatic recommendations on the action needed to ensure high-quality practical work occupies a central and sustained role in all secondary schools.

6. Practical work in Primary science education should build on the natural curiosity of children, enabling them to experience and explore the material and natural worlds. This process will continue in secondary schools, but it will be advanced by the development of discipline-specific skills and the use of specialist equipment enabling students to use a more abstract and measured approach. For brevity we refer to these as "laboratory skills", although noting that this definition should include the skills that are developed outside of the laboratory through fieldwork.

7. In this submission we report on some of the early findings of our work. In particular we note the concerns of universities regarding the laboratory skills of first year science undergraduates and issues coming to our attention regarding the impacts of recent policy on practical work. As part of our work over the coming year we plan to explore the laboratory skills required by employers and to what degree employer needs are currently being met by science at school and college.

8. We would be pleased to share our findings with the Committee as they emerge, and to discuss how the work of Gatsby might complement the Committee's recommendations for action by other stakeholders, including the DfE.

Preparing Students for Success in Science at University

9. In April 2011 Gatsby commissioned a small piece of research exploring the perceptions of science staff in the 15 Russell Group universities in England (excluding the LSE) regarding the standard of laboratory skills possessed by new undergraduate students. 34 respondents from 12 universities completed an online survey and 12 respondents also participated in follow-up interviews.

10. Our results can only be indicative of issues that need further investigation, but the Committee might be interested in the headline findings and quotes from respondents. These are given in the four points (a) to (d) below. We are still analysing the results (and defining what a larger-scale study might look like) but would be willing to share the full report with the Committee on request.

(a) Across the board, respondents reported that new undergraduates lack at least some confidence in the lab (100%), and are not well equipped with lab skills (97%). Specific deficits in lab skills included manual dexterity, the ability to set up apparatus and making accurate observations.
   - "They find it difficult to diagnose and think through problems and are quick to blame equipment rather than their own technique."
   - "They can't apply these tools and these skills outside the narrow environment in which they were taught."

(b) While 29% of our respondents reported a decline in the last five years in new undergraduates' scientific *knowledge*, over half (57%) felt that the level of laboratory skills had declined in the same period. This was despite all respondents (100%) stating they had increased the grades required for entry to their courses.
   - "Although it fluctuates from year to year it is noticeable that at entry students lack confidence in the lab, and the situation is getting worse."
   - "With our increased entry requirements we have some excellent students with a deep understanding of concepts but our average to lower ability students struggle more now than 10 years ago."

(c) The largest factor contributing to the lack of lab skills was cited as students' limited exposure to practical work at school. Respondents reported teaching students who had done very little practical work and whose teachers relied heavily on demonstrations and/or videos.
   - "Many students are telling us that they have done no practical work at school so they struggle with basic skills like using a microscope, with which they previously would have had some experience."
   - "Many of them claim to never have carried out an experiment only watched teacher/videos of. Most of them have no idea how to act in a lab or where to even begin when carrying out an experiment, ie no idea what equipment is called."

(d) University teaching staff have made a number of changes to their lab-based teaching in response to the change in skills of new undergraduates, including: simplifying first-year lab courses by providing more step-by-step instructions, removing complex experiments or allowing more time; increasing the focus and/or time spent on basic skills; increasing the levels of support through more staff time or demonstrators; and introducing online pre-labs.
   - "We have redesigned the whole first year course—removing much of the material previously taught and starting at a lower level and with much less expected in each class."
   - "Progress through the [undergraduate] lab course is to an extent set back by the poor standard of skills among the intake. This has a knock-on effect on the types of experiments, and their complexity, that we can offer in the later years of the degree."

11. We believe that even this small-scale survey should elicit concern regarding how well schools and colleges are preparing students for entry into science degree courses. These indications become all the more stark when one considers that: (1) the universities surveyed are taking the best A-level students (the reported entry requirements ranged from BBB to A*AAA); and (2) that all universities are increasingly operating in a more competitive environment where finances are stretched and the pressure to widen their student intake will continue.

Practical Work in the National Curriculum

12. Gatsby recently submitted evidence to the government's current review of the National Curriculum in which we set out our thinking on the purposes for practical work and our recommendations for the review team. A copy of our submission is available on request; the points relevant to this Inquiry are provided below.

13. The main purposes of practical work in the curriculum are to:
   - enhance the learning of science concepts and explanations;
   - develop understanding of the processes of science; and
   - develop laboratory skills.

14. Since the introduction of the National Curriculum there has been a steady erosion of the teaching of laboratory skills. This erosion is a cause of significant concern to industry and higher education institutions. Reversing this trend would also increase the engagement of young people in science and lead to greater participation in science post-16.

15. It is unacceptable that the assessment of laboratory skills has been reduced to the point where a GCSE student who is unable to, for example, use a microscope or heat measured volumes of liquid without breaking test tubes is still able to achieve maximum marks for their practical work as long as they can write about how they should have done it.

16. The current National Curriculum review is an opportunity to re-examine the role of practical work. In particular, the review must ensure that the Science Curriculum sets high expectations of attainment in the laboratory skills that employers and higher education value.

17. We recommend that:

(a) The National Curriculum review team should provide an impact assessment to show explicitly how any changes to the Science Curriculum will actively encourage better practical work in schools.

(b) The Science National Curriculum should state explicitly the laboratory skills that students are expected to develop at each Key Stage.

(c) The review must ensure that the National Curriculum allows sufficient time and space for teachers to undertake a much wider range of practical activities with their students than is currently the case.

(d) The review must consider how the requirements of the National Curriculum regarding practical work at Key Stage 4 can be translated into assessment objectives across the range of science GCSEs.

(e) The review should involve higher education and employers in a much more meaningful way than has been the case in previous National Curriculum reviews. Included within these discussions should be a focus on ensuring that employer and HE requirements for laboratory skills are met, something we believe has been wholly absent from previous reviews.

Barriers to Practical Work—Impacts of Recent Changes to the Education System

18. As part of our new study into practical work we have begun to visit schools and talk to Awarding Organisations, Local Authority advisers and CPD providers in order to better understand the barriers to practical work and what might be done to alleviate them.

19. In our preliminary work it is clear that recent changes to the educational landscape may well have an impact on practical work and we highlight some particular areas for further investigation below. We hope the Committee will engage the DfE in discussion on these issues.

Laboratories and preparation rooms

20. We still hear of too many schools where practical work is limited by the amount of laboratory, preparation and storage space available, despite many of these schools going through refurbishment or being new builds. Particularly worrying are reports that some Academies have reduced the number of labs and prep areas and therefore may be compromising the quality of their science provision.

21. We would be interested to hear what plans the DfE has to ensure all schools (including Academies and Free Schools) adhere to the guidelines it itself has produced on the accommodation necessary for practical science.

School budgets and science equipment

22. The cost of some equipment and consumables associated with practical work remains prohibitive for some schools, and the number of schools and range of equipment that fall into this category are both likely to increase in the coming years as schools' budgets come under increasing pressure. A school science department must balance the costs of kit essential for practical work with the substantial demands for photocopying, stationery and textbooks.

23. The constant upheaval in the curriculum will continue to divert funds away from practical equipment towards new textbooks and work sheets; schools would benefit from a period of curriculum stability in order to focus their resources on improving their science provision.

24. While we appreciate—and support—the government's commitment to devolve to individual schools decision-making on issues such as budgeting, it will be crucial in the coming years that headteachers, senior management teams and governors are helped to understand the importance of practical science. Without government support for this—even if only in Ministerial announcements and the DfE guidance material issued alongside the new National Curriculum—it is likely that the status of practical science will continue to decline in schools.

25. Finally, some schools successful in increasing uptake of the sciences at A-Level are telling us they are likely to struggle to afford the extra equipment needed to provide these students with quality practical work. Some schools have told us that the decrease in post-16 funding for sixth forms from the Young People's Learning Agency (to bring schools into line with FE Colleges) will impact on practical provision, particularly in schools successful in motivating more students to continue with science into A-Level. More research is required to understand how widespread this effect is likely to be and we would encourage the Committee to explore this issue with its witnesses.

Teacher training and Professional Development

26. Teaching laboratory skills and undertaking practical experiments demands expertise and experience from science teachers, so it would be expected that it should form an explicit part of their training and professional development. For trainee teachers, however, it is not clear who has responsibility for this part of their training—their university or their placement schools. There is therefore a risk that it occurs in neither, or is overly dependent on the status of practical science in the trainee's school.

27. The DfE should use the review of standards for Qualified Teacher Status to clarify the expectations for science teachers to have appropriate competencies in practical work.

28. Local Authorities have traditionally played a pivotal role in networking science departments from different schools through the offices of a science consultant and/or adviser. At the height of the last government's "National Strategies" programme this regional field force numbered around 300, but since the government decided to end the National Strategies and reduce the role for Local Authorities in school support, the number has dwindled to about 40. It is no longer clear from where schools can rely on getting advice on practical teaching, or who will take responsibility for networking science departments so that practice can be shared.

29. The Committee may wish to ask the DfE what plans it has to ensure that schools still have access to the support and advice on practical science (including health and safety) previously freely available to schools from Local Authority advisers and consultants.

Technicians

30. It is disappointing that successive governments appear to have had so little interest in supporting the role of school science technicians, despite the potential for developing them as key staff in supporting more efficient management of purchasing and use of equipment and materials.

31. School science technicians provide essential support for practical work, particularly in schools where the department is dominated by inexperienced teachers or where staff turnover is high. And yet the pay and conditions of technicians are appalling, including a lack of real career structure, term-time only contracts and lack of support for professional development.

32. This is as true now as it was in 2002, when the House of Commons Science and Technology Committee reported:

> "The pay and conditions under which technicians are employed strike us as downright exploitative. We can see no reason why technicians should be paid during the term time only. Those technicians who prefer not to work during the holidays, carrying out essential tasks such as equipment maintenance, should be employed on part-time contracts; others should be treated like teachers and paid an annual full-time salary. The lack of opportunities for career or pay progression needs to be addressed."[14]

33. Nine years on, we still agree. We hope that the current Inquiry will lead to more progress in this area than has hitherto been the case.

Health and Safety

34. Concerns regarding health and safety are often used to explain a reduction in the amount of practical work undertaken in a school. We have heard a number of science teachers, even some in high-performing schools, speculate on practicals which might or might not be banned. However, there are almost no national bans on practical work in science.

35. In the past, schools have been able to consult their Local Authority science adviser/consultant or the national organisation CLEAPSS for advice and support on risk assessments and safe management of practicals. With the demise of Local Authority advisory roles (see paragraph 28), we are concerned that decisions regarding health and safety, and on which science practicals are "allowable", may be taken by individuals who do not have the necessary experience, or access to external expertise.

36. We would encourage the Committee to ask the DfE what sustainable mechanisms the Department proposes for ensuring that all school science departments have access to correct, authoritative advice on health and safety in practical work.

[14] "Science Education from 14 to 19" (July 2002), House of Commons Committee on Science & Technology.

Curriculum, qualifications and timetabling

37. In an effort to strengthen science education at Key Stage 4 and increase progression to post-16 sciences the government has supported increased participation in Triple Science (three separate GCSEs in physics, chemistry and biology) among 14–16 year olds. We support these moves. However we have been told that many schools have not been able to allocate Triple Science any more teaching time than "double science" (two GCSEs), and that practical work has suffered as a result.

38. If this means that students studying physics, chemistry and biology at GCSE in order to progress to A-Level sciences and beyond are gaining fewer laboratory skills, this is clearly a situation that needs rectifying. We suggest the Committee might wish to investigate how widespread this issue is when questioning witnesses and also to press the DfE on what research it has undertaken or has planned on the curriculum time schools are dedicating to Triple Science and the subsequent effect on practical work.

Science & Engineering Education Team
The Gatsby Charitable Foundation

11 May 2011

Written evidence submitted by CLEAPSS (Sch Sci 26)

ABOUT CLEAPSS

Founded in 1965, CLEAPSS has promoted effective practical science in schools for over 40 years.

CLEAPSS currently has 13 staff consisting of eight advisers and five support staff.

At its core CLEAPSS is a Consortium of all the Local Education Authorities in England, Wales and Northern Ireland. At present all maintained primary and secondary schools are members of CLEAPSS as are many independent schools, a significant number of colleges and many overseas schools.

CLEAPSS is funded by subscription from Local Authorities (on behalf of their schools) as well as subscriptions directly from individual schools/colleges in other categories. CLEAPSS is independent of any other commercial or non-commercial organisation and as such its advice and guidance is completely impartial.

CLEAPSS provides model risk assessments (MRAs) for practical activities in science, Design & Technology and Art & Design for both primary and secondary phases. Membership of CLEAPSS enables an employer to discharge its duties under the 1975 H&S at Work Act in respect of these subject areas.

In addition to H&S guidance CLEAPSS provides advice on ways to carry out practical activities so that they work, are safe and are effective at supporting learning. CLEAPSS has facilities at its offices on the campus of Brunel University in Uxbridge to enable it to test equipment and try out new ideas for practical work. As a result CLEAPSS staff have developed a wealth of experience devising and evaluating practical activities.

CLEAPSS advice and guidance, contained in publications such as *Hazcards* and the *Recipe book*, is recognised by Ofsted and the HSE as the definitive basis for safe practice for practical work in schools.

RESPONSE

1. *How important are practical experiments and field trips in science education?*

(a) Effective practical work is critical for developing pupils' ability to think scientifically and with this to develop their understanding of how science and scientists have arrived at what we currently understand about the world.

(b) Scientific theories are developed and tested through rigorous analysis of reliable and accurate evidence. Pupils need to be able to recognise accurate, reliable evidence and know how to collect it. Practical work gives pupils the experience of collecting evidence about the behaviour of the real world.

(c) Practical work can be used to support a wide range of learning outcomes for pupils—possibly more than any other individual teaching and learning strategy—the SCORE project "Getting practical" (www.getting practical.org.uk) explores ways to ensure teachers maximise the impact of practical work on pupils' learning by ensuring clear learning outcomes are identified for each activity.

(d) The UK government clearly recognises the strategic and economic importance of upcoming generations developing high level skills in the sciences, engineering and mathematics. A good supply of young people with science, technology, engineering and maths (STEM) skills is important to promote innovation, exploit new technologies, produce world-class scientists and for the UK to compete internationally.

(e) The 2008 SCORE report on practical science in schools in the UK noted as a key finding that the importance of practical work in science is widely accepted and it is acknowledged that good quality practical work promotes the engagement and interest of students as well as developing a wide range of skills, science knowledge and conceptual understanding. In the words of one teacher "science without practical work is like swimming without water".

(f) More recently (14 April 2011), in its response to the Department for Education's Call for Evidence regarding the National Curriculum Review, SCORE stressed the importance of fostering scientific thinking and encouragement of laboratory work. SCORE emphasises that "essential knowledge" in the sciences includes ... the acquisition of procedural skills (particularly those associated with practical laboratory and field work, and analysis), as these are essential for acquiring and testing scientific knowledge.

2. *Are practical experiments in science lessons and science field trips in decline? If they are, what are the reasons for the decline?*

Evidence from enquires by schools and colleges to the CLEAPSS Helpline suggests that practical activities are in decline in some, though not all schools. Some of the reasons are outlined below.

(a) A lack of confidence on the part of teachers and technicians arising from:

(I) H&S considerations. These are a contributory factor but CLEAPSS does not believe that H&S issues alone are responsible for declining confidence to carry out practical work with pupils. (see section 3)

(II) Pupil behaviour—Poor pupil behaviour is often cited as preventing practical work. Teachers do not always acknowledge the relationship between good teaching and learning (including effective practical work) and pupil behaviour. As a result many become caught in a cold war type stand-off where the teacher won't do the practical because the pupils won't behave but the pupils won't behave because they are not allowed do the practical work.

(III) Lack of familiarity with practical activities, particularly amongst younger teachers—this is a vicious circle—many young teachers experienced less practical work when they themselves studied science in school—they have no first had experience of many of the practical activities that those from an older generation regard as entitlement experiences for pupils learning about the world around them.

(IV) Experiments that appear not to work. Limited staff/technician expertise can mean that experiments don't work. Teachers lose confidence in practical work and may use computer simulations, or book work, as a substitute. This is evident from the helpline enquires we receive.

(b) Limited access to subject specific CPD—Teachers do not (or are not allowed by senior managers) to attend CPD that would improve their use of practical work, despite there being plenty of opportunities on offer from CLEAPSS and other organisation such as Science Learning Centres, learned societies etc. As a result the majority of CLEAPSS CPD is delivered to technicians who then have the unenviable task of convincing teachers to adopt the ideas. CLEAPSS courses specifically for teachers often fail to recruit because:

(I) Funding—often quoted as a reason for not releasing teachers on CPD. CLEAPSS believes that it is a more question of priorities than of absolute funding.

(II) An inflexible interpretation of the "Rarely Cover" agreement makes it difficult for teachers in many schools to attend CPD.

(III) Excessive focus on short term improvements in pupil outcomes mean that those in schools deciding on CPD priorities rate subject specific CPD lower than generic teaching and learning training.

(c) Insufficient technical support—Effective, meaningful practical work is difficult to realise in schools without adequate support from specialist, knowledgeable technicians. In the present climate technician numbers are being reduced.

(d) Loss of specialism—Many secondary schools no longer have a balance of science teachers across the science specialisms, for example many science departments in London do not have any physics specialists at all. Teachers, teaching outside their specialisms, need to be supported by an appropriately qualified colleague. The lack of such support has a particular impact on practical work as although it may be possible to "mug up" on the theory it is much more difficult to develop the repertoire of techniques needed to support a rich variety of practical experiences.

(e) Teachers have limited opportunities to develop or rehearse practical work. High contact ratios and high lab occupancy rates along with other duties reduce the time available for this essential aspect of developing confidence.

(f) Time constraints. Practical work in many areas of modern biology (microbiology and gene technology in particular) is too complex to be carried out in one lesson. A current move to 50 minutes lessons in many schools is likely to exacerbate this problem. Preparing the equipment can also be time consuming. Equipment costs are high.

(g) Reduced priority for science in years 5 & 6 as a consequence of the removal of the statutory end of key stage tests in science.

(h) An over reliance on uninspiring and poorly researched published schemes. These often contain practical activities that have been re-hashed may times over and feature vague instructions that lead to practical sessions that don't work or in some cases can even be dangerous. (linked to time constraints above and to lack of teacher confidence). The changing nature of the teaching profession

means that many teachers no longer see developing new activities (practical or otherwise) as part of their job—they have become deliverers of someone else's ideas.

(i) Limited focus on practical work in Initial Teacher Training (ITT). The time given to developing this aspect varies dramatically across the ITT sector. As an indicator of this, the time spent introducing student teachers to CLEAPSS resources varies between ITT courses from no mention of it at all to a full day of hands on experience using CLEAPSS resources to risk assess practical activities.

(j) Unsuitable accommodation. Despite good advice contained in Building Bulletin 80, Science Accommodation in Secondary Schools, published by the Dept for Education and amplified by CLEAPSS, the design of science teaching spaces in new buildings is frequently poor. Problems reported to CLEAPSS include, inadequate size of rooms, unhelpful layout of the science suite, lab designs which do not lend themselves to class practical work and reduction, from the traditional calculation, in the total number of labs provided. For instance, the rooms may have the gas supply and electrical sockets on the outside wall so that pupils have their back to the teacher or the rooms may have only one or two sinks.

3. *What part do health and safety concerns play in preventing school pupils from performing practical experiments in science lessons and going on field trips? What rules and regulations apply to science experiments and field trips and how are they being interpreted?*

(a) Teachers and technicians often cite health and safety law as a deterrent to practical work. This is misguided. The HSE want pupils to experience the handling of chemicals, aspects of hygiene when dealing with microorganisms and be shown how radioactive materials can be manipulated safely.

(b) School science is in reality very safe. Teachers and technicians are however worried about litigation and schools are concerned about insurance claims in case something goes wrong. CLEAPSS is aware that in reality events of this kind are very, very rare and are even if they do occur they are very unlikely to result in a prosecution or civil case against an individual teacher or technician.

(c) CLEAPSS believes that by adopting the "common sense" approach to risk assessment it promotes H&S should not represent and unmanageable burden for teachers or technicians and as such should not prevent exciting and effective practical work from taking place in schools. Under various Regulations (eg COSHH, The Management of Health and Safety at Work, and others) the employer is required to undertake a risk assessment for activities done and materials used as part of the practical work. An employer may provide model (or generic) risk assessments. In science and D&T, the vast majority of school and college employers in England, Wales and Northern Ireland provide the model risk assessments produced by CLEAPSS (SSERC in Scotland). Before undertaking an activity as part of a lesson, a teacher must consult relevant model risk assessment(s) and should adjust or adapt the outcomes of the model risk assessment to meet the needs of their individual circumstances. The significant findings of any risk assessment procedure are best recorded on documents in daily use, such as a scheme of work, lesson plans, worksheets or technician's notes.

(d) Myths abound. A survey in 2005 found that of 40 chemicals or activities thought by callers to the CLEAPSS Helpline to be banned; only two were actually banned nationally.

(e) Impact of recent European legislation, Classification, Labelling and Packaging of Substances and Mixtures (CLP) and Registration, Evaluation, Authorisation & restriction of CHemicals (REACH):

(I). The CLP legislation is indicating additional hazards on a number of chemicals even though in reality the substance has not changed at all—this increases the perceived risk (for example, petroleum jelly is now labelled as a class 1B carcinogen). CLEAPSS is receiving many enquiries from teachers and technicians worried about a perceived greater risk.

(II) REACH—The shift of emphasis to the identification of *hazard* as opposed to *risk* (the latter factors in the level of exposure) has already lead Ireland to issue a blanket ban on the use of chemicals identified as "substances of very high concern" (SVHC) in schools. As well as removing certain activities from the schools' curriculum at a stroke CLEAPSS believes this is unnecessarily alarmist and works against a common sense, proportionate, response to risk assessment.

(f) H&S can become a barrier to effective practical work in certain circumstances:

(I) Where schools or colleges engage agencies from outside education to carry out H&S audits. In these circumstances CLEAPSS finds that H&S "inspectors/advisers" in question have little experience of how practical work operates in schools and attempt to apply regulations in a manner more suited to an industrial or commercial context. One of the strengths of CLEAPSS guidance is that it interprets regulations in a manner that makes sense in a school or college context.

(II) Where there is an excessive focus on the product of the risk assessment process—for example attempting to record and store detailed risk assessments for every practical activity. Filing cabinets full of dusty forms do not contribute to safe practice in the classroom.

4. *Do examination boards adequately recognise practical experiments and trips?*

(a) CLEAPSS believes that in general the models for assessed practical work, in particular the enquiry based activities, implemented by awarding bodies at GCSE restrict the range of practical work done in schools.

(b) CLEAPSS is involved in advising awarding bodies on the practical component of their assessments. CLEAPSS believes however that its involvement is often at too late a stage in the development process. Over 400 calls to the CLEAPSS Helpline over the last 18 months mentioned the word "assess" or "assessed" and involved problems with assessment activities provided by awarding bodies. Further calls involved activities similar to those known to be used in assessments. Had CLEAPSS been consulted before the activities were published, most of the queries would not have arisen.

(c) Many of the current models of assessing practical skills are so tightly restrictive that many teachers feel they have inadequate time to make proper use of the full range of practical activities that would support good science teaching and learning. Teachers feel obliged to follow particular approaches in order to enable their students to recognise the format of examination questions/assessment items. Pressure from the assessment model can reduce practical work to a formulaic activity akin to jumping through hoops.

(d) Many of the activities on which assessments are based are dated in their approach. As a consequence they can require large amounts of materials which can in turn cause disposal difficulties for technicians as well as having significant cost implications for schools.

(e) CLEAPSS suspects that many assessment activities are devised on the basis of a vague memory of an activity and are not trialled sufficiently before being adopted as formal assessments.

(f) CLEAPSS has found that often insufficient research goes into the availability and costs of the resources used in the activities. Educational science suppliers require advanced warning in order to amass the required stocks of chemicals, microorganisms, enzymes and equipment to satisfy the requirements of thousands of candidates.

5. *If the quality or number of practical experiments and field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in Higher Education?*

(a) Pupil's choices at post-16 are very closely linked to the subjects they enjoyed at GCSE level. When interviewed about science pupils invariable identify the practical work as the aspect of science they enjoy the most and the one that most helps them learn. Any reduction in practical activity and fieldwork is likely to have a negative impact on recruitment to post 16 sciences.

(b) The employment, FE and HE sectors often comment that students have fewer skills when they arrive now than they had in the past. This can mean that extra tuition, supervision or training is required.

(c) Hazardous materials are encountered in the home, at work, in the garden and certain hobbies. The consequence of mishandling or ingesting these chemicals results in visits to the doctors' surgeries and Accident & Emergency centres. Information collated by RoSPA indicate that at least 9,000 injuries involving a range of hazardous chemicals were recorded per year (data from 2000 -2002, the latest available in their online HASS and LASS database)[15] It is important that schools teach children the life skill of handling hazardous material safely and with respect.

(d) Practical activities in science are an obvious vehicle to teach pupils about risk—developing a sensible approach to evaluating risk is an important life skill for everyone.

6. *What changes should be made?*

(a) School technicians deserve greater recognition, a clearly identified career structure and guaranteed access to high quality on-going professional development are needed.

(b) CPD in effective practical work for teachers should be viewed with the same level of importance by senior management as courses which are more obviously aimed at improving examination results. (Ironically more effective use of practical work would improve learning and bring about the very improvements in pupil outcomes that schools seek.)

(c) Greater coordination of activities designed to promote the importance of practical science—for example through an extension of the "Getting Practical" programme to act as a focal point for promotional activities.

(d) Easily accessible resource bank(s) containing detailed instructions of how to carry out a wide range of common science practical activities. Teachers could source reliable/safe practical activities, deciding what the learning outcomes are for their particular lesson. Awarding bodies and publishers could access a range of activities that worked and were safe to include in curriculum materials and assessment items.

[15] RoSPA Home and Leisure Accident Surveillance System (LASS and HASS), based on data from the then DTI for the UK. This data is no longer being collected. http://www.hassandlass.org.uk/query/MainSelector.aspx

(e) A high profile information campaign backed by the HSE (supported by CLEAPSS and SSERC) to ensure that schools and colleges respond appropriately to the changes to chemical labelling associated with CLP and REACH regulation and do not unnecessarily reduce practical activity.

(f) CLEAPSS believes that there is considerable scope to adopt reduced or micro-scale approaches to practical work in schools. Advantages include, reduced hazards leading to greater access for pupils to activities, better model for the techniques used in the "real world", reduced cost and easier disposal with less environmental impact. These techniques are in use widely around the world but are virtually absent from schools in the UK. There should be a concerted effort to promote this approach—for example by including reduced/micro-scale activities as part of formal assessments.

7. *Is the experience of schools in England in line with schools in the devolved administrations and other countries?*

(a) CLEAPSS often receives enquiries from teachers, technicians and curriculum developers/publishers in other countries (both in Europe and further afield) requesting permission to use its resources—particularly in relation to risk assessments. From these conversations CLEAPSS is strongly of the opinion that support for and hence practice in practical work—particularly that carried out by pupils—is less well developed elsewhere than it is in the UK.

(b) The United Kingdom has an enviable tradition of practically based teaching in science. There is a risk that practical work in science could be taken for granted (ubiquitous, invisible in plain sight) and as such will not receive the support/development necessary to retain its central role.

Steve Jones
Director
CLEAPSS

11 May 2011

Supplementary written evidence submitted by CLEAPSS (Sch Sci 26a)

This paper provides additional evidence relating to technician hours, technicians role in supporting practical work in schools and the potential for reduced or micro-scale approaches to make a significant contribution to practical science in schools.

TECHNICIANS

A comprehensive guide to the crucial role played by technicians in school science can be found in CLEAPSS Guide G228 *Technicians and their jobs* a copy of which is attached to this additional submission.[16]

This guide draws on the findings of a national survey of science technicians conducted in 2001 by the Royal Society and the Association for Science Education.

The RS/ASE report recommended that:

— there should be a national framework for technicians' pay and job descriptions;
— a common formula should be adopted to determine the number of technician hours that schools need;
— technician training should be properly funded;
— there should be a nationally-recognised induction programme;
— there should be a recognised career structure; and
— heads of science and governors should look at the way technicians are managed.

How many technicians are needed?

The RS/ASE report proposed a common formula for calculating the number of technician hours needed

— Technician hours per week needed = total science teaching hours × 0.85.

The figure of 0.85 is known as the **service factor**. This figure was recommended by the ASE to ensure adequate technical support for the science curriculum. The ASE also stated the quality of the technician support that could be expected for different service factors.

Service factor	*Quality of technician support*
0.85	This is the recommended allocation of technician support to science teaching for a compact suite of laboratories with adjoining preparation and storage space. All functions are feasible, including access to training and the development of opportunities to meet a school's changing needs.

[16] Not printed here

Service factor	*Quality of technician support*
0.75	At this level of allocation, provision of the full range of functions will depend upon recruiting well-qualified and experienced technicians. Where the full range is possible there will be a need to prioritise functions and decide on the emphasis of support required. It may still be possible to achieve a balance between resource-related, design & development and direct support activities.
0.60	It will not be possible to deliver all functions adequately and a restricted range of priorities will need to be identified. Efficient management of resources and administration are likely to be affected and activities related to the design & development of practical programmes and direct support will be in jeopardy. Functions possible may well depend on the skills and experience available and a policy for training will be essential if an effective service is to be maintained.
0.45	Functions will be markedly reduced and in most cases no more than simple, immediate, maintenance and control will be possible. In the long term, efficiency in these will be impaired. The availability and range of resources will become restricted and the development of effective practical programmes is likely to be impaired. A supervisory structure for the less experienced may have to be provided from elsewhere. Regular training will be essential but difficult to provide.

It should be noted that these factors are based on a 52 week working year and not a term time only pattern of working.

Although no comprehensive survey has been completed since, CLEAPSS believes that technician working hours have steadily decreased over the past 10 years with the majority of secondary schools struggling to achieve the lowest service factor. In addition term time only working has become more common place and very recently there has been an increase in calls to the CLEAPSS helpline from technicians working in schools where a further reduction in working hours in being proposed. It would appear that the link between the sufficiency of technician support, the quality of practical activity and ultimately the outcomes for pupils is still not widely appreciated.

Technicians as Champions for Effective Practical Work—an Opportunity

This idea was raised in one of the oral evidence sessions where CLEAPSS was not present.

CLEAPSS believes that there is significant potential for technicians to work alongside teachers in co-deigning the practical component of learning in science. Teachers determine the learning intended for pupils and are ultimately responsible for designing the lesson however in many cases experienced technicians can offer a valuable insight into suitable practical activities to support pupils learning.

In the current climate it is difficult for teachers to be released from teaching to attend CPD focusing on developing practical expertise. With no cover implications it is easier for technicians to access CPD in school time—this is reflected in the take up of CLEAPSS CPD where the ratio of technician training days to teacher training days is roughly three to one.

At around £85.00 per day CLEAPSS training is very cost effective. It is designed to allow technicians to learn not just safe and effective ways to set up and clear away practical tasks but also to experience what the pupils actually do in the activities. This puts the technician in a strong position to support teachers. CLEAPSS has adopted this strategy as a pragmatic response to the increasing difficulty of accessing teachers directly through CPD.

Discussions with technicians attending CLEAPSS CPD sessions (in excess of 1,000 technicians attend CLEAPSS CPD each year) suggest that in some schools technicians already support teachers with the design of practical activities but that where this occurs it is opportunistic rather than planned. Whereas a technician might, for example, be called upon by a newly qualified teacher to help select and adapt a practical activity to suit a particular lesson they are much less likely to be able to persuade a more experienced teacher to try out a new technique that they have come across through a CPD opportunity or a technician network. In many science departments the technician's expertise with practical activities is under-valued by teachers in CLEAPSS' opinion this is profoundly unhelpful, leading to resentment on the part of technicians and missed opportunities for improved practical learning opportunities for pupils.

CLEAPSS has recently piloted a 12 day CPD programme for new science technicians. One of the aims of this programme is to increase the technician's confidence and encourage then to see themselves as partners with teachers when it comes to devising practical activities. Initial feedback from the participants and their schools has been very encouraging.

Reduced and Micro-Scale Approaches to Practical Work

In essence reduced and micro-scale approaches are about using smaller quantities of materials in practical activities. The smaller quantities necessitate different practical techniques and different apparatus.

CLEAPSS believes that reduced and micro-scale approaches have an important part to play in the future of practical work in science education.

The use of reduced or micro-scale approaches to science is common countries in the far-east, middle-east, Africa and parts of Europe, both in science education but also in research and commercial fields. The driver for the adoption of these approaches varies between contexts but includes a lack of specialist laboratory accommodation, difficulties in obtaining apparatus and reagents and tight controls over disposal of waste into the environment.

In UK education reduced and micro-scale approaches are currently uncommon. It has been observed, that in school chemistry, for example, the standard apparatus has not changed at all in the last 100 years, to put it simply, chemistry teachers in the UK are still predominantly "bucket chemists". In contrast science technicians are overwhelmingly positive about the micro-scale approaches they are introduced to on CLEAPSS courses but invariable go on to bemoan their lack of influence over teachers practice in the classroom.

Common objections to the use of reduced or micro-scale approaches from teachers in schools in the UK:

- The equipment and methods are not in our text books.
- Exam boards do not use these approaches in practical examinations.
- It's not what I expect with chemical equipment; there is no Bunsen burner in many of the experiments.
- Too small and fiddly for me and my pupils to use (mostly from teachers of boys).
- It is not spectacular enough to hold the attention of my pupils.

In contrast to the above list CLEAPSS' experience of working on micro-scale approaches suggests the following:

- It allows a once dangerous experiment to be carried out more safely, sometimes as a class practical rather than a demonstration.
- It shortens the time taken to complete practical activities so lessons are less rushed.
- It will, in the long run, reduce the cost of equipment and of consumable materials.
- It enables the teacher to have a firmer teaching relationship and better class control.
- It enables the user to obtain stunning visible effects when filmed or projected onto a whiteboard.
- It reduces technician time in disposal and clearing up.
- It reduces waste, a factor that is becoming important in the UK.
- It can show equivalent, or in some cases better, quantitative results.

Examples of effective, low cost, reduced scale chemistry activities can be seen on the CLEAPSS YouTube Channel http://www.youtube.com/user/CLEAPSS

Steve Jones (Director)
CLEAPSS

July 2011

Written evidence submitted by the National Union of Teachers (Sch Sci 27)

1. The National Union of Teachers (NUT) is the largest teachers union representing teachers and head teachers at all key stages across England and Wales. To inform its submission the NUT invited comments to the questions posed by the Select Committee from science teachers and health and safety representatives.

How important are practical experiments and field trips in science education?

2. Practical work is crucial to the teaching of science. Science is after all a practical discipline and proceeds by practical tests of hypotheses. Science teachers consulted by the NUT feel that there is not as much practical work being undertaken in schools as they would like and there are a number of reasons for this. New teachers will encounter practical science work within schools' schemes of work and due to time pressures and needs, may not be tempted to look outside these schemes. The overall result is that many new teachers, in particular, may not feel confident in planning, teaching and following up practical and field based science lessons. The end result is a narrowing of the scope of practical work and class demonstrations. Teacher training should allow trainees time to experiment with a wide range of practical work, and science teachers should have a range of high quality opportunities as part of their continuing professional development to reinforce their ability to teach science through investigative, and enquiry based, science practical lessons and work in the field.

3. In addition to being invaluable to science teaching and learning, field trips have clear cross-curricular benefits particularly in relation to personal, social and health education (PSHE).

Are practical experiments in science lessons and science field trips in decline? If they are, what are the reasons for the decline?

4. The overloaded and over-prescribed nature of the National Curriculum, especially in primary schools, means that the scope for the open-ended practical is much reduced. Scientists frequently spend a long time on practical tests only to come to the conclusion that the theory was wrong in the first place, but they learn a lot on the way. New teachers will have studied at university using modern techniques and equipment which will not be available or relevant in school. This means that their previous experience, university education and training all contribute to restricting the practical work that new teachers feel confident in undertaking in school. Learning objectives, level statements and pressure to push the student to achieve centrally imposed targets based on narrow definitions of pupil attainment all contribute to narrowing the scope of practical work. This leads teachers to do one experiment that shows the general trend and to fill in the detail as a straightforward theory lesson. Such practice lends itself to the prescribed method of teaching in that the three stages are easily identifiable and can be easily observed by Ofsted or school management.

5. Although a new teacher may be a highly qualified Biologist, for example, he/she may not have the skills and background to teach chemistry or physics with the necessary enthusiasm and expertise. This again highlights a shortfall in teacher training and courses are needed in the basic skills of setting up equipment, demonstrating, researching and carrying out practical work outside the narrow confines of the scheme of work.

6. In summary, teacher training is inadequate and rushed. The constricted National Curriculum, pressure to achieve targets and to move onto the next, leaving little time to consider issues around a topic and the insistence on a narrow one size fits all, rigid and boring method of teaching, have all conspired together to narrow the range of, and opportunity for, good class practical work. Teachers also need access to high quality professional development opportunities throughout their career in order to develop their expertise of lessons based on practical science and field work. Such professional development opportunities should be identified by teachers themselves rather than imposed upon them.

7. Field trips are a very useful adjunct to science teaching adding breadth, depth and relevance to what is taught in science lessons. However, to undertake a field trip involves a large amount of paperwork in terms of risk assessment plus a great deal of work for the organising staff. These staff will already be under pressure in terms of time and to achieve targets.

8. Inevitably a well organised field trip will take a number of staff out of school for at least a day. This has knock on effects in terms of extra workload for staff not going on the trip and possible financial ramifications in terms of payments for supply staff. Again the pressure to achieve national curriculum targets means that if the targets can be achieved without the hassle of a field trip why bother? The fact that education in its widest sense implies an opening of the mind, stimulating thought and enquiry, something encouraged by, for example, a visit to the Science Museum, seems to be ignored by Ministers who seem to see education solely in terms of examinations passed or national curriculum targets achieved. The effect of a good field trip cannot be measured in terms of targets achieved.

9. In recent years for many schools and pupils, the opportunities to participate in science field trips and other activities outside the classroom are perceived as prohibitively expensive. If insurance premiums continue to rise as a result of the real or perceived fear of litigation, then outdoor education centres will be less likely to be able to subsidise the cost of places and schools will be even more reluctant to participate in activities outside the classroom. The cost effectiveness of school visits is a particular issue for small rural primary and secondary schools who may also be faced with increased transport costs.

10. As the Select Committee on Education and Skills noted in their 2005 Report "the provision of activity centres and other facilities is closely linked to the way in which outdoor education, and education more generally, is funded." (paragraph 64)[17] Centrally held budgets were increasingly under pressure, even then, as more funding was delegated to schools. The current cuts to local authority budgets are very likely to have a severely detrimental impact on school activity centres and transport provision.

What part do health and safety concerns play in preventing school pupils from performing practical experiments in science lessons and going on field trips? What rules and regulations apply to science experiments and field trips and how are they being interpreted?

11. Health and safety considerations are important where practical work is concerned. An experienced teacher will run practical work because he/she has done so before many times and knows what the risks are. According to one Primary Head teacher children too can benefit from "an emphasis on health and safety responsibilities of all concerned." These "enhance the self sufficiency and PSHE experiences for the children and are a key factor in taking them on this kind of experience."

12. Health and safety regulations, insofar as their application to school practical work is concerned, are not always well understood by teachers, or local authority safety advisers whose background may be industrial.

[17] http://www.publications.parliament.uk/pa/cm200405/cmselect/cmeduski/120/12006.htm

13. It is felt that there is a distinct lack of guidance from the Health and Safety Executive who do not appreciate the circumstances in which science teachers work and guidance produced by CLEAPSS[18] often tends to encourage the production of unnecessarily complex risk assessments. As a result the risk assessments produced range from the ridiculously complex to none at all. Some science departments call for risk assessments that would frighten new teachers away from even trying new practical work while other science departments rely on risk assessments produced by commercial scheme authors that are largely irrelevant to the situation in which teachers may find themselves. Such "Out of the Classroom" guidance is viewed by teachers as taking priority over any decision to carry out experiments or run a field trip. In addition teachers are also put off by local authorities insisting on adherence to their policies and protocols to the letter.

Do examination boards adequately recognise practical experiments and trips?

14. In response to this question science teachers consulted by the NUT responded "No and they never have done". There is a feeling that exam boards "are only interested in getting the content of their course assessed from a theoretical point of view that can be validated by either computer marking or by moderated exam scripts".

15. It is important to recognise, however, that awarding bodies operate within the constraints of a regulatory framework for qualifications, and that the design of that framework can be politically motivated. An example is the variety of changes over the years related to maximum and minimum amounts of a qualification which can or should be assessed through coursework, and the eventual removal of coursework at GCSE entirely in favour of "controlled assessments". It is through flexible assessment methodologies such as coursework that good quality investigative science, based on practical work and work in the field, is facilitated, and by which students are encouraged to become the more independent and inquisitive learners that a science education should particularly lend itself to.

16. All teachers need to be enabled to acquire and develop their skills as an assessor, including in relation to practical and field based science. It is important to recognise that are aspects of science, as with other subjects, which contribute to a richer and fuller development of knowledge, skills and understanding of science but which may not be easily and readily assessed through the traditional constraints of examination based qualifications.

If the quality or number of practical experiments and field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in higher education?

17. There is a danger that the lack of practical experience will mean that mainly theoretical scientists leave school and who then face increased difficulties in their Higher Education course choices many of which are more practically based than GCSE and A Level courses. Consequently, we are not producing enough technically minded scientists. In the words of one science teacher: "We need more technicians in industry and less Stephen Hawkings. Maybe it is no surprise that the number of students attending HE science courses is declining and the number of those achieving certain grades is falling?". It is noteworthy, however, that some gains have been made recently in enhancing the uptake of separate science subjects at GCSE, and some increases in enrolment of science subjects at A level also.

18. It is vital that a range of options continue to be made available in order to meet the needs, aptitudes and aspirations of different learners. For some learners, scientific "literacy" to meet the demands of the 21st Century are sufficient. For other learners, it is vital that there are clear progression routes to study at advanced level and in higher education, and/or that scientific education provides a solid foundation to work in specific industries with a strong scientific focus.

19. In developing such learning routes, however, it is paramount that no young person is prevented in the future for progressing to the next level of scientific education should they wish to do so.

What changes should be made?

20. We have to decide whether we want to educate our children or simply to push them through pressured, restrictive, sometimes boring, target led experiences. Education involves understanding and interest, not just the ability to regurgitate facts.

21. Teacher training and professional development for science teachers needs to be re-examined, as does the process of risk assessment. Risk assessments need to be simple and relevant. Schools need simple guidance on how and what to risk assess.

22. GCSE and A Level exam courses need to be developed in such a way that appropriate time can be devoted to experiments and field trips which enhance and consolidate the learning that takes place. The assessment process should include a significant amount of work related to such experiments/field trips that can be marked and moderated by those who actually teach the course (and for which they are appropriately recompensed).

[18] CLEAPSS is an advisory service providing support in science and technology for a consortium of local authorities and their schools including establishments for pupils with special needs.

23. It is vital that children and young people from lower-income families, or those facing increasing financial uncertainty, are not excluded from taking part in practical lessons or field trips because the costs involved are prohibitive. Schools are increasingly more sensitive to the needs of children who live in low income households to ensure that they are not stigmatized nor socially excluded from school activities. It is also hoped that despite squeezed budgets the Government will give serious consideration to how it will structure funding to ensure all children can access practical and outdoor learning experiences.

National Union of Teachers

11 May 2011

Written evidence submitted by SCORE (Sch Sci 33)

ABOUT SCORE

SCORE member organisations aim to improve science education in UK schools and colleges by supporting the development and implementation of effective education policy. SCORE is chaired by Professor Graham Hutchings FRS and comprises the Association for Science Education, Institute of Physics, Royal Society, Royal Society of Chemistry and Society of Biology.

SCORE welcomes the opportunity to provide evidence for the Science and Technology Committee's inquiry into practical experiments in school science lessons and science field trips.

In summary the SCORE response covers the following:

- The importance of practical work[19] in the teaching of the sciences to the 5–19 cohort. Good quality practical work develops a range of skills, science knowledge and conceptual understanding and it promotes the engagement and interest of students—all of which is likely to impact positively on learner progression in the sciences, both into higher education and careers. This is vital in meeting the growing demand from employers for STEM[20] skills, and in maintaining the UK economic competitiveness.
- The enablers of practical work in the sciences for the 5–19 cohort. Appropriate teacher and technician support, resourcing and assessment are essential if science departments and primary teachers are to use good quality practical work in the teaching of the sciences.
- Improving the quantity and quality of practical work in the sciences. It is suggested this is through: evidence based research to inform the design, assessment and resourcing of practical work; accountability to ensure all young people have access to good quality practical work; and the promotion of good practice and resources.

1. *Importance of practical work in the teaching of the sciences to the 5–19 cohort*

1. SCORE members regard high quality practical work as an integral element of all teaching and learning in the sciences. This was also noted in the recent report from Ofsted[21]. SCORE considers practical work to encompass learning activities in which students observe, investigate, and develop an understanding of the world around them through:

- having direct, often hands-on, experience of phenomena or manipulating real objects and materials, and
- where primary data/observations are not possible or appropriate, use secondary sources of data to examine experimental observations (for example: aerial photographs to examine lunar and earth geographic features: spectra to examine the nature of stars and atmosphere: sonar images to examine living systems).[22]

2. Good quality practical work should have three overarching purposes:[23]

- It enables and enhances the learning of scientific concepts and explanations and ensures students have seen what they ought to have seen in order to understand a scientific idea; sometimes this is by giving them an experience or feeling of a phenomenon, particularly an abstract one such as inertia. Much of the practical work that takes place in schools will be intended to bridge the conceptual gap from the world that students see around them to the more abstract representations used by scientists.

[19] In this document the term practical work refers to practical laboratory and classroom activities and field work.

[20] STEM (Science, Technology, Engineering and Mathematics)

[21] Ofsted *Successful Science* Jan 2011 http://www.ofsted.gov.uk/Ofsted-home/Publications-and-research/Browse-all-by/Documents-by-type/Thematic-reports/Successful-science

[22] Lunetta, V N, Hofstein, A and Clough, M P Teaching and learning in the school science laboratory. An analysis *of research, theory, and practice* 2007 pg 394

[23] The Gatsby submission to the Government's Call for Evidence for the review of the National Curriculum April 2011

— It engenders an understanding of scientific process, enabling students to experience and understand the difference between the knowledge claims made by the sciences and those made by the humanities. Through practical activities students experience what it is like to "think like a scientist" and have a "cultured" approach towards science education, understanding "why they know what they know" and "how they know what they know" and not merely accepting knowledge as fact[24].

— It develops laboratory skills. Students should be given opportunities to develop their manipulative skills through the use of apparatus and by following protocols.

3. As well as developing these essential skills, good quality and appropriate practical work is widely acknowledged to promote the engagement and interests of students towards the sciences, which is also likely to impact positively on learner progression in the sciences, both into higher education and careers.

4. In addition, practical work contributes specifically to the teaching and learning of biology, chemistry, physics, and primary science:

— The Society of Biology regards high quality practical work in biology as activities that: illustrate the beauty and complexity of the living world; promote an understanding of how to extract information from complex living systems; provide an experience of testing hypotheses and analysing and evaluating variable data; support the teaching of mathematical, statistical and modelling skills; highlight and promote discussion of ethical issues; give students the foundation of skills to continue into academic or vocational training and ultimately enable them to tackle global challenges.[25]

— The Royal Society of Chemistry regards high quality practical work in chemistry as activities that: allow students to experience the wonder of chemistry; are integral to teaching rather than extension activities; deliver learning outcomes; provide opportunities to illustrate scientific ideas; allow students to apply their knowledge and understanding to investigate and test scientific theories; reinforce the theoretical concepts and content in a way that generates enthusiasm and excitement in the students; allow students to interpret the reliability of data and the validity of scientific claims; provide students with the opportunity to develop the skills necessary to meaningfully interact with chemical issues and challenges in their future lives either as scientists or as informed citizens.

— The Institute of Physics regards high quality practical work in physics as activities that: illustrate the concepts taught theoretically in lessons e.g. interference, diffraction, thermal expansion, latent heat from a cooling curve, ray optics; stimulate skills in independent investigation; develop laboratory skills in physics and handling laboratory apparatus; reinforce the idea that physics is an experimental discipline and that many of the major theoretical and experimental advances have been stimulated by unexpected experimental results; and develop an appreciation of the need to think about accuracy in measurement and of experimental errors.

— The Association for Science Education regards practical work activities to lie at the heart of primary science. Children need opportunities to develop practical and enquiry skills in order to engage with the world in a scientific way and to make sense of what they are learning about living things, the environment, materials and physical processes. Hands-on experience promotes curiosity and engagement and provides opportunities for the discussion and questioning which develop understanding. Practical work can take place inside or outside the classroom, and can happen at any point in a unit of work or lesson. It may be a five minute demonstration, a short activity to practice using an unfamiliar piece of equipment or an extended enquiry. What it must be is a varied and integral part of the learning process via appropriate learning objectives which promote progression in both skills and content knowledge, through activities for thinking as well as doing.

5. SCORE acknowledges that in the UK more practical work takes place in science lessons than in most other countries (indicated by international comparisons such as TIMSS). However, there remains concern among the science community that schools in general are not doing enough (or doing the right kind of) practical work and that its quality is uneven[26].

6. High quality practical work develops the skills which employers (STEM and non-STEM related) and Higher Education Institutions demand. It stimulates creativity, curiosity and critical thinking; illustrates concepts, knowledge and principles; underpins knowledge formation; promotes student engagement with the scientific method; encourages active learning and problem solving; allows collaborative working; and provides opportunities to collect and analyse data and apply mathematical skills.

[24] The SCORE submission to the Government's Call for Evidence for the review of the National Curriculum April 2011 http://www.score-education.org/media/7650/scorencevidence.pdf

[25] Society of Biology *Practical biology position statement* December 2010 http://www.societyofbiology.org/policy/policy-statements/practical-biology

[26] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

7. In a recent CBI report, 43% of employers in the UK were reported to be having difficulty recruiting staff with skills in STEM, with manufacturers and science-related businesses having the most difficulty finding highly-skilled people to fill their posts. Even more companies (52%) expect to have difficulty finding STEM-skilled people in the next 3 years[27]. The education system must support young people in developing STEM skills not only for the individual learner to progress but for the UK to maintain its commercial competitiveness in the world.

8. While the importance of practical work is well documented, all education policy must be based on strong evidence. SCORE would therefore like to see further commitment to research designed to ascertain the impact of practical work on students' attitude, attainment and progression in the sciences. A greater understanding of the role that practical work plays in the learning process at all stages of science education would enhance our ability to design, assess and resource good practical work in the future.

2. *Enablers of practical work in the teaching of the sciences for the 5–19 cohort*

2.1 Appropriate resourcing of facilities, consumables and equipment

9. If the Government is to maintain its commitment to STEM and to increase the number of young people progressing in science education, it must be prepared to appropriately resource science education. The sciences are a statutory requirement in the National Curriculum. They are practical subjects and by this very nature often more expensive than other school subjects.

10. There is well-documented evidence of the shortfalls in funding for equipment and upkeep of laboratories. These funding inadequacies should be addressed within a wider strategy aimed at improving laboratory facilities.[28] All secondary schools should have access to well-maintained, well-equipped, well-designed, dedicated laboratories and adequate access to functioning ecosystems to support field work. Primary schools should also have appropriate access to practical work, including access to functioning ecosystems.

11. To the best of our knowledge, despite recent government initiatives in England such as Building Schools for the Future and Project Faraday which aimed to improve laboratory facilities, there has been no monitoring on the improvements achieved. There are also concerns that these programmes were not sufficiently informed by science teachers' and technicians' needs[29].

12. At secondary level, senior school management must ensure that science departments have adequate funds to maintain and refurbish laboratory facilities. At primary and secondary level, senior school management must ensure their schools can afford the purchase and upkeep of consumables and equipment that enable practical work activities. It is important schools also budget for scientific field work activities. These may include transport costs to sites and payment to field studies centres. It should be noted there are also a number of ways that schools can undertake field work activities without incurring these costs.

2.2 Technician support

13. School science technicians are essential to the delivery of laboratory and field work in secondary schools and therefore in providing a high quality science education. In their report[30] CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services) state that "experienced and skilled technicians can give direct support to practical activities ... by ensuring that a wide range of apparatus and materials is available, appropriately maintained and stored effectively. Technicians not only contribute to the health and safety, economy and efficiency of the department, but they also enable science teachers to offer varied and stimulating science lessons".

14. In 2002 the Royal Society and the Association for Science Education estimated that up to 4,000 additional science technicians were required to provide adequate technical support to all school science departments[31]. There is already a known shortfall in technician support and there is concern among SCORE members that the devolution of funding from central government to schools may result in an increased shortfall. Anecdotal evidence suggests that reductions in technician staff time as well as redundancies have already occurred in a number of science departments.

[27] CBI Building for growth: b*usiness priorities for education and skills, Education and skills survey 2011* May 2011 http://www.cbi.org.uk/ndbs/press.nsf/0363c1f07c6ca12a8025671c00381cc7/f14c02961d1d92ac8025788800442fdb/$FILE/CBI_%20EDI%20Education%20&%20Skills%20Survey%202011.pdf

[28] RSC *Laboratories, Resources and Budgets: Provision for science in secondary schools* April 2004 http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/Laboratories2004.asp and RSC *Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools* October 2006—http://www.rsc.org/images/Labsreport_tcm18–65943.pdf

[29] RSC Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools October 2006—http://www.rsc.org/images/Labsreport_tcm18–65943.pdf

[30] CLEAPSS *Technicians and their jobs* Updated August 2009 http://www.cleapss.org.uk/attachments/article/0/G228.pdf?Free%20Publications/

[31] The Royal Society and The Association for Science education *Supporting success: science technicians in schools and colleges* January 2002 http://royalsociety.org/Supporting-success-science-technicians-in-schools-and-colleges/

15. The Association for Science Education collects technician workforce data every 10 years[32]. The 2010 data, in comparison to the 2000 data set, suggests a number of trends which the Select Committee should consider:

- The school technician workforce represents an aging population with numbers between 50–60 years of age up by 50%.
- An increasing number of school technicians (up to 29%) are the only wage earner in the household.
- In 2000 the majority of technician posts required O-level or GCSE qualifications. In 2010 this number has fallen and posts are now more likely to be advertised for graduates. In addition the number of graduate technicians has changed from 22% to 37%, but there are now fewer graduates from City and Guilds.
- There is also a noticeable difference in the duties carried out by technicians, particularly in demonstrating practical activities to teachers (87% from 37%), to students (69% from 38%) and to other technicians (73% from 32%). In addition, 96% commented that one of their duties was to try out new practical activities (an increase of 11%) and 85% stated that they were responsible for setting up IT equipment, up from 70%.

16. It is crucial that senior school management recognise and support the need for a high quality science technician service. Senior school management should, for example, be aware of the minimum requirement for technician time which was developed by CLEAPSS and Association for Science Education[33]. This calculation is based on the service factor of 0.65 (or ideally 0.85) recommended by the Association for Science Education to ensure adequate technical support in the science curriculum.[34]

17. **I**t is essential technicians are supported in their work and accorded the professional status they deserve. There should be substantial investment in technician continuing professional development (CPD)[35]. The CLEAPSS guide explores this in further detail.[36]

2.3 Health and safety

18. The 2008 SCORE report[37] and the 2011 report by the Outdoor Science Working Group of the Association for Science Education[38] found that although there are currently no serious threats to practical science from health and safety requirements, there is a negative impact resulting from perceptions of the restrictions imposed by regulations, particularly in the arrangements for field trips. Health and Safety legislation was never intended to inhibit the teaching of practical science but to ensure that it is carried out with minimum risk. It was designed to protect the health and safety of employees (e.g. teachers and laboratory technicians) and those affected by those work activities (students), not to prevent them from undertaking practical work in school laboratories.

19. The Health and Safety at Work Act (1974) as amended, applies to all workplaces, including schools. This means that the schools via their employers (the Local Authorities) have a duty to ensure the health and safety of teachers, technicians and students. In fulfilling this duty, schools and their governing bodies need to be satisfied that adequate arrangements are in place to ensure that laboratory activities are carried out safely. Practical science can be taught in schools without risk to the health and safety of students provided appropriate precautions are taken.

20. The Royal Society of Chemistry 2005 report "Surely that's banned?" illustrates in detail the level of misconceptions of assumed banned experiments and the implications this has on practical work[39]. The risks associated with the teaching of practical science need to be kept in perspective. Public understanding suggests that Health and Safety legislation is the main reason why chemistry experiments are prohibited, even though very few cases of injury to children have been recorded. In fact, legislation does not "ban" any chemicals or procedures likely to be used in school chemistry. The fear of litigation has led to health and safety legislation being used as an excuse to avoid the teaching of practical chemistry skills.

21. Laboratory-based classes make a positive contribution to understanding the sciences and should be actively encouraged. Governing bodies should be reassured by knowing that, even in today's risk-averse society, provided that proper risk assessments have been carried out and appropriate risk controls or precautions are in

[32] ASE *UK School Technicians Survey* 2010—486 respondents IN PRESS

[33] CLEAPSS *Technicians and their jobs* Updated August 2009 http://www.cleapss.org.uk/attachments/article/0/G228.pdf?Free%20Publications/

[34] The Royal Society and The Association for Science education *Supporting success: science technicians in schools and colleges* January 2002 http://royalsociety.org/Supporting-success-science-technicians-in-schools-and-colleges/

[35] The Royal Society and The Association for Science education *Supporting success: science technicians in schools and colleges* January 2002 http://royalsociety.org/Supporting-success-science-technicians-in-schools-and-colleges/

[36] CLEAPSS *Technicians and their jobs* Updated August 2009 http://www.cleapss.org.uk/attachments/article/0/G228.pdf?Free%20Publications/

[37] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[38] Outdoor Science: a report from the Association for Science Education Working Group, January 2011 http://www.ase.org.uk/news/ase-news/the-uks-leading-science-education/

[39] RSC *Surely that's banned* October 2005 http://www.rsc.org/images/Surely_thats_banned_report_tcm18–41416.pdf

place, all reasonable steps have been taken to safeguard the safety of students. Evidence suggests that practical science in schools does not and has not, posed a significant risk to students.

22. Specifically for chemistry, the more specific Control of Substances Hazardous to Health (COSHH) Regulations apply. The COSHH Regulations (2003) require the assessment and control of risks associated with work activities involving the use of hazardous substances, which includes most chemicals. All that is required to teach practical chemistry safely is to look at the way in which chemicals are used and to consider how to control the exposure to these chemicals by students (and teachers) so that any risks to health and safety are acceptably low. The COSHH Regulations do, however, prohibit the use of a very limited number of specified substances that are not, in any case, used in schools. The COSHH Regulations do not imply that the use of other chemicals are "banned" or that experiments are "prohibited". Nevertheless, anecdotal evidence suggests that some Local Authorities (LAs) and school governing bodies are citing legislation as a reason to discontinue practical chemistry teaching. Anxious parents have contributed to this situation by expecting a risk-free environment for their children.

23. There is, however, a need to be vigilant that amendments to existing regulations and new proposed legislation do not unintentionally restrict the teaching of practical science.

24. Guidance should also be provided to teachers and their employers (LAs) about what is and is not permitted with regard to practical teaching and in this regard information on the hazards likely to be found in school laboratories is given in the data sheets published by CLEAPSS, the Association for Science Education, SSERC (Scottish School Equipment Resource Centre), Heath and Safety Executive and the Royal Society of Chemistry. Specifically for primary schools the Association for Science Education has developed the publication *Be Safe!*[40] to provide guidance on health and safety matters for those teaching primary science.

25. With respect to scientific fieldwork, it should be noted by the Committee that field work in geography is commonplace in schools and colleges, despite facing the same apparent barriers encountered by science.[41]

2.4 Teacher support

26. In the SCORE practical work report[42], the main reasons cited for teachers' confidence in undertaking practical work were experience (including experience gained e.g. as a scientist, prior to becoming a teacher), knowing the subject and having enthusiasm for it. Teachers surveyed in the SCORE report also responded that they did not necessarily feel confident in carrying out practical work outside their specialist discipline, and in a recent ASE survey[43], 33% of teachers felt inexperienced in practical work.

27. As teachers should feel confident in the learning objectives of each practical activity and be confident in undertaking the activity with the students, it is important that practical pedagogy is embedded at Initial Teacher Education level. It is also vital that all science department staff (teachers and technicians) and primary teachers and subject leaders have access to high-quality CPD to enable them to respond to changing student needs but also to changes in the curriculum, changes in available equipment/technology and changes in legislation regarding health and safety.

28. SCORE supports the Getting Practical programme, hosted by the Association for Science Education, which provides professional development to support teachers, technicians and high level teaching assistants at primary, secondary and post 16 levels in the delivery of effective practical work in the sciences. The Department for Education has unfortunately decided not to continue funding this programme beyond July 2011. SCORE regards it as essential that the work and messages of the Getting Practical programme should continue[44].

29. Although practical work across the sciences has many similarities, there are also differences. For instance in each of the sciences there are specialist pieces of apparatus, specific techniques as well as different learning outcomes in terms of knowledge and ways of thinking. Therefore, whilst there is overlap in the skills needed to carry out and manage effective practical work in each of the sciences, there are also subject-specific skills which are more likely to be associated with subject specialists.

30. The severe shortage of chemistry and physics specialist teachers has resulted in much of the responsibility for students' secondary science education falling on the shoulders of teachers with biology or general science qualifications. For the immediate future this will continue to be the case (it is estimated by the Institute of Physics that even if an extra 1000 physics teachers a year are recruited, it will take 15 years to address the current imbalance of specialist teachers in the sciences). This is likely to have an impact on the quantity and quality of the specialist laboratory and field work that takes place in the individual sciences and therefore on the student's attitude towards these subjects. There is, therefore, a long term need to encourage and support teachers in using practical work outside of their specialism.

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[40] Association for Science Education *Be Safe! Fourth Edition* 2011

[41] Tilling, S. Fieldwork in UK secondary schools: influences and provision. Journal of Biological Education, 38(2), pg 54–58 2004

[42] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[43] ASE survey on practical work and fieldwork—388 respondents April 2011

[44] Getting Practical *A report on the achievements of the programme 2009–2011* May 2011 http://www.ase.org.uk/documents/getting-practical-report/

31. Subject-specific CPD should be an entitlement for science teachers as part of their overall CPD entitlement, including instructions on contemporary science and developments in research techniques. For specialist subject teachers this should provide them with opportunities to remain engaged with their subject and to grow and develop teaching expertise in their specialism. For non-specialist teachers, subject specific CPD should help to address any relevant gaps or misconceptions in their subject knowledge and pedagogical content knowledge. At secondary school level the Stimulating Physics Network and Chemistry for Non-Specialists programme aim to tackle this specifically. In a report from the Royal Society it was recommended that there is a similar need for a "science for non-specialists" course at the primary and lower secondary level. This would help develop teacher confidence in using practical activities in the teaching of the Key Stage 2/3 science curriculum[45].

32. SCORE would like to see a commitment to ensuring that individual school and college science departments have a balanced and full complement of science subject specialist teachers to teach courses in physics, chemistry and biology. This would enable science departments to support the delivery of practical work by less experienced teachers, training teachers and those teaching outside their specialism, through mentoring schemes, sharing good practice and observation. At primary school level it is equally important non-science specialist teachers are supported to use practical work in their science teaching.

2.5 Assessment

33. There are concerns that the current assessment demands are damaging and restricting for practical work. In the SCORE report[46] and a recent survey from the Association for Science Education[47], exams and assessment were listed by secondary teachers as the second most common constraint to the delivery and quality of practical activities in science lessons (exceeded only by constraints in the curriculum). Assessment should not drive the science curriculum (of which practical work are integral) yet with league tables and accountability it continues to do so.

34. SCORE recommends the following points are considered on how practical work should be assessed:

- There are arguments that the assessment of practical work ensures its place in the science curriculum and helps protect the provision of facilities.
- While SCORE supports the removal of national tests at the end of Year 9, it has led to the secondary science curriculum being increasingly driven by the assessment requirements of GCSE. SCORE also supported the removal of the Key Stage 2 National Tests for science, as they distorted the primary science curriculum. However, an unintended impact of this change led, in some cases, to less time being spent on science. There is a perception in some schools that science is no longer important (or core).
- Since its introduction in 1988, the National Curriculum has required students to undertake their own investigative work at Key Stage 4. While SCORE supports the intentions of such investigative work in developing practical skills, assessment targets encourage schools to concentrate on investigations which maximise student performance rather than develop a range of laboratory skills. In many cases this has resulted in practical activity that is narrow in scope and variety and quite often repetitive.
- Controlled assessments have contributed to the limited scope and breadth of practical work. This is because practical tasks set by awarding organisations in controlled assessments must meet the following requirements; be deliverable within a 30–60 minute slot; 100% reliable; deliver results for every student; be prepared by a technician quickly; and use equipment available in every school in the country.

35. There is a need to explore and research effective ways to assess practical work, and to support awarding organisations in developing appropriate examination questions.

36. Teachers also require support in the assessment of practical work. Teachers need to be clear what it is that they would like students to know, understand and do, and whether their assessment approaches are fit for purpose. Teachers' understanding of the purposes, validity and reliability of the various approaches to assessment in all its guises still appeared to be a significant factor in what and how they teach.[48]

2.6 Time and variety

37. In order to be effective, practical work at primary and secondary level must be well planned, with an understanding of clear learning outcomes. This requires substantial time to be set aside for teachers and technicians to develop activities; under current pressures this time allocation simply does not exist.

[45] Royal Society *Science and mathematics education, 5–14—a state of the nations report* July 2010 http://royalsociety.org/State-of-the-Nation-Science-and-Mathematics-Education-5–14/

[46] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[47] ASE survey on practical work and fieldwork—388 respondents. April 2011

[48] A SCORE commissioned study by Justin Dillon and Robert Fairbrother, King's College London and Robin Miller, University of York IN PRESS

38. In the SCORE report[49], and a recent survey from the Association for Science Education[50] time constraints were cited by teachers as a major barrier. A recent survey by Professor Justin Dillon[51] also found that teachers reported that time for planning individually and collectively was inadequate. This was particularly true of teachers who were not qualified in the subject that they found themselves teaching. This reinforces the need for an increased workforce of specialist science teachers. Schools have also commented on the amount of time allocated to science and the length of lessons.

39. The science curriculum in schools should allow sufficient time and space for teachers to undertake a wide range of practical activities with their students. Practical work in schools should include, but not be restricted to, investigations and enquiry activities. Students should experience authentic investigations during school science where students formulate meaningful hypotheses (i.e. in contexts where they have not been taught the expected answer already) and where there will be more than one cycle of activity. There is already some expertise around in this regard, for example the British Science Association's CREST scheme, but it is classed as extra-curricular, and is not available to students unless schools opt-in.

40. Other practical activities should include assembling apparatus, pre-defined procedures, observation and measurement tasks, analysis, experience of phenomena, field work and teacher demonstrations.

41. It is important however to distinguish between quantity and quality. The quality of practical work experiences should be judged by the progress students make in their learning, and be measured against agreed success criteria. Practical work should not be judged by the quantity of time spent on it. For example, complete investigations will probably be rare activities, as elements of the investigative process and of the practical techniques can be studied in shorter time periods.

3. *Improving the quantity and quality of practical work in the sciences through evidence based research, accountability and promotion of good practice*

3.1 Evidence based research

42. SCORE is embarking on a major research project to investigate the resourcing of practical work that currently takes place in schools and colleges in England. This work will update existing datasets on the appropriate levels of resourcing required to enable practical activities to take place. A baseline for equipment and consumables was first developed by the Royal Society in 1997[52]. This was subsequently enhanced and updated by the RSC in 2004[53] and 2006[54] to include laboratory facilities. In addition, in 2008 CLEAPSS and ASE[55] developed a baseline for technician support.

43. Given the new levels of autonomy given to schools, this work will demonstrate to senior school management the resource requirements of a science department. On a national scale, the work will demonstrate the level of funding required to best support science education. It will also enable a wider scale investigation into how many schools and colleges in the UK currently reach an acceptable standard.

3.2 Accountability

44. Good quality practical work is integral to science and all young people should have access to it through their science education. There should be a mechanism in place to ensure all schools and colleges are able to (and do) provide this.

45. Ofsted provides such a mechanism and SCORE welcomes the reference to practical work in the Ofsted subject specific guidance documents in science. However, these subject specific inspections operate on a very small scale. SCORE strongly recommends that Ofsted increases the number of subject specific inspections to provide statistically useful data on the impact of policies, structures and initiatives in school departments, particularly with respect to practical laboratory and field work.

46. Field work in geography is currently a statutory requirement within the National Curriculum and therefore is to be experienced by all students. Field work is just as vital to the sciences as it is for geography, particularly in the teaching and learning of biology, yet it and practical laboratory work are not given the same statutory protection. This is counterproductive to efforts to promote practical work in the sciences.

47. The recent SCORE submission to the Government's Call for Evidence on the review of the National Curriculum urged the content statements in the National Curriculum to be written in such a way as to recognise

[49] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[50] ASE survey on practical work and fieldwork—388 respondents. April 2011

[51] A SCORE commissioned study by Justin Dillon and Robert Fairbrother, King's College London and Robin Miller, University of York IN PRESS

[52] Royal Society *Science teaching resources: 11—16 year olds* 1997

[53] RSC *Laboratories, Resources and Budgets: Provision for science in secondary schools* April 2004 http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/Laboratories2004.asp

[54] RSC Improving school laboratories? A Report for the Royal Society of Chemistry on the number and quality of new and re-furbished laboratories in schools October 2006—http://www.rsc.org/images/Labsreport_tcm18–65943.pdf

[55] CLEAPSS *Technicians and their jobs* Updated August 2009

that the sciences are to a large extent practical subjects, and for the statutory guidelines to include explicit reference to procedural skills in the laboratory and in the field[56].

48. In 2004 it was reported by the RSC[57] that a quarter of all school science facilities were graded as unsafe or unsatisfactory, and a further 41% were basic/uninspiring. This is not acceptable and there is a strong case that schools should be held to account on their practical laboratory and field work facilities. The major SCORE research project referred to in Paragraphs 42 and 43 will provide essential information to ensure this is possible.

49. As part of its regulation of awarding organisations Ofqual should be held responsible for ensuring that specifications and all accompanying textbooks support high quality practical work.

3.3 Resources and promotion of good practice

50. Since the publication of the SCORE strategic framework[58] for the enhancement of practical work in science in schools and colleges there has been a strong, coordinated approach from the science community to raise the profile of practical work and to maximise the awareness of the support that is available. This should continue to be the basis for any future work.

51. The framework produced by SCORE in 2008 was distributed to all primary and secondary schools[59]. The framework gave a definition of practical work in science, described the purposes of practical work and proposed ways to implement effective practical work in schools. Accompanying the framework were dedicated resources that linked the indicators of high quality practical work to selected biology, chemistry and physics activities for primary and secondary schools.[60]

52. These messages and showcasing of good practice are also supported by the Getting Practical website[61] and the Practical websites[62] which were developed by Nuffield Foundation and CLEAPSS in collaboration with the Society of Biology, Royal Society of Chemistry and Institute of Physics. These websites include tried and tested physics, chemistry and biology experiments, in sufficient detail that they will work in any school laboratory. In addition, the sites provide notes about teaching and learning, demonstrate an integrated approach to the development of mathematical skills and advice on health and safety issues. The sites support teachers and technicians who wish to develop their practical skills in the sciences, and are regularly updated.

53. Members of SCORE play a leading role in supporting the use of high quality practical work through a variety of schemes. SCORE members also actively promote collaboration between schools, colleges, universities and other stakeholders to facilitate sharing of practice aimed at enquiry based practical learning.

54. There are many resources available for teachers and technicians to support practical laboratory and field work. It has been reported to SCORE that a significant number of calls to the CLEAPSS Helpline refer to problems in published protocols for practical activities. While it would not be helpful to require specific practical activities in the National Curriculum Programme of Study, teachers need to be able to recognise good-quality material. Materials sent to CLEAPSS by publishers for health & safety checks often include activities that simply do not work. Resources on practical work should be checked for suitability and practicality before publication. The Practical websites mentioned in paragraph 52 provide one example of where this principle is already in place.

SCORE

11 May 2011

Written evidence submitted by the Teacher Scientist Network (TSN) (Sch Sci 34)

SUMMARY

Herein we highlight the unique and highly important role practical science provides to young people of all ages. There are many real barriers in the classroom to providing effective science practical lessons and these barriers—the types of investigations, a lack of curriculum time, resources, and the support of teaching staff and money—are often compounded together to have a detrimental effect upon young peoples understanding and ability in the sciences. This lengthy supply chain from school to University to STEM employers is adversely affected along its length potentially damaging the recovery of UK plc and its places a world leader in Science and Technology. Suggestions and exemplars follow.

[56] The SCORE submission to the Government's Call for Evidence for the review of the National Curriculum April 2011 http://www.score-education.org/media/7650/scorencevidence.pdf

[57] RSC *Laboratories, Resources and Budgets: Provision for science in secondary schools* April 2004 http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/Laboratories2004.asp

[58] SCORE *Practical work in science: A report and proposal for a strategic framework*, 2008 http://www.score-education.org/media/3668/report.pdf

[59] http://www.score-education.org/media/3662/framework.pdf

[60] http://www.score-education.org/media/3677/secondary.pdf and http://www.score-education.org/media/3674/primary.pdf

[61] http://www.gettingpractical.org.uk/

[62] www.practicalbiology.com , www.practicalphysics.com , www.practicalchemistry.com

Introduction

This submission, on behalf of the Teacher Scientist Network, has been prepared by Dr. Philip H. Smith, MBE, coordinator. It represents the views of the teacher-dominated TSN Steering Group that guide our activities. These are geared towards enhancing local school science in Norfolk and North Suffolk with the active involvement of the local science community.

Our teacher membership numbers approximately 300 teachers who teach science at all phases of education: primary to sixth-form. TSN was formed in 1994 and is a registered charity receiving funding from a variety of sources through grant-income. TSN is independent from but generously hosted by John Innes Centre in Norwich providing a strategic base for our activities within the Norwich Research Park.

The Importance of Practical Science

1. It is widely accepted that future developments in Science and Technology will underpin the growth and development of the UK economy and UK plc. Such developments require an ongoing supply chain of talented pupils both interested and able to push forward the boundaries of our present understanding in science. How can we help foster this supply chain? Whilst knowledge and facts about science can be gathered from peer reviewed journals, text books and the internet, the opportunity to engage young people in "learning by doing" in carrying out their own investigations and experiments is a unique facet of science the importance of which needs to recognised by school authorities and regulatory organisations everywhere. Such opportunities engage learners of all ages, exciting them and contributing to their wish to study the sciences further at University and beyond.

2. However, we accept that only a small percentage of pupils will become future scientists. The remainder of the pupil population will become those, who unless they have a thorough understanding of science, potentially mistrust science and scientists and are more easily led by misleading media headlines. We would argue therefore that our aspiration for a more "scientifically literate society" will support the development of a strong science base in the UK.

3. These aspirations require mechanisms to develop the innate curiosity and knowledge in our young people about the world around them and the way in which the world and its components are organised and work. Practical science lessons and science field trips are powerful, and almost unique, ways to achieve this.

4. Every week the feedback TSN receives from our teacher members supports the idea that practical experiments in science lessons and science field trips are in decline. The reasons for this are cited as a packed curriculum, heavily dominated by knowledge gathering (with implications on timetable time for practicals) and, in some cases, a lack of resources.

Issues of Time and Resources

5. In 2009, Darwin year, when working with teachers to develop resources to aid teaching and learning in Evolution, high school teachers suggested to us that they were required to cover the topic in about 3 hours of teaching time which clearly leaves very little time for practical investigations once the theory component has been covered.

6. Time will also have an impact on the use of field trips. Many curriculum areas will be enhanced by visits to science institutes or science departments of local Higher Education Institutes (HEIs), many of which are keen to host such visits). The House of Lords Science Committee, Science in Society, February 2000 were actively encouraging research scientists to facilitate such visits, "It is the responsibility of research scientists to communicate to the rest of us the excitement of making new discoveries and the importance & implications of their work." Research centres like the John Innes Centre and the Institute of Food Research (both funded by the BBSRC) ably support staff and students in enhancing the student experience of such visits to the site. Such visits enable the applied nature of the science they are learning in school to be actively demonstrated.

7. The combination of coach costs and the impact of a half or full-day "away from school" makes many teachers question making such visits even though their value (when well organised) has been recognised for sometime. The ASE Chief Executive was quoted in June 2002 saying "science education in schools can only benefit when teachers and pupils have direct contact with professional scientists and the world of work."

8. This problem however is not a new one—the Teacher Scientist Network (TSN) was formed in 1994, at the launch of the then "new" national Curriculum. TSN facilitates the formation of 1:1 long-term, sustainable links between teachers and scientists, who work in partnership, allowing the scientist to bring "real-science" direct to the classroom. This eliminates the problems associated with time away from the classroom but still presents a challenge to be able to carry out engaging and relevant practical's in the limited time allocated to practical science in the classroom or laboratory. A range of other activities—Master Classes, Kit Club endeavour to bringing teachers closer to "real life science." Most importantly TSN activity is delivered in a "bottom-up" way providing what teachers ask for, not what some large organisation, removed from the classroom, thinks they need.

Supporting Teachers: Training and Continued Professional Development

9. When the National Curriculum was introduced the Norwich Research Park was approached to consider how best the science community could be used to support local science teaching. It was felt that the most effective mechanism was to make long-term partnerships between teachers and scientists. At this time, primary science teachers did not feel confident enough to teach science effectively (and this situation continues today1) and high school teachers were concerned that they were not up-to-date. TSN continues to make these links, and currently has approximately 60 partnerships operating across Norfolk and North Suffolk. These scientists are supported by senior managers from across the Norwich Research Park allowing staff to take time out to work with their teacher partners in the classroom. The work is vital and supports the development of teacher confidence to successfully implement practical sessions in the classroom that are well-designed and addressing real-life research challenges (and therefore more engaging). Whilst the value of practical science cannot be under-estimated, it is important the practical is done well.

10. In calling for more to be done to raise the profile of practical science, TSN urges the Committee to recognise that good practical's in school science lesson are facilitated by good teachers themselves supported by good science technicians. Good teachers are those who are confident teachers, up-to-date in their subject knowledge and practically adept themselves. These teachers will be those most able to inspire future scientists.

11. The development of such teachers begins with the training of new teachers (best supported by the post-graduate certificate of education (PGCE) delivered widely at HEI's around the UK). Students on the PGCE science course offered by the University of East Anglia, benefit from a 1-day workshop about using modern biotechnology procedures in the classroom (teachers learning "on the job" do not have such opportunities). Techniques such as restriction digestions, polymerase chain reaction, bacterial transformations are ubiquitous in life-science laboratories around the world and in the classroom offer pupils the chance to experience relevant modern laboratory techniques. Providing trainee teachers with the skills to carry out these practicals in their own classroom increases the likelihood that such practical lessons will engage and inspire young people. The other component of this, the availability of sufficient resources to carry-out the practical, is addressed in paragraph 15 below.

12. Beyond their PGCE, teachers need to be able to keep up-to-date. To achieve this they need to receive sufficient, high-quality continued professional development (cpd) enabled by the full support of the Senior Leadership Team (SLT). The enabling aspect includes non-teaching time or time away from school and the funds to support attendance on courses. The continued support of the Department of Education for the Science Learning Centre Network is to be applauded but too often such centres are not able to recruit sufficient numbers of teachers on their courses because of the absence of senior management support for science cpd (in terms of funding and time and the rarely cover issue). As a result many of the courses offered by the SLC's are required to focus upon assessment diluting the subject knowledge component.

13. TSN actively promotes the GIFT workshop for teachers. A 2.5 day, pan—European workshop to enrich teachers subject knowledge with a different theme each year. As the UK representative for this event, TSN has found it increasingly difficult to fill its quota of 4-funded places for UK teachers particularly in the last 2 years. Strong anecdotal evidence from TSN teachers suggests that finding support from the SLT for 3 days away from school to develop their subject knowledge cannot be justified. The workshop is held in parallel with the European Geosciences Union (EGU) General Assembly and so the dates are fixed by this event. Teachers receive from the EGU a stipend to cover accommodation, meals and travel.

14. TSN's Master Class programme for high-school teachers continues to provide an almost unique opportunity for teachers to focus upon their subject knowledge, reinvigorating their interest in a subject and bringing themselves up-to-date in a particular topic. Topics for TSN Master Classes are suggested by teachers themselves and not designed to cover just curriculum material. The bigger picture enthuses and excites teachers, and the more able ones extract components of the day to enrich their teaching. The Master Class programme (www.tsn.org.uk/Master_Class.htm) includes lectures from leading academics from around the UK in the morning and relevant practical activities in the afternoon.

Lack of Resources

15. So often teachers reported to TSN that they lacked the resources to carry out practical science (particularly in primary schools). With this in mind, TSN started to develop its Kit Club in 2000 to provide a library of free-to-loan resources for teachers to borrow. They both encourage hands-on investigative science and provide essential curriculum materials (eg. torso and skeleton) that schools don't have the budget or space to provide (http://www.tsn.org.uk/kitclub.htm). Again, the content of the Kit Club is built upon teacher input—what teachers ask for to help them deliver more hands-on science in their classrooms. Importantly many of the resources facilitate hands-on, investigative science, recognising the true value of experiential learning in the classroom.

16. The rapid and sustained growth of TSN's Kit Club (both in terms of the number of schools who are registered users (presently 213), and the number of kits available to loan (100), is evidence of the limited availability of sufficient, high-quality, affordable resources in schools, particularly primary schools. Such deficiencies clearly would have a negative impact on practical science teaching in our schools were it not for the availability of TSN' free-to-loan resources in the Kit Club.

Health and Safety

17. Heath and Safety concerns have certainly had a negative impact on the amount of practical work carried out in UK schools. Although, the direct impact may be less than the perceived impact. In other words, many teachers believe certain practicals are banned when in fact they are not (a report by the RSC in 2005 supported this perception, http://www.rsc.org/ScienceAndTechnology/Policy/EducationPolicy/SurelyThatsBanned.asp). Another RSC publication first published in 1995 (Classic Chemistry Demonstrations: One Hundred Tried and Tested Experiments) was subsequently cited by Harrison2 as timely to support chemistry teachers, http://www.rsc.org/images/Classicdemos_full_tcm18–198883.pdf).

18. Additionally, the lengths teachers must now go to to provide documented risk assessments has certainly hindered their willingness to organise practical lessons. Risk assessments are carried out before a practical and teachers try to think of every possibility, but children are sure to come up with some direction you hadn't anticipated! That of course is the beauty and thrill of open-ended investigations, allowing children to follow and develop their own curiosity, yet this can be constrained by health and safety.

Consequences

19. Whilst the timing of this inquiry is to be applauded, TSN feels the focus on 11–18 is an oversight. The central understanding of how to carry-out a scientifically valid investigation is laid down in primary schools ("a fair-test"). Additionally, with the preponderance of non-specialist teachers in the primary sector, many find the scientific enquiry aspect of the curriculum difficult to teach. Regretably, many primary practicals tend to be very prescriptive, and therefore predictable, suppressing both the teachers and pupils enthusiasm. The consequence of this is that some pupils will have decided that "science is not for them" by aged 11 so potentially the raft of 14–19 initiatives will be lost on such pupils.

20. Teachers also report to us that the practical investigations at KS4 for GCSE are very ineffective at preparing students to feel confident with the scientific method.

21. The lack of practical experience has huge impacts at university level. Many students do not know how to do quite simple manipulations such as filtration or the correct use of a burette or a pipette. The lack of teaching basic laboratory and field skills in schools, undermines any attempt to teach these subjects at an advanced level and impacts on the skills base offered to employers seeking to employ technician grade employees aged 16+.

Future Developments

22. TSN believes that the curriculum needs to provide more opportunity for open-ended investigations at all ages—primary through to sixth-form. The relevance and importance of following the scientific methods needs to emphasised and learnt by doing. The science community should be encouraged and enabled to support science locally (after all it is in their own interests). Pupils respond differently to "their scientists" than "their teachers" and this can have positive outcome on their learning.

23. In highlighting what appears to be a need for curriculum change, TSN is conscious that the one thing teachers would welcome is a sustained period of time without change! This would allow time for the many preceding changes to become embedded and some formal evaluation of success or failure to be gauged. During this time, certainly the creative and talented teachers (of whom there are many) may feel galvanised to research and develop their own new practicals. The withdrawl of KS3 SATs has certainly provided a small opportunity for them to do this. However, at the end of the day, senior managers will need a curriculum / performance driver in order to actively promote such an opportunity and this would need to be identified.

References

1. Harlen, W. *Science as a key component of the primary curriculum: a rationale with policy implications*. Perspectives on Education 1 (Primary Science), 2008: 4–18. http://www.wellcome.ac.uk/perspectives
2. Harrison, T. Review of "*Classic Chemistry Demonstrations: 100 tried and tested experiments* by Ted Lister, in Science in School Issue 13, Autumn 2009. http://www.scienceinschool.org/print/1044

Declaration of Interests

The coordinator of the Teacher Scientist Network ia a member of the partners executive of the East of England Science Learning Centres, based at Bayfordbury, Herts. The SLC network is referred to above in Paragraph 12 (https://www.sciencelearningcentres.org.uk/centres/east-of-england).

The TSN Steering Group comprises teachers from across the region from primary and secondary education and representatives from each of the Institutes and HEI's supporting TSN's activity. Affiliations of the members of the TSN Steering group can be found at http://www.tsn.org.uk/contacts.htm

Teacher Scientist Network

11 May 2011

Written evidence submitted by The Association for Science Education Outdoor Science Working Group (Sch Sci 39)

The *Association for Science Education* (ASE) is the largest subject association in the UK. Members include teachers, technicians and others involved in science education. The Association plays a significant role in promoting excellence in teaching and learning of science in schools and colleges. Working closely with the science professional bodies, industry and business, ASE provides a UK-wide network bringing together individuals and organisations to share ideas and tackle challenges in science teaching, develop resources and foster high quality Continuing Professional Development. The Association for Science Education can trace its origins back to 1900. Incorporated by Royal Charter in October 2004, the ASE operates as a Registered Charity.

The *Outdoor Science Working Group* (OSWG) was convened by ASE in 2004 in response to a long and continuing decline in the use of outdoor fieldwork to teach science in the UK's schools, particularly at secondary level. The OSWG feels that this is detrimental to the quality of science education and reduces the opportunities for children to appreciate everything that science has to offer them, both as future citizens and potential recruits to science careers. The ASE OSWG is chaired by ASE, and includes representatives from university science education departments including King's College London, Keele, Birmingham and Southampton, and science education bodies such as Field Studies Council (FSC), Science and Plants in Schools (SAPS) and British Ecological Society (BES).

1. This response is submitted in addition to the SCORE response covering practical work and fieldwork in science, to which ASE contributed as a member organisation of SCORE.

2. This response focuses on fieldwork aspects and draws on two reports from ASE's OSWG in 2011[63] and 2007[64]. This response is informed by evidence from members of ASE's OSWG and their organisations together with an ASE survey of science teachers and others involved in science education. The survey evidence presented here is a summary of responses from 388 teachers who contributed to an online survey carried out by ASE in 2011[65]. 90% of respondents were secondary school teachers in England, with subject teaching equally divided across science disciplines (35% Physics; 33% Chemistry; 32% Biology).These data have not been published previously.

Are science field trips in decline? If they are, what are the reasons for the decline?

3. The survey data indicates there is a huge range in provision between schools, ranging from regular trips for most years to none at all. Whereas most teachers (67%) thought that the level of provision had remained the same as previous years, a significant minority (29%) felt that it had declined. Only 4% thought that it had increased. Stated reasons for the decline included inadequate time available for planning and taking students out of classroom, disruption to school timetables and increasingly, a lack of funding.

4. Elsewhere, there is strong evidence from a variety of sources including a survey in 2010 indicating a decline in the number and duration of biological fieldtrips over the past 40 years.[66]

5. The survey data indicates that 33% of respondents feel inexperience of teachers in carrying out practical work is an issue and 22% indicated that they would welcome more professional development opportunities to develop their confidence with practical work. ASE's OSWG has consistently identified that there is a shortage of secondary science teachers with the confidence, competence and commitment to lead fieldwork. In response, the ASE OSWG has released two reports[67] which have made recommendations to remedy this shortage.

[63] Outdoor Science Working Group (2011). *Outdoor Science. A co-ordinated approach to high-quality teaching and learning in fieldwork for science education*. Association for Science Education/Nuffield Foundation. Field Studies Council Occasional Publication 144.

[64] Outdoor Science Working Group (2007). *Initial Teacher Education and the Outdoor Classroom: Standards for the Future*. Field Studies Council and Association for Science Education. Field Studies Council Occasional Publication 122.

[65] ASE survey of teachers on practical work and field work, 388 responses including smaller numbers of responses on specific fieldwork questions (April 2011)

[66] Lock, R. (2010). Biology fieldwork in schools and colleges in the UK: an analysis of empirical research from 1963–2009. *Journal for Biological Education* 2: 58–34

[67] Outdoor Science Working Group (2011). *Outdoor Science. A co-ordinated approach to high-quality teaching and learning in fieldwork for science education*. Association for Science Education/Nuffield Foundation. Field Studies Council Occasional Publication 144.
Outdoor Science Working Group (2007). *Initial Teacher Education and the Outdoor Classroom: Standards for the Future*. Field Studies Council and Association for Science Education. Field Studies Council Occasional Publication 122.

How important are field trips in science education?

6. Over two thirds (68.3%) of teachers feel that field trips are important or very important. Table 1 summarises the overall responses.

	Secondary	*Primary*
	n=199	n=11
Very Important	29.1%	0.0%
Important	39.2%	81.8%
Mildly Important	22.6%	18.2%
Not Important	4.0%	0.0%

Table 1. 2011 ASE teachers' survey. How important are field trips in science education?

7. The importance of field trips is also evidenced both through the level of activity (see Figure 1) that is going on, but also the strength of accompanying statements.

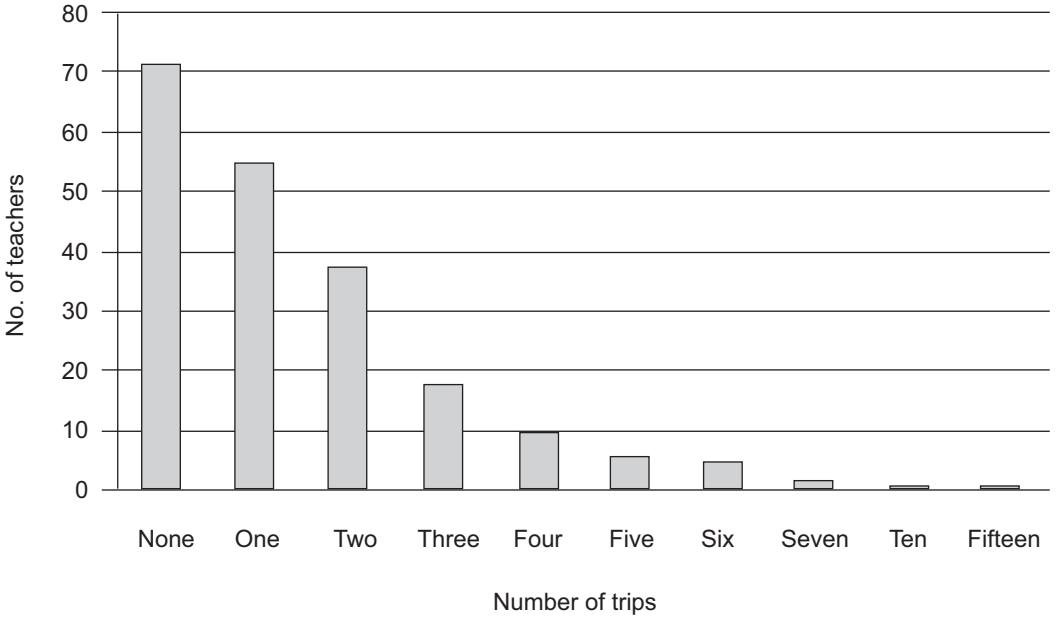

Figure 1. ASE 2011 survey. How many field trips have you undertaken or intend to carry out in the 2010/2011 academic year?

Exemplar Statements

8. "My fondest memories of my A level course were the field trips and they formed my desire for science and to teach. They are about seeing science in context and not in theory, whether it is seaweed on a rocky shore, fossils in a quarry or the Haber process in a chemical plant. Good field trips are more than discovery; they are also about teamwork, leadership and other personal skills."

9. "Field trips show that science is for real and not just something that is done at school. They give a greater understanding of the world of science. They can help generate more interest and can help spark the less interested students. They can show students a possible way forward for careers. They can help students understand the real world around them."

10. "Out of classroom science enables pupils to understand the complexity of the real world and how it can be investigated. It provides opportunities for learning how to observe, raise questions, investigate in contexts where there is often not a "right answer" and deal with "messy" data (data that shows variation and therefore consideration needs to be given as to its quality). Many real world issues involve such "messy" data—it is important that students learn that evidence is seldom as clear cut as in a contrived lab-based experiment. Uncertainty in data is inevitable and students need to learn that this is inherent in science and not the fault of the scientists "doing it wrong"."

11. "Field trips allow pupils to experience environments and activities that they may not otherwise have access to (due to socio-economic factors, location, etc). Field trips encourage pupils to develop an appreciation of the environment and the need for environmental conservation and sustainability. Field trips to museums and workplaces allow pupils to learn about science in context and provide future opportunities for STEM careers."

12. The survey data indicates that field trips involve all age phases (activity as a proportion of total secondary school field trips are shown in brackets below), but also notes with concern that barriers are most pronounced at GCSE (Key Stage 4) level:

— Key Stage 3 (34%)
— Key Stage 4 (22%)
— A level, 16–19 (46%).

13. Field trips can occur at any time of the academic year (activity as a proportion of total secondary school field trips are shown in brackets below), but most activity is disproportionately placed in the post exam period in Summer Term, mainly because of exam and timetabling constraints, and the increased availability of cover staff:

— Autumn Term (17%)
— Spring term (16%)
— Summer Term (67%).

14. A wide range of sites and activities are being used by UK teachers, which include (in declining order, with number of references in brackets):

— Ecology sites/local habitats (including school grounds) (63)
— Field Centres (28)
— Museums (21)
— Wildlife park/zoos (19)
— Science/technology centres (19)
— Space centres (incl. CERN) (16)
— Universities (15)
— Industry (16)
— Farms (8)
— Botanical gardens (5).

Others (<5) included: hospitals, powers stations, theme parks, research labs, mines and quarries, aquaria, reservoir, army barracks and a recycling plant.

What part do health and safety concerns play in preventing school pupils from going on field trips? What rules and regulations apply to field trips and how are they being interpreted?

16. Table 2 below summarises the responses of teachers to the barriers to practical work. It is likely that health and safety concerns will be more prominent when considering field trips and these undoubtedly act as a deterrent. However, a large number of written responses identified the administration and paperwork—including the need to find and fund staff cover—as the main obstacles, rather than the health and safety risks themselves.

How much of a barrier do you consider these issues to be when deciding whether to carry out practical work in science at your school?

	Greatest Barrier	*Less of a Barrier*	*Not a Barrier*	*Response counts*
Resources and facilities	36.6% (111)	41.3% (125)	22.1% (67)	303
Teachers' inexperience	32.6% (99)	41.4% (126)	26.0% (79)	304
Health and safety	15.8% (48)	53.3% (162)	30.9% (94)	304
Technical support	21.8% (66)	45.2% (137)	33.0% (100)	303
Exams and assessment	45.2% (137)	38.3% (116)	16.5% (50)	303
Pupils' behaviour	37.9% (114)	43.2% (130)	18.9% (57)	301
Curriculum (content and resources)	38.5% (116)	49.5% (149)	12.0% (36)	301
Time	52.1% (158)	37.3% (113)	10.6% (32)	303
CPD Provision	15.9% (47)	52.2% (154)	31.9% (94)	295
				Answered question 306
				Skipped question 82
				Others please specify 31

Table 2 ASE survey 2011

17. ASE's OSWG welcomes many of the findings of Lord Young's Review[68] and his proposals to simplify the process that schools and other organisations undertake before taking children on outdoor learning experiences.

[68] Common Sense; Common Safety (2010) http://www.number10.gov.uk/wp-content/uploads/402906_CommonSense_acc.pdf

Do examination boards adequately recognise science field trips?

18. The survey data indicates that nearly three quarters (71%) of the teachers who expressed an opinion (Yes or No, n=160) felt that examination boards did not adequately recognise the work carried out on field trips (71%, n=160). It was noted that some awarding organisations had stronger recommendations than others. Some commented that a stronger recommendation would support a greater take up of field trips.

19. Elsewhere evidence links the amount of fieldwork to curriculum and assessment. Fieldwork has not been compulsory in the national curriculum for science, unlike geography. As a result, geography numbers have grown for the Field Studies Council courses over 20 years, replacing science as the major contributing subject to Field Studies Council visitor numbers. Geography teachers are twice as likely to do residential fieldwork at Key Stage 3, and ten times more likely at GCSE level; they were also twice as likely to do local fieldwork at both levels.[69]

If the quality or number of field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in Higher Education?

20. The OSWG believes that a continuing decline in field trips will lead to a downward spiral in provision. For example, an increasing the number of science graduates who lack prior experience in fieldwork will reduce the number of trainee and early career science teachers with the confidence, competence and commitment to teach fieldwork themselves.

21. A reduction in field trips will affect the quality of science education—for example weakening the opportunities to observe and practice the learning of science in the context of the "real world", reducing the chances of a wider range of learners to fulfill their potential and weakening the development of critical skills such as data handling and analysis. The main sources of inspiration and motivation for some students will disappear, thus reducing potential recruitment to the UK's science knowledge base.

22. This is of particular concern with the pressing need to address the world's major environmental challenges. It is noted that the UKCES4 report[70] highlights the areas of conservation and environmental protection as being one of the biggest growth areas in terms of employment over the last 10 years. By 2020, approximately 4% of the work force will be involved in "green jobs" in a variety of capacities with education standards including level 2–4 and beyond 5; many of which will include elements of fieldwork. Similarly, the NERC funded ERFF report 7[71] highlights fieldwork as being one of it's ten most wanted skills required for the next ten years, highlighting a decline in the knowledge base in this area.

What changes should be made?

23. The evidence from this research and earlier ASE OSWG-hosted national workshops points to the wide-ranging educational benefits of teaching and learning science through fieldwork in the natural and built environments. These benefits are widely recognised;[72] yet despite the strengths and advantages that fieldwork can bring to teaching at all ages, there has been a decline in the provision and condition of outdoor education in science. ASE's OSWG believes that this trend is detrimental to science education.

24. The recommendations below will provide a strong foundation for a shared and coherent approach towards increased uptake and improved quality of teaching and learning through fieldwork in science education.

Recommendation 1

Reviews of initial teacher training, Qualified Teacher Status standards and continuing professional development such as the current independent review of qualifications to raise the standards of teaching, led by Sally Coates, must ensure that fieldwork training is expected and provided for all trainee science teachers. **All trainee science teachers should be expected to prepare and lead at least one fieldwork session themselves, and to take part in a fieldwork trip**. A co-coordinated programme of teacher training in fieldwork should therefore be established to promote effective pedagogy for all university tutors and school teachers involved in pre-service and early career training.

[69] Tilling, S. (2004). Fieldwork in UK secondary schools: influences and provision. *Journal of Biological Education* 38 (2): 54–58.

[70] Skills for Jobs: Today and Tomorrow (2010) http://www.ukces.org.uk/upload/pdf/NSSA_Volume%201_FINAL_BOOKMARKED_110310.pdf

[71] Most Wanted Postgraduate Skills Needs in the Environment Sector http://www.nerc.ac.uk/funding/available/postgrad/skillsreview/summary.pdf

[72] Dierking, L. *et al.* (2003) Policy statement of the "informal science education" ad hoc committee House of Commons Education and Skills Committee (2005) *Education outside the classroom* Department for Education and Skills (DfES) (2006) *Learning outside the classroom manifesto* House of Commons Children, Schools and Families Committee (2010) *Transforming education outside the classroom* Ofsted (2010) *Science Survey Visits*. Generic grade descriptors and supplementary subject-specific guidance for inspectors on making judgements during visits to schools

Recommendation 2

A dedicated outdoor science web-site, aimed at teachers, technicians and outdoor educators, should be created to signpost, exchange and compare high-quality fieldwork training resources. The website should encompass local and context-specific support and include contacts for expert advisers, local support networks, existing good practice, training events and fieldwork providers as well as published materials.

Recommendation 3

Performance management and designations (for example, to AST or Excellent Teacher level) should include **an opportunity for early-career teachers to demonstrate their effective use of fieldwork** and for more experienced teachers to demonstrate their own role in providing fieldwork training for colleagues in other departments and schools (including across age phases and transitions).

Recommendation 4

Awarding bodies should be provided with the flexibility and support to **significantly increase open-ended summative assessment** and assessments that recognise skills which are primarily developed through fieldwork.

Recommendation 5

A coordinated research programme should be developed to further investigate the full range of educational impacts of fieldwork in science including case studies in formal/ informal contexts, day/residential venues, local/remote sites and rural/urban communities.

Recommendation 6

Leading educational bodies, learned societies and high-profile supporters of outdoor education should use their combined influence to **support positive attitudes towards fieldwork in science** amongst their contacts and audiences (including headteachers, governors and parents). These institutions and individuals should focus particularly on areas such as raising the profile of fieldwork in whole school policies and development plans, a reduction in health and safety bureaucracy and the development of in-service professional development programmes.

Marianne Cutler
ASE Director of Curriculum Innovation and Chair of ASE's OSWG
Association for Science Education Outdoor Science Working Group

10 May 2011

Written evidence submitted by NASUWT (Sch Sci 40)

The NASUWT's submission sets out the Union's views on the key issues identified by the Committee in the terms of reference for the inquiry and is based upon the work of its representative committees and other structures, made up of practising teachers and lecturers working in all relevant sectors of the education system.

The NASUWT is the largest union representing teachers and headteachers in the UK, with over 280,000 serving teacher and school-leader members.

Executive Summary

- The NASUWT notes with concern the citation by the Committee of press reports that the number of practical experiments in science lessons in schools and science field trips may be in decline.
- The Union is aware of no credible evidence that this is in fact the case and is clear that the press reports to which the Committee appears to refer seek to advance an argument that provisions in relation to health and safety are militating against schools undertaking activities of this nature.
- Learning outside the classroom can provide valuable educational experiences and curriculum enrichment, providing it is planned, properly resourced, linked to the curriculum and has clearly identified intended learning outcomes.
- While the Coalition Government has confirmed that science will remain a compulsory element of the curriculum for pupils in the 5–16 age phase, its programme of reforms place current curricular entitlements to learning outside the classroom and practical activities at risk.
- The lack of any requirement on academies and free schools to offer learning outside the classroom or practical science-related learning guaranteed in other schools currently through the provisions of the National Curriculum, could deny pupils in these schools the chance to benefit from these activities.
- Cuts in school and local authority budgets are likely to lead to pressures on schools to limit pupils' access to learning outside the classroom or to practical activities in science, based on their relatively high cost, as well as increased financial demands being made of parents.

— It is essential that processes and procedures put in place in respect of health and safety in schools and local authorities allow the health and safety of all those participating in or overseeing learning outside the classroom or practical activities to be managed effectively.

— Schools should be encouraged to make use of quality assurance arrangements that support the delivery of learning outside the classroom, including providers that are pre-approved, thereby reducing costs and associated bureaucracy.

Background and Context

1. The NASUWT welcomes the opportunity to submit evidence to the Science and Technology Committee inquiry into school science lessons and science field trips. The range of issues highlighted in the terms of reference of the inquiry highlight four fundamental areas of concern:

— the extent to which the curriculum and qualifications framework promote the use of learning outside the classroom and practical learning in science;

— the impact of the Coalition Government's drive to expand significantly the number of academies and free schools within the state-funded education system;

— the implications of real-terms reductions in education-related expenditure; and

— the health and safety context within which learning outside the classroom and practical activities take place.

2. Each of these considerations is explored in more detail below. However, at the outset, the NASUWT must raise its concerns about the citation by the Committee of press reports that the number of practical experiments in science lessons in schools and science field trips may be in decline. The Union is aware of no credible evidence that this is, in fact, the case and notes with concern that the press reports to which the Committee appears to refer seek to advance an argument that provisions in relation to health and safety are militating against schools undertaking activities of this nature. The NASUWT takes the view that reports of this nature are being advanced as part of an ill-considered and unsustainable attempt to discredit the existing framework of health and safety law and regulation applicable to schools.

3. While the NASUWT recognises fully the right of the Committee to consider issues relating to learning outside the classroom and the use of experiments in pupils' science learning experiences, the Union recommends that the Committee ensures that it takes forward its work in this area on the basis of valid and reliable evidence rather than partial reporting in some sections of the media.

The role of the curriculum, qualifications and school accountability framework

4. The NASUWT believes that all pupils are entitled to access a broad and balanced curriculum. In particular, the curriculum should recognise different forms of learning, including academic and practical learning, and offer rich, engaging and relevant learning experiences. Not only is this a fundamental right of all children and young people, it is also critical to tackling disaffection, addressing poor pupil behaviour and ensuring that learning objectives for pupils with special educational needs or who are gifted and talented are secured effectively. The curriculum should help learners to become confident and successful and enable them to make a positive contribution to society.

5. The NASUWT recognises that learning outside the classroom can provide valuable educational experience and curriculum enrichment, providing it is planned, properly resourced, linked to the curriculum and has clearly identified intended learning outcomes. Learning outside the classroom activities can enable pupils to be more engaged and enthusiastic learners and can provide an important means by which key learning objectives in relation to science can be secured for pupils.

6. Equally, the provision of an effective science curriculum requires pupils to be given opportunities to engage in practical experiments and activities in order to extend and consolidate their understanding of key concepts and principles.

7. The importance of learning outside the classroom and of practical activities in science is reflected in the provisions of the statutory programmes of study for the subject set out in the National Curriculum. This curricular framework serves as a common learning entitlement for all pupils in all schools and thereby ensures that pupils' learning in science incorporates effective use of opportunities to learn outside the classroom and to undertake practical activities to support and consolidate their learning.

8. The Committee will therefore be concerned by proposals set out in the education White Paper, *The Importance of Teaching,* for future reform of the curriculum. While the White Paper confirms that science will remain a compulsory element of the curriculum for pupils in the 5–16 age phase, it intends to revise the content of the curriculum so that it is more focused on knowledge rather than skills. Developed on this basis, the entitlement to learning outside the classroom and practical activities set out in the current curriculum may be marginalised.

9. While it is clear that in seeking the best possible learning outcomes for pupils, teachers recognise fully that learning outside the classroom and practical activities are essential elements of a rounded and engaging science experience, the potential removal of curricular entitlements in this regard could result in greater

pressures being placed on teachers to focus, to a disproportionate extent, on knowledge-related areas of learning rather than the practical application of this knowledge.

10. The implications of the school accountability regime are a critical consideration in this regard. The Coalition Government has made clear that it intends to intensify the use of performance tables and other data-related means of holding schools to account, while proposals being taken forward in relation to the reform of the school inspection regime make clear that this will rely to an even greater extent on performance data in the formation of judgements about school performance by inspectors. The potential negative consequences of perceived failure by schools in terms of their performance data and inspection outcomes will become even more pronounced as a result of the Coalition Government's proposals for school accountability as set out in the White Paper. In a context where curricular guarantees in relation to learning outside the classroom and practical experiences are diminished, restrictive teaching and learning approaches which seek merely to secure the best possible performance data outcomes are likely to be incentivised to an inappropriate extent. The Committee will therefore wish to consider in more detail the potential implications of curricular reform and the impact of the school accountability regime on the ability of schools to ensure that learning outside the classroom and practical learning in science plays an effective part in the science learning offer available in schools.

11. The Committee is right to highlight the importance of the qualifications structure in the promotion of learning outside the classroom and the use of practical experiments in science learning. Currently, specifications for science-related GCSEs and A-levels set out clear requirements in relation to field trips and practical learning. However, it should be recognised that the inclusion of such activities in specifications is not a discretionary matter for awarding bodies but is instead a requirement for the accreditation of these qualifications by the Office of Qualifications and Examination Regulation (Ofqual).

12. Currently, a key function of Ofqual in establishing these requirements is that they are consistent, where applicable, with the requirements of the statutory National Curriculum. Given the specific reference to learning outside the classroom and practical activities in the science National Curriculum, it is therefore appropriate that they are included within GCSE and A-level specifications. However, any removal of these requirements from the National Curriculum that may result from the reforms being taken forward by the Coalition Government could therefore leave open the possibility that they could also be removed from the accreditation requirements set out by Ofqual.

13. In addition, the decision by the Coalition Government to allow state-funded schools to offer the International GCSE (IGCSE) as a Level 2 qualification should also be regarded by the Committee as a matter of concern given the absence of any requirement in IGCSEs for practical learning or for learning outside the classroom. The reversal of the requirement on schools to ensure that all schools offer science-related diplomas will also serve to remove an important means by which practical activities and learning outside the classroom can be promoted for many pupils given the ways in which these qualifications are designed and structured.

Academies and Free Schools

14. The Committee will also be aware of the intention of the Coalition Government to expand significantly the number of academies within the state-funded education system in both the primary and secondary sectors and to promote the introduction of free schools. Notwithstanding the extent to which the revised National Curriculum will include provision for practical learning and for learning outside the classroom, it is important that the Committee notes that academies and free schools will not be under any requirement to ensure that their curricular offer is in line with the requirements of the National Curriculum.

15. Instead, academies and free schools are subject to an ill-defined and difficult-to-enforce requirement set out in their funding agreement with the Secretary of State for Education to provide a 'broad and balanced' curriculum. Given the lack of any meaningful description of the basis upon which this curricular requirement is to be established in practice, it is therefore possible that pupils attending such schools will not be offered the range of activities in this respect that might continue to be provided for within the terms of the revised National Curriculum. Any failure in these schools in respect of provision of opportunities for learning outside the classroom or practical education in science must therefore be regarded as a direct responsibility of the Secretary of State.

16. In relation to academies and free schools, it should also be recognised that currently under the terms of the Education Act 1996, schools are not permitted to charge for activities, including learning outside the classroom and practical activities that form part of pupils' curricular entitlements. However, if academies and free schools are able to define their own curricular offers in relatively narrow terms that exclude explicit provision for learning outside the classroom or for some science-related practical activities, it is possible to envisage circumstances where schools could claim that as these activities, where offered, are outside the core curriculum, they are liable for charging. For economically disadvantaged families, this could represent a serious barrier to access learning outside the classroom or practical science-related activities in certain schools. It also raises the prospect of increased social segregation between pupils as some would be able to access school-based activities regarded as optional extras, while others would not. The Committee will therefore want to consider seriously investigating this potential consequence of the academies and free-schools programme, and

the NASUWT would welcome the opportunity to share its particular concerns in this regard with the Committee in more detail.

Reductions in public expenditure on education

17. It should be recognised that learning outside the classroom and practical science-related learning represent relatively high-cost elements of educational provision for schools, given the resources, materials and additional expenditure that can be involved. In this context, expenditure plans set out by the Chancellor of the Exchequer in the Coalition Government's Comprehensive Spending Review (CSR) risk undermining the ability of schools and local authorities to ensure that pupils' curricular entitlements in this regard can be met effectively. While the Government has asserted that during the course of the CSR period, expenditure on schools will increase in real terms, it is clear that per-pupil spending overall will decline as a result of increases in pupil numbers during the period.[73] There are also legitimate concerns about the extent to which the Government's proposals for its Pupil Premium will lead to real-terms reductions in funding for a significant number of schools.[74] These concerns are further compounded by significant reductions in local authority expenditure for which schools will face pressures to compensate through diverting their own resources to replace diminished local authority provision of key education-related services.

18. As a result of these decisions, there is emerging evidence that schools are facing pressures to reduce learning outside the classroom opportunities or, where possible, reduce expenditure on practical learning provision as a direct consequence of increasing cost pressures and declining overall budgets. In addition, the NASUWT is aware of reports that constraints on funding are leading to increased demands for financial contributions from parents to support activities of this nature. The NASUWT is clear that the potential effect of these changes to levels of funding available to schools on learning outside the classroom and practical learning opportunities in science have not been taken into sufficient consideration by the Coalition Government in developing and implementing its policies in this area. The NASUWT therefore recommends strongly that the Committee seeks to undertake its own assessment in this regard and the NASUWT would welcome the opportunity to work with the Committee in progressing its activities in this area.

Health, safety and science education in schools

19. It is well established that activities related to learning outside the classroom and practical activities in schools are associated with risk to the health and safety of staff and pupils. For staff, failures in relation to the health and safety of pupils and other colleagues can have significant legal consequences and place their future careers in jeopardy. In the NASUWT's view, it is therefore critical that these risks are identified, assessed and managed effectively. Approaches based on denying that such risks exist or that downplay their nature and extent are unacceptable.

20. In its evidence to the former Children, Schools and Families House of Commons Select Committee's inquiry into learning outside the classroom undertaken in 2010, the NASUWT set out its concerns about the impact of an increasingly litigious environment on the ability of schools to organise learning outside the classroom, especially where schools believe that they may be vulnerable to compensation claims. Teachers have been vulnerable as a result of delays in the conduct of investigations where problems have arisen or where they have individually been cited in legal action that has been instigated by parents or carers. In some instances, employers have been unwilling to provide proper representation or support for teachers, further exacerbating teachers' professional and personal liability concerns. The Union's casework continues to confirm that employers will often decline to support individual teachers on grounds of perceived 'conflict of interest' between the employee and the pupil.

21. Therefore, it is essential that processes and procedures put in place in respect of health and safety allow these issues to be addressed effectively and thereby ensure the health and safety of all those participating in such activities. The NASUWT would reject firmly any proposals to amend these arrangements in a way that would hinder their ability to ensure that all staff and pupils can benefit from effective risk management procedures. Some of the distorted and inaccurate narrative in this respect that has developed as result of the Review of health and safety undertaken by Lord Young of Graffam, *Common Sense, Common Safety,* can only be regarded as highly unhelpful.

22. With regard to the contention referred to by the Committee that these arrangements deter schools from offering learning outside the classroom experiences or practical, science-related activities, the Union's experience is that such claims are entirely without validity. Work undertaken by the NASUWT to survey its members' views of causes of bureaucracy and excessive workload in schools fail to identify health and safety responsibilities related to learning outside the classroom or practical activities as significant.

23. In addition, recent developments in these areas have worked to simplify health safety arrangements and enhance manageability at school level. For example, the Learning Outside the Classroom Manifesto, taken forward by the previous administration in close collaboration with the NASUWT, led to the establishment of a Quality Badge Scheme which accredited providers as effective in the management of health and safety and

[73] HM Treasury (2010), *Spending Review 2010,* The Stationery Office, London.

[74] Chowdry, H; Greaves, S; and Sibieta, L (2010), *The Pupil Premium: assessing the options*, The Institute of Fiscal Studies, London.

benchmarked effective practice in this area. The Union is clear that the extension of this scheme has increased confidence within the school system in relation to the incorporation of learning outside the classroom experiences into school science curricular. It must therefore be regarded as a matter of serious concern that the sustainability of these schemes has been placed at serious risk by the cuts in education-related public expenditure being taken forward by the Coalition Government.

24. The NASUWT therefore recommends that the Committee should review the positive impact of the Manifesto and the Quality Badge Scheme on practice in schools and should ensure that its work in this area takes into full account the outcomes of this review.

Ms Chris Keates
General Secretary
NASUWT

13 May 2011

Written evidence submitted by the Health and Safety Executive (HSE) (Sch Sci 42)

INTRODUCTION

1. HSE supports completely the importance of school science, and of the educational and personal development benefits that science field trips provide for pupils. HSE further recognises and supports the economic necessity of properly preparing Great Britain's future workforce, and the role that science and technology (S&T) should play in GB's future. HSE itself employs a considerable number of scientists and technologists, and our policy positions are underpinned by an S&T evidence base.

2. Unfortunately, some schools and teachers have seen health and safety law as a barrier that discourages them from organising practical science activities and providing pupils with the opportunity to take part; or that health and safety law requires them to apply overly bureaucratic controls that prevent teachers running dynamic science lessons. We believe this perception results from a basic misunderstanding of the expectations placed upon schools and teachers under the Health and Safety at Work etc Act 1974, coupled with related concerns about insurance requirements and fears of teachers being sued if a child is injured. HSE's interest is in criminal action (prosecutions). HSE does not investigate or take action in relation to civil claims. This submission therefore tackles the issue and impact of criminal liability and not civil liability.

3. HSE believes there is no reason why health and safety should stop schools carrying out science experiments or field trips. On the contrary, we see the proper integration of health and safety considerations into the overall delivery of the curriculum as being both natural and good teaching practice. It helps children appreciate hazards and risks, and learn how to manage them—all that is required in most cases are a few sensible precautions. Active and experiential learning is widely recognised as one of the best ways for people to learn so it is important that it is not curtailed unnecessarily. HSE has worked with educational science bodies over many years to establish and publicise what those precautions should be and to ensure they are sensible, practical and proportionate. HSE continues to work closely with those organisations.

HEALTH AND SAFETY LEGISLATION

4. The Health and Safety at Work etc Act 1974 (HSWA) aims to secure the health, safety and welfare of people at work and the protection of people other than those at work from risks arising to their health and safety out of work activities. HSWA applies throughout England, Scotland and Wales. While responsibility for education is devolved, enforcement of HSWA is a reserved matter. Enforcement bodies drawing on HSWA may work across borders, as do many schools and organisations that run school field trips.

5. HSWA places duties on those who are best placed to control risks. It is simply constructed, with duties on:

- employers in respect of the health, safety and welfare of their employees (HSWA s2) and in respect of the health and safety of other persons who are not their employees but who could be affected by the work activity eg pupils (HSWA s3);
- on the self-employed for their own health and safety and the health and safety of other persons who may be affected by the conduct of the self-employed person's undertaking (HSWA s3);
- on persons in control of premises (HSWA s4);
- on manufacturers, suppliers etc of articles and substances for use at work (HSWA s6); and
- on employees in respect of their own health and safety and the health and safety of others their conduct at work could affect (HSWA s7).

6. The most relevant element of HSWA to the health and safety of pupils is Section 3. This places general duties on employers and self-employed to persons other than their employees. Section 3(1) states *"it shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety"*. The primary responsibility for pupil safety under this section sits with the employer of the staff in the school (see para 15).

7. HSWA also recognises that a failure to control risks may be due to the actions or omissions of another individual. For example, individual employees have duties under HSWA s7 to take reasonable care while at work for their health and safety, the health and safety of others who could be affected by their acts or omissions and, as regards any duty or requirement imposed on their employer or any other person, to co-operate with their employer/the other person so far as is necessary to enable the duty or requirement to be performed or complied with.

8. HSWA is supplemented by specific regulations designed to target risks in a sector eg construction, or across several sectors eg radiation.

9. Additionally, the Management of Health and Safety at Work Regulations 1999 make the general requirements of HSWA more explicit. For example, the Regulations require employers to make a suitable and sufficient assessment of the risks to the health and safety of their employees and other persons affected by the conduct of the undertaking (this includes pupils in schools). Having done a risk assessment the employer should identify the steps needed to comply with health and safety law.

10. The Control of Substances Hazardous to Health Regulations 2002 deal with the use of substances hazardous to health, which could include substances used in a science laboratory. For example, these Regulations require employers to ensure that the exposure of their employees to substances hazardous to health is either prevented or, where this is not reasonably practicable, adequately controlled (regulation 7). Employers are, so far as is reasonably practicable, under a like duty in respect of any other person, whether at work or not, who may be affected by the work carried out by the employer (regulation 3(1)).

11. The legislation is generally goal setting—leaving the employer to determine how best to manage the risks that are created. In schools, guidance setting out good practice is provided by HSE, Local Authorities and other sector organisations. This advice on compliance provides an important steer on sensible solutions. The aim is that the organisation will determine proportionate and sensible ways to control the risks that deal with its own needs and circumstances. In this way the legislation does not stifle innovation or impose burdensome controls. It leaves the organisation choices about how to manage their own risks.

Health and Safety Legislation in Schools—Responsibilities

12. Health and safety legislation applies to all sectors and phases of the education system, whether schools are state controlled or part of the independent sector. It is relevant to all the school activities and impacts on staff, pupils and visitors.

13. The employer of the staff at the school has the primary responsibility in ensuring the health and safety of employees and pupils who may be affected by the school activities. The employer varies with the type of school—and can be a Local Authority, a Board of Governors or a Proprietor. While this overall responsibility lies with the employer, head teachers and the school management team have considerable influence in the day-to-day running of schools. The local managers take on an important leadership role for management of all the issues within the school including the management of risks. Taken together these arrangements set out a framework that teachers work within when teaching lessons and leading field trips.

14. In the vast majority of case the headteacher in an individual school is not the employer of the staff, but as the senior local manager will have wide-ranging responsibilities. A school leader's responsibilities for health and safety in the broadest sense of the phrase exceed those requirements set out in HSWA. For example in England the National Standards for Head teachers, the OFSTED inspection framework, and requirements for safeguarding and protection of children all include minimum standards for a range of health and safety or risk management issues.

15. Under Civil Law schools and their leaders also owe a duty of care to their pupils. The law of negligence is based on a significant body of case law that has developed over many years. Schools are expected to take all reasonable care—and in effect act in a way that a reasonable parent would act. Civil Law is often cited as one the primary barriers to a range of opportunities for children as teachers and schools fear civil action. HSE does not investigate civil claims.

16. Most schools have good health and safety management arrangements in place which complement the wider actions in schools to promote the well-being of pupils and staff. The approach to managing risks in schools are well established and reflect sound management practices common across many other public and private sector organisations. HSE expects schools to have:

- clear objectives, policies and procedures integrated into the school's wider management systems;
- clearly understood responsibilities—for Local Authorities, head teachers, teachers, Governors and other staff;
- access to competent advice to ensure the focus is on real risks, and to avoid applying bureaucratic approaches to risk management; and
- arrangements for involving the workforce in health and safety.

What Impact does Health and Safety Legislation have on Field Trips?

17. Good health and safety arrangements will help schools to provide children with a range of valuable learning experiences. It is important that schools aim to manage risk responsibly and sensibly—not trying to eliminate it altogether. Sensible health and safety means that children are exposed to well managed risks, which helps them learn important life skills, including how to manage risks for themselves. Sometimes things may go wrong—particularly where children are involved in more complex S&T experiments or field trips as part of more advanced courses eg in the sixth form. HSE has only ever expected schools and teachers to adopt sensible, obvious and widely understood precautions, such as wearing protective eyewear when conducting chemical experiments.

18. Teachers need to make judgements about how their science lessons are delivered—including making choices between pupils taking part in practical experiments or whether demonstrations by the teacher are more appropriate. These professional judgements do not need to be made in isolation by individual teachers—they can form part of the school or department's policy. However, such approaches do need to adapt to circumstances. A group of pupils with a history of discipline issues may not be the ideal candidates for higher risk experiments where discipline is important. Alternatively, demonstrating low risk experiments to the same group may not be appropriate when a hands-on experiment would better engage their interest. Such judgements are taken on a day-by-day basis by teachers on many issues and this sensible decision-making should also be applied to risk management. For example, HSE is more concerned with situations where judgments are not applied or applied recklessly—not when a decision simply proved to be a mistake.

19. Within some Local Authorities and/or schools there is a tendency for managers, school leaders or teachers to implement bureaucratic procedures. The employer may impose some of these systems on schools. In other cases, schools may slavishly follow a model risk assessment, giving no thought to whether that assessment applies to the local circumstances. Sometimes this leads to risks not being managed—but in many cases these approaches will lead to schools going beyond what is sensible to manage relatively low risk situations.

20. A small number of schools and teachers do not treat health and safety in a proportionate manner. Essential health and safety controls may be disregarded or dismissed as bureaucracy—a typical symptom of this in science laboratories is the retention of out-of-date or banned substances or poor storage of flammables. Accidents during science in schools are rare, but typically occur when there is no consideration of the real risk and a diversion from long established safe practice followed by most other schools. These are issues that can be managed by strong school and departmental leadership that encourages and supports innovation and tackles bad practice in equal measure.

What Impact does Health and Safety Legislation have on field trips?

21. Organising and running any school trip can put a lot of pressure on teachers. Sometimes there are genuine concerns about requirements and responsibilities—but most trips simply involve everyday risks. There are some unfortunate myths about individual teachers being held liable and personally sued. HSE can only comment on perceptions about criminal prosecutions as HSE does not investigate or take action on claims about civil liability. In the very small number of cases where teachers have been individually prosecuted, it has happened because they have ignored direct instructions and departed from common sense—by taking actions that a rational person would not take. HSE wants to encourage those organising trips to simplify the planning and authorisation arrangements for trips that involve everyday risks—and focus their attention on how best to manage the risks on those few school trips that have significant challenges, but which also provide pupils with the extremely valuable learning and developmental benefit.

22. Many thousands of activities take place every year in schools and other youth organisations. Young people take part in foreign exchange visits, adventure activities, work placements and a wide range of curriculum based field activities. Most of these events take place without incident, the learning is immense and the young people are left with memories of an enjoyable experience, which means that both the enjoyment and the learning will stay with them for a long time. The problem we face is that isolated incidents get a huge amount of media coverage. The reality is that they are rare events. There is little or no coverage of the many events which take place without incident and the enormous benefit which young people derive from them.

Guidance on School Science and Field Trips

23. HSE has worked closely with S&T stakeholders for many years. These important sector organisations have provided guidance, risk assessments, case studies and advice to schools that aim to encourage sensible management of risks in school science. Two of the key organisations with an interest in school science are CLEAPSS (Consortium of Local Education Authorities for the Provision of Science Services) and the Scottish Schools Equipment Research Centre (SSERC).

24. CLEAPSS provides support for member Local Authorities in England and Wales. CLEAPSS works in the field of school and college science, from foundation stage through to A Level or equivalent. CLEAPSS provides general support for practical work with information, advice and training about laboratory design and practice, technicians and their jobs, equipment, materials, living organisms and especially health and safety. This guidance is well recognised by practitioners in schools. Some support for technology, art and design is

also provided. Guidance includes model risk assessments, a laboratory handbook, specific publications, guides and leaflets. In addition courses and workshops are run for teachers and technicians

25. One example where HSE worked with CLEAPSS was in the development of practical guidance for the use of ionising radiation in schools. Practical experiments greatly enhance the process of teaching the properties of radiation in schools and are important in aiding students' understanding of the subject. HSE had input into the development of a good practice guide published by CLEAPSS in 2008 that aimed to support practical work whilst enabling schools to apply sensible and proportionate precautions.

26. A sister organisation SSERC performs a similar function in Scotland. SSERC is a registered educational charity which covers science, technology and safety in schools in Scotland. It is funded by its member organisations (including the 32 Scottish Local Authorities) and is part funded by the Scottish Government. It provides a service for Local Authorities, teachers, student teachers and technicians in Scotland and has a recognised lead role in science education, providing Continuing Professional Development (CPD) for managers, teachers and technicians. SSERC promotes and supports safe and exciting learning and teaching in science and technology.

27. The Association for Science Education (ASE) is a UK wide charity promoting high quality science education. The ASE is the largest subject association in the UK. Members include teachers, technicians and others involved in science education. ASE plays a significant role in promoting excellence in teaching and learning of science in schools and colleges. Working closely with the science professional bodies, industry and business, the ASE provides a UK-wide network bringing together individuals and organisations to share ideas and tackle challenges in science teaching, develop resources and foster high quality Continuing Professional Development.

28. The Education Departments across Great Britain produce guidance for Local Authorities and schools on a range of health and safety issues:

- In England, the guidance produced to assist the planning of school trips is under review. This means that guidance for schools will be made leaner so as to enable a clearer distinction between what the law requires and what is simply good practice.
- In Wales, the Welsh Government hosts the "Education Visits Guidance" which was devised and periodically reviewed by Local Authority Outdoor Education Advisors. Whilst minimising needless bureaucracy was always a governing principle of the Educational Visits guidance, in conjunction with offering the risk-benefit approach to learning, a review by Outdoor Education Advisors is currently being undertaken.
- In Scotland, guidance is contained in the Scottish Government's "Health and Safety in Educational Excursions—A Good Practice Guide" published in 2004. A recent review of this guidance concluded that it was still fit for purpose. In addition, the Learning and Teaching Scotland website has web based resource material for teachers covering a variety of outdoor learning scenarios including field trips.

What do the statistics tell us about health and safety in schools?

29. Slips, trips and falls remain the most common cause of major injuries in every workplace. They account for around 40% of all injuries reported in schools. A total of 50 058 injuries[75] in primary and secondary schools were reported to HSE for the five year period 2005–06 to 2009–10. Approximately 30% of these involved employees; the remaining 70% involved non employees, which includes pupils.

30. Risk from practical science lessons and field trips can be put into context through analysis of accident reporting statistics—particularly taking into account the millions of children[76] taught science each year. In the five-year period 2005–06 to 2009–10 in the primary and secondary education sectors 478 injuries to employees and members of the public (ie pupils) were reported as occurring during science lessons. A full breakdown of the statistics and explanatory notes are provided at Appendix 1.

31. Over the same five year period HSE has taken 29 prosecutions in the education sector—18 in the primary, secondary and vocational sectors. Of these, 16 have concluded with a conviction. One of the remaining two cases is unfinished, the other under appeal.

32. None of these 18 prosecutions related to school science. Two related to school trips, but these were not field trips, and three related to classroom activities, but these were not science rooms or science lessons. Nevertheless, despite the small number of prosecutions that are unrelated to science there may be a ripple effect that influences the perceptions amongst schools and science teachers.

[75] RIDDOR data needs to be interpreted with care because it is known that non-fatal injuries are substantially under-reported. Currently, it is estimated that just over half of all such injuries to employees are actually reported.

[76] DfE 2010 School Census—In January 2010 there were around 8.1 million pupils (headcount) in all schools in England

Tackling the Perceptions of Bureaucracy

33. HSE has promoted a very clear policy on sensible risk management. Since 2006, HSE has sought to make clear the importance of organisations recognising the balance between benefits and risk and focusing on real risks rather than trivia. In 2007 HSE established the Sign up to Sensible Risk Campaign to combat the growing number of myths that are undermining important health and safety legislation. Local Authorities were invited to publicly sign up to the campaign to encourage them to be sensible and proportionate in their decision-making, their advice giving and their own enforcement. This aimed to have an impact on guidance Local Authorities gave to schools within their control.

34. HSE believes that risk management should be about practical steps to protect people from real harm. The aim is to achieve a balance between the unachievable aim of absolute safety and the kind of poor management or risk that damages lives and the economy. HSE has produced model risk assessments to ensure that organisations understand what sensible assessment involves.

35. Between 2007 and 2010 HSE used a series of cartoons called Myth of the Month to challenge the urban myths so prevalent in the media and wider society relating to health and safety. These misleading stories and myths can distract people from the serious business of managing real health and safety risks. The cartoons highlighted ridiculous "elf and safety" stories that have featured in media reports, and gave details of the real purposes of health and safety management. These cartoons tackled a wide range of issues from the misuse of risk assessment to the banning of events or use of everyday equipment like stepladders.

36. Monthly cartoons were targeted at the many myths across education including:

- Egg boxes banned from craft lessons as they might cause salmonella—August 2007.
- If a pupil is hurt the teacher is likely to be sued—February 2008.
- Health and safety rules stop classroom experiments—November 2009.

37. In 2009 HSE launched its new strategy—"*The Health and Safety of Great Britain—Be part of the solution"*. While the overriding mission of the Strategy was to prevent death, injury and ill health to those at work and those affected by work activities, it recognised particular issues that needed to be addressed:

- The increased risk aversion in society as a whole; and
- Health and safety increasingly being used as a convenient excuse for not doing a whole host of activities.

38. The strategy includes a set of common goals including leadership, competence and management of major hazards. Also included is the goal to focus on the core aims of health and safety and by doing so help distinguish between real health and safety and trivial or ill-informed criticism.

Demonstrating Leadership on Sensible Health and Safety

39. HSE's efforts to tackle over zealous approaches to health and safety, particularly in education, have been led by HSE's Chair, Judith Hackitt. The Chair has attended conferences, challenged stories in the media to put the record straight, supported key organisations and individuals in their promotion of school science, and proactively sought to encourage schools bringing science to life through practical experiments and field study. HSE believes all these actions are important to help encourage schools to inspire and motivate the next generation of scientists and engineers, and widen children's understanding of risk.

40. For example, in January 2009 the HSE Chair worked with the Chief Executive of the Institution of Chemical Engineers to encourage teachers to re-introduce exciting and engaging practical classroom demonstrations. This was designed to promote the IChemE's "Top 10 Flash Bang Demos". These demonstrations encourage teachers to add greater practical focus to their lessons. The chair took part in a visually exciting science experiment to enhance the message.

Current Priorities for HSE—Common Sense Common Safety

41. In 2010 the Government published *Common Sense Common Safety*—a report of a review of the operation of health and safety laws commissioned by the Prime Minister. It makes recommendations for reducing unnecessary bureaucracy and for the proportionate application of health and safety law and identifies proposals for tackling the compensation culture. HSE is working with stakeholders to respond to the recommendations in the report in a number of key areas—including education.

42. One specific recommendation is to simplify the guidance and procedure for risk assessment in classrooms. HSE has been working with stakeholders to produce tools to help teachers understand the risks within their classrooms—helping reduce the burden on teachers by enabling them to focus on the real risks and not divert them from their important teaching role. A risk assessment tool was trialled between November 2010 and February 2011 and, following feedback from stakeholders, will be re-launched as a simple checklist for traditional classrooms.

43. *Common Sense Common Safety* also placed recommendations on other organisations. HSE has established an Education Working Group to oversee the development of responses to the education related

recommendations in *Common Sense Common Safety*. The Working Group includes input from the Education Departments across Great Britain and other stakeholders.

44. The responses to the education recommendations in *Common Sense Common Safety* across the three nations are likely to be progressed in slightly different ways. For example, in England the Department for Education (DfE) is developing a Single Consent Form to simplify the process for taking children on educational visits. DfE will support this with guidance for schools that aims to reduce the perceived bureaucracy associated with organising school trips.

45. In Scotland, the *Common Sense Common Safety* recommendations are in line with much of the work that is already in hand to reduce barriers to young people accessing learning opportunities that are beneficial to them. An Outdoor Learning Safety Management working group has been appointed to report to Scottish Ministers in spring 2011. This group is addressing many of the issues covered in the report. The proposal is for a single skeletal policy on outdoor learning safety that would be used nationally by Scottish Local Authorities. The aim is to have a simplified approach to outdoor learning which will reduce bureaucracy and variation between Local Authorities. As part of this approach, the use of consent forms will be considered.

46. Similarly, in Wales, barriers to enhance and develop learning through realistic health and safety, has been the mainstay principle of the Welsh Assembly Government in its interaction and communication with Schools. The recommendations in *Common Sense Common Safety* were accepted by the Minister for Education and Skills, recognising the simplification of systems, and the removal of needless bureaucracy. Work is currently ongoing in Wales, including participation in the HSE led educational working group to ensure a common theme is maintained.

47. While it is not a recommendation in *Common Sense Common Safety*, HSE has offered to clarify how health and safety law applies to school trips in a High Level Statement to provide schools, Local Authorities and teachers with clear messages about sensible risk management on school trips. This will apply equally to science field trips. HSE wishes to encourage all schools and Local Authorities to remove wasteful bureaucracy imposed on those involved in visits and activities—so that the focus is on the real risks[77] and not on paperwork. The high level statement will make clear that HSE's primary interest is real risks arising from serious breaches of the law and that any HSE investigations are targeted at these issues. The statement will outline the considerations HSE takes into account in reaching decisions about prosecution following an accident, and make clear that such action is very rare. The Statement will provide a further opportunity to actively promote the existing policy lines relevant to school science field trips.

APPENDIX 1

Reported injuries to employees and members of the public (1) in primary and secondary education (2) occurring during science lessons (3) 2005–06—2009/10p (4)

	2005–06	*2006–07*	*2007–08*	*2008–09*	*2009–10*
Major injury—employee	4	3	4	1	1
Over-3-day injury—employee	0	3	11	6	10
Non-fatal injury—member of public	58	62	66	99	150
Total—reported injuries	62	68	81	106	161

NOTES

(1) Injuries are reported and defined under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR).

(2) Standard Industrial Classification of Economic Activities (SIC) codes 80100 "Primary education", 80210 "General secondary education" and 80220 "Technical and vocational secondary education". The SIC system is used in UK official statistics for classifying businesses by the type of activity they are engaged in. The latest version is SIC2003.

(3) A search was conducted of the "ICC notifier comments" field in order to capture details of such incidents. The following terms were used: "science", "physics", "chemistry", "biology", "geography", "laboratory". Any interrogation of the comments provided by notifiers is by its nature an error-prone process. This is because RIDDOR notifiers have freedom to express the details they supply in the way that they feel is most appropriate. As a consequence of the flexibility allowed during notification, it is very difficult to group together specific incidents from the individual reports that are submitted, hence there is no easy way of ensuring that all records are accounted for.

(4) The annual basis is the planning year from 1 April to 31 March. Statistics for 2009–10 are provisional, denoted by "p".

[77] The Courts have made clear that when health and safety law refers to risks, it is not contemplating risks that are trivial or fanciful. It is not its purpose to impose burdens on employers that are wholly unreasonable (R v Chargot (2009) 2 All ER 660 [27])

General Caveats on RIDDOR Data

RIDDOR data need to be interpreted with care because it is known that non-fatal injuries are substantially under-reported. Currently, it is estimated that just over half of all such injuries to employees are actually reported.

Health and Safety Executive

6 June 2011

Written evidence submitted by Ofsted (Sch Sci 44)

I am pleased to forward a short written submission from colleagues at Ofsted in response to the call for evidence and questions issued as part of the above inquiry.

I also enclose[78] a copy of our recent survey report on science education in England from 2007 to 2010, which was published at the start of this year. This report, *Successful science*, is one of Ofsted's triennial surveys on the national curriculum subjects.

Paul Harrison
Parliamentary Affairs Manager
Ofsted

27 May 2011

Ofsted response to the House of Commons Science & Technology Committee's call for evidence on practical experiments in school science lessons and science field trips

Ofsted's most recent evidence on science education is summarised in the report *Successful science: an evaluation of science education in England 2007–10*, published in January 2011.

1. *How important are practical experiments and field trips in science education?*

The importance of practical work is summarised in the first key finding of the *Successful science* report:

> *In the schools which showed clear improvement in science subjects, key factors in promoting students' engagement, learning and progress were more practical science lessons and the development of the skills of scientific enquiry.*

This importance is emphasised in the report's recommendations that:

> *Primary schools should ensure that pupils are engaged in scientific enquiry, including practical work, and are developing enquiry skills.*
>
> and
>
> *Secondary schools (and colleges) should ensure that they use practical work and scientific enquiry as the key stimulus to develop scientific knowledge, understanding and skills.*

However, practical work needs to be well planned, with clear learning objectives if students are to benefit from it. In paragraphs 20–22 of the report, Her Majesty's Inspectors (HMI) analyse what makes effective practical work. In the schools visited where students' progress in science was no more than satisfactory, the opportunities for them to design and carry out experiments were limited; too much of the practical work was prescriptive, with students merely following instructions. In the schools where the highest standards were observed, students were involved in planning and carrying out regular science investigations, so that they understood the processes involved.

Two contrasting examples of practical work in science are provided in paragraph 35 of the report. The first illustrates how simply exposing students to practical work does not, in itself, promote learning. The second illustrates some of the best practice observed, where the teacher had very effectively prepared students to generate their own questions, form hypotheses and plan and carry out their own practical work. This example also demonstrates how ICT can be used to enhance the analysis of data generated by experimental work.

One section of the *Successful science* report focuses specifically on features of outstanding teaching and learning, and the case studies in paragraphs 93 and 95 deal particularly with practical, experimental work. Another section of the report indicates how satisfactory lessons can be improved, to make them good; case studies relating specifically to practical work are provided in paragraphs 101, 103, 104, 105 and 107.

Many schools organise one-day science-related trips to science exploratories, museums and zoos etc. However, few organise field trips that might involve exploration of the natural environment; school grounds tend to be used for this area of learning. Few schools organise science-related field trips that involve overnight stays.

[78] This publication is available at: www.ofsted.gov.uk/publications/100034

Inspectors report that enrichment and extra-curricular activities generally had a positive impact on primary pupils' attitudes to science (paragraph 49). The range of extra-curricular activities seen in secondary schools was broader than that in primary schools, but activities did not usually engage large numbers of students (paragraph 56).

2. *Are practical experiments in science lessons and science field trips in decline?*

There is no evidence from inspectors' visits to schools that there is a decline in practical work carried out in science lessons. In referring to the key issues from the previous triennial science report (published in 2008), the *Successful science* report comments that scientific enquiry continues to be at the heart of the most successful science education. It also notes that practical work has had a high profile in the last few years, and that its importance has been widely recognised.

Ofsted has no evidence to indicate that there has been a decline in science field trips.

3. *What part do health and safety concerns play in preventing pupils from performing practical experiments in science lessons and going on field trips?*

The evidence from specialist science visits is that schools give good consideration to health and safety issues. Guidance for schools generally places sensible restrictions on what they can and cannot do in science.

There may be individual schools where health and safety considerations have affected practical science work and field trips. However, there is no evidence from the visits to schools carried out by HMI that this is a widespread or serious problem.

4. *Do examination boards adequately recognise practical experiments and trips?*

This question could be interpreted in a number of ways. In paragraph 20 of the *Successful science* report, inspectors note that schools in which practical work was too prescriptive were often influenced too much by the specific ways in which practical work and scientific enquiry skills were assessed for GCSE and, as a result, were less concerned with providing opportunities for wider-ranging investigations.

Ofsted

27 May 2011

Supplementary evidence from Greg Jones (Sch Sci 47)

1. Risk assessments are an essential part of science experiments but they should not be "set in stone" but amended in the light of changing circumstances. They are analogous with security at Portcullis House, Westminster, which has changed significantly over the years in response to the threats to our society from terrorism. In the light of new knowledge, new procedures have been put in place to minimise the risks to all and, as with risk assessments, are reviewed regularly.

2. There are too many examples of risk assessments for certain experiments available. What would improve the situation is that a generic one should be drawn up for each experiment, sent to every exam board to be incorporated with their appropriate syllabus and then adapted by each institution for their particular laboratory circumstances.

3. These generic risk assessments could be drawn up by practicing scientists within such bodies as the Association for Science Education, the Institute of Physics, the Royal Institute of Chemistry, the Institute of Biology and the Institute of Education. These risk assessments should then be sent to the exam boards for them to incorporate with their science syllabi before being sent to schools and colleges for their adaptation.

4. The effect of having such generic risk assessments, for all the experiments that will be covered by exam syllabi, would be to stop science teachers "re-inventing the wheel" and to have a base level of compliance for assessing experimental risks.

5. The use of Information Technology (IT) equipment within science lessons is as a tool which supports the teaching and learning. They can be used for a variety of activities; from dataloggers and visual measuring devices to interactive whiteboards and experiment simulators.

6. Using IT within science can also encourage the development of important research skills, which are an essential part of scientific investigations at both GCSE and A Level, but it should never replace or detract from the carrying out of actual practical scientific experiments.

7. The amount of money that school/college Science Departments have to spend on IT or are allocated as part of the overall IT budget within the institution is extremely variable. Consequently, the amount of IT used within science lessons is also variable.

8. In spite of this, the minimum requirements of IT and its use within science lessons is laid down by exam board syllabi but I feel that amount of IT needs to be increased still further if schools/colleges are to prepare students adequately for studying a University science course.

9. During school/college refurbishment programmes, often the question that is asked is "what kind of science lab provision is needed in the future?" Too often the answer from Head teachers is that "Science can be carried out in a normal classroom." New school buildings, especially under PFI/new build academies, have tended to cut corners on science lab specs to keep costs down.

10. This kind of attitude further erodes the possibilities of carrying out practical scientific experiments/ investigations by students in an appropriate setting and leads to more theory work, and consequently less practical work, in science lessons.

11. Science teachers are good role models for students as they illustrate the skills that are needed in a particular workplace. Practical skill is just one of the main tools that teachers have in their "toolbag" but the size and complexity of that skill has diminished over time due to the constraints of exam syllabi and the perceived need to "teach to the exam".

12. The consequence now is that students who become teaches are less confident in doing practical work in science lessons, so less practical work is done. This downward spiral can only be reversed by increasing the amount of practical work that needs to be done and as a result teacher confidence in doing practicals/ experiments will increase accordingly. The change to Initial Teacher Education (ITE) requirements in 2007 meant an increase in the amount of time spent on teaching practice, with a consequent reduction in the time spent with the ITE provider. This has certainly lessened opportunities for trainee teachers to practice their skills. If not much practical work is going on at their placement schools, trainees may have hardly any chance to become confident in taking practical classes themselves.

13. Fun for both teachers and students needs to be put back into science, particularly at Key Stages 4 and 5. Teachers and students can have fun together by doing more experiments, improving their practical/ experimental skills and increasing their ability to learn more science through practical investigations.

14. Time is needed to develop any skills and practical ones need as much, if not more, as most others. But that time can only come from "freeing up" the science curriculum, by reviewing and reducing the content of all science exam syllabi and by making them more modern, interesting and practically based.

15. Field trips are beneficial to both students and teachers alike as they improve working relationships, encourage teamwork, promote problem solving, consolidate teaching and learning as well as create fun and interest.

16. For students, field trips often result in a better attitude to work, to the subject and to the teachers involved as well as an increased maturity for some individual students—all of which are beneficial for making them better scientists.

17. All teacher training courses, whether carried out through Universities or through schools/colleges, need to be revised to free up time for student teachers/Newly Qualified Teachers to practice their experimental skills on a weekly, if not daily, basis.

18. Education is always changing and science curricula are no different. It would be better to change and then have no more change for a number of years in order that the result of that change can be consolidated and built upon. Teachers are not averse to change but "change for change's sake" and "changes every year" do not engender teachers to change.

Greg Jones

28 June 2011