Call for views: individuals' responses

The responses in this document are reproduced verbatim. Please note that not all respondents answered every section of the Call for Views, or all questions within each section. The original complete survey is provided in the Appendix.

Contents

Gary Anderson

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?

Primary school Specialist Teachers in Mathematics and Science. Attractively funded. I notice the MaST (postgraduate certificate in primary mathematics specialist course is in early stages and already increasingly expensive to be a participant on - this is restricting particpation) eg Kings College /Institute of Education/ University of Rohampton www.ioe.ac.uk/study/PGC9_MAT9IM.html

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Talking. PUPILS TALKING about mathematics is, I suggest, an under estimated and underused tool in the primary classroom. But when used will be seen to significantly impact on learning. Will Professor Dolan be providing neuroimaging evidence that a pupil talking (thinking aloud) about a mental mathematics task in using more of the brain than perhaps any other activity? Along side evidence that use increases capacity this seems to offer an essential element to any list of skills that are important to progress. I suspect however that OFSTED would support my limited observations that "speaking and listening" learning objectives are rarely stated for mathematics teaching.

2. b) How may the acquisition of such skills best be assessed?
teachers - trained to know what to look and listen for - are best placed on a day to day basis

Bert Barber

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Accommodation for teaching Practical Work (see later)

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
More practical based teaching. Use of simple apparatus and generation of interesting practical 'ideas' to motivate learning.

8. Other comments:
I provide CPD to Primary teachers. There is an appalling lack of Simple Practical Science CPD. It's all to do with assessment and learning tick lists! I have yet to come across 1 state school in KS1/2 that has bought basic proper apparatus (erg a retort stand).,

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
In a room set up for practical work for both Science and to a lesser degree for Maths. Practical Maths also motivates the children.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
A 'Practical' classroom should be available for all Primary Schools to access. While we are teaching Science in classrooms we are not allowing children to develop their practical "doing" skills at an age when they would most benefit from it.

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
See 'c' above

8. Other comments:
1 lesson per week of Science in a Primary Classroom setting with no equipment and little 'Practical' training is setting up a very poor foundation for Science learning later in schooling. Get the children's interest, and make them think.

T Bonella

1. a) What is good about UK science and mathematics education?
Its breadth.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
We should recognise that everyone needs 'science for the citizen' and 'maths for everday life' courses, and some need 'science/maths for science/maths/engineering' courses. The second can not be adequately provided by tacking a few extras onto the first.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
At Westminster, the willingness to muck about with education as part of political posturing and point-scoring. Within schools, the inability/unwillingness of governing bodies to monitor the effectiveness of headteachers. NPQH notwithstanding, there are heads who lack the management and leadership skills necessary to do the job properly.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
By accepting that different trades/professions need significantly different skills and knowledge, and training/teaching accordingly.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
I can't, because lack the detailed knowledge of systems and outcomes as, I suspect, do most of those who hold forth on this topic. For example, I am told by an acquaintance, educated to Bac in France and thereafter in England, that maths teaching in France is much more rigorous (proofs etc) but much less broad. Is this a 'high-quality' system?

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
I don't know. Do we need to learn from others? Should we not do a thoughtful, 'peer-reviewed' analysis of our requirements and the methods available to achieve them.

8. Other comments:
Once, I would have said that education should be in the hands of an agency, ultimately accountable to Parliament but not subject to daily interference. When I look at Ofqual, which has overseen the dilution of GCSE and A-level specs, or at Ofsted, which, in my own experience, has not only failed to identify but sometimes openly ignored weaknesses in schools, I don't now think that such a body is the answer.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
This is a foolish aspiration. The size of the teaching profession (if it can be called that, given the childish antics of the major unions) is such that it cannot aspire to pay comparable to that available in the financial sector (or that available to vice-chancellors). Nor, for those with a passion for science, can the constraints of teaching in most secondary schools compare with the satisfaction of research. We can just about recruit sufficient teachers, but 'top career choice'? no.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
For primary, A-level science/maths. For secondary, first degree in a 'numerate' subject.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes, if it proves effective. The value of labour should rise until supply and demand are matched. To retain as well as recruit, the incentives should be in the form of higher pay, rather than bribes at the point of entry. The unions will squeal: ignore them.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
I think that the moves towards more time in the classroom (Teach First, GTP) are positive. Few teachers to whom I have spoken have fond memories of, or much respect for, the theory of pedagogy that they had to sit through. On the other hand, I have met physics graduates who say that they would have wanted more time spent on practical work appropriate to teaching secondary-level physics. As for the non-physicists who find themselves teaching the physics components of science courses ....

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
See c) above.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Another pointless aspiration. Primarily because we can't agree on how to measure quality. Personally, I'd be interviewing teachers five or ten years after they qualified, and their ex-pupils after similar intervals, so no secretary of state would give my philosophy a second glance. Furthermore, as long as programmes are run by human beings, they will vary, as any scientist would surely acknowledge.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
A variety, as now.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Schools, with the necessary theoretical input provided by tertiary institutions. Because one can nod off in a university lecture theatre, or become suicidal at the thought of drafting another piece of drivel on 'reflective practice'.

8. h) How much of this training should be spent gaining experience in the classroom?
90+%

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
One academic year for trg and another on probation, as now.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
The subject moves on, and teachers should be able to reflect this in their teaching.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
By having the time, funds and motivation to attend short courses.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Throughout their careers. Day courses once per term, weekend/week-long once per year.

4. d) Should CPD be voluntary or mandatory? Why?
Voluntary, with an expectation that everyone will do it. Mandatory trg would go the way of INSET in many schools: irrelevant waffle from some hack who makes a living from it.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Time. 'Rarely cover' has become 'rarely allowed out'. Its cultural; some teachers happily attend courses after school, at weekends and during holidays. Others refuse to do this. As an attendee, and now also a provider, of CPD, I see the same faces repeatedly.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
I don't understand the question.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
No. This is on a par with the modularisation (sorry; there ought to be a better word) and 'as many resits as you like' ethos which has devalued secondary education. A Masters degree is something to be worked for separately, even if attending short courses assists the process.

1. a) How and where should we be training laboratory technicians?
On formal courses, in universities (or polytechnics, if we still had 'em)

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Updates in the relevant sciences, and the technologies available to support school practical work.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Certainly in supporting the teaching of less-able students. Though this supposes that heads are prepared to set pupils on science course by attainment, which some are not. Again, train in schools with academic support from tertiary institutions.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Teachers can contribute but, unless they are given both initial and continuation trg in that field, they cannot be expected to have the necessary breadth of knowledge. Careers 'roadshows' would be helpful.

1. a) What impact do teachers’ leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
It helps to have a head of dept who will put the case for science teaching, especially when the SMT consists largely or wholly of non-scientists. Anecdotal vidence is available, but will only become useful data if someone funds a large survey of teachers' experiences

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
An understanding of what motivates their teachers, a realisation that few decisions are not improved by prior consultation, a willingness to accept a variety of approaches (ie, a healthy suspicion of 'best practice')

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
Campaign for the provision of 'staff colleges' for teachers, that could offer courses at different levels.

4. d) How can leadership pathways for experienced teachers be introduced into careers?
They exist.

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
The head. The attitude of parents to the school.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
In my experience, quite inadequate. They seem to lack the data and the professional knowledge have a significant influence. The convention that they stay out of classrooms, and only talk to teachers (who hardly recognise them) at awkward social occasions, is a real hindrance.

9. Other comments:
This is the point at which I lost the will to live. I suggest that the length of this survey, and the fact that it is not possible to save a partially-completed form, will deprive the RS of a good deal of data.

Alison Braddock and Stephen Williamson

This response only addresses **Part 3 'Continuing Professional Development (CPD) for teachers'**. It includes evidence based on the feedback and results arising from the activities conducted under the Welsh Government Project described below.

Background
Stephen Williamson and Alison Braddock of the Wales Institute of Mathematical and Computational Sciences (WIMCS) would like to make the following submission. It is their own views which do not necessarily reflect those of WIMCS.

WIMCS was appointed as a hub for the National Science Academy (NSA), a Welsh Government funded initiative in Wales in April 2010. WIMCS was then invited by the NSA to propose projects which would increase interest in the study of science and mathematics. Through its work with other partners such as the Institute of Physics (IoP), University Schools of Education, and the Engineering Education Scheme Wales, and its direct meetings with secondary maths teachers and LEA advisers, it had become clear that the provision of subject specific CPD in maths and science in Wales was fragmented and insufficient. In addition it was clear from the General Teaching Council Wales (GTCW) statistics that a significant number of teachers did not have a degree in the subject they teach (see Appendix A). WIMCS therefore proposed to the NSA a pilot project centred on maths, physics and chemistry which used the IoP's existing teacher twilight network model. The pilot project 'Support for the provision of subject specific Continuing Professional Development for those teaching Maths, Physics and Chemistry at secondary level in Wales' began in February 2011 and has operated in the areas around the Universities of Cardiff, Glamorgan and Swansea. WIMCS was the overall project manager and managed the Maths element, and the Physics and Chemistry elements were managed by the Institute of Physics and the Royal Society of Chemistry respectively.

The project consisted of three key elements:
1. Twilight sessions for secondary teachers. The twilight sessions were 2 hour workshop sessions.
2. A 1½ day conference attended by 42 teachers and 10 educationalists (Including LEA advisers) entitled 'Inspiring Young People in Maths, Physics and Chemistry'.
3. A survey regarding secondary teachers in Wales sent to all 223 state maintained secondary schools and colleges in Wales with an approx 10% response rate.
    a) a questionnaire to headteachers that included questions on CPD activities.
    b) a questionnaire for each teacher of maths and science sent to a sample of 50 schools that
    included questions on CPD activities.

This response is based on the findings from the project. WIMCS subject to WG approval would be pleased to circulate in confidence the full survey results and report, and its report on the 'Inspiring Young People ...' conference.

Responses to Part 3 (Continuing Professional Development (CPD) for teachers)
a) What are the benefits of subject-specific CPD for science and mathematics teachers?

Evidence for Quality of Teaching being key to pupil achievement
All the evidence is that the quality of teaching is the most significant factor affecting the achievements of pupils.
International research in education indicates that the quality of teaching is the most important factor influencing individual pupil achievement and system performance (Barber & Mourshed, 2007; Dinham, Ingvarson & Kleinhenz, 2008; Slater, Davies & Burgess, 2009).
The importance of teachers regularly refreshing their own practice through professional development activities and interaction with educational research has long been recognised.

Elmore (2004, 96) 'Professional development, in the consensus view, should be designed to develop the capacity of teachers to work collectively on problems of practice within their own schools and with practitioners in other settings, as much as to support the knowledge and skill development of individual educators. ... educators learn more powerfully in concert with others who are struggling with the same problems...'

The Vordeman report (2011) feels: 'Professional development should be a career-long commitment involving not just external courses but also working with colleagues, ... Ensuring the availability and quality of a suitable range of CPD programmes and opportunities open to all markets is essential'.

The authors of the report also feel that to ensure 'maths teachers undertake regular and appropriate professional development, together with an entitlement for them to have access to it; ring-fenced funding would be needed.'

The Barber & Mourshed report for McKinsey and Company in 2007, suggests that successful education systems improve teacher quality through:

- recruiting high quality graduates into teaching and providing them with excellent initial training
- high quality professional development that promotes rigorous standards of teacher pedagogy

Barber, M. & Mourshed, M (2007) *How the World's Best Performing School Systems Came Out on Top*. New York: McKinsey and Co.

In addition, Dinham et al. indicate that teacher quality would benefit from the development of a clear career structure which focuses on classroom teaching, rather than through management responsibilities. Dinham et al, has outlined a 4-stage process:

- trainee teacher
- registered teacher
- accomplished teacher
- leading teacher

Dinham, S., Ingvarson, L. & Kleinhenz, E. (2008) *Investing in Teacher Quality: Doing What Matters Most.* Business Council of Australia.

In Scotland this has manifested itself as Chartered Teacher following the McCrone Report (2000) 'A Teaching Profession for the 21st century'.

In Wales, although 2007-10 saw the piloting and evaluating of a similar Chartered Teacher qualification and the establishment of Chartered Teacher Standards, its introduction has not been supported.

Benefits

We would list some of benefits as:

1. Giving teachers the confidence to deliver parts of the curriculum they are not so familiar with.
(Curricula change/ Advanced (Further) Mathematics).
2. Helping part qualified teachers teach areas they are not necessarily familiar with (non subject specialists).
3. Giving teachers alternative ways of teaching topics.
4. Helping teachers by guiding them to resources.
Eg For Maths: model answers, problems, external resources like student ambassadors, positive role models, roadshows, educational films, maths masterclasses, inspirational speakers.
5. Helping teachers by giving them new skills.
Eg Help to use IT programs like GEOGEBRA.
6. Giving time for teachers to think about subject pedagogy
Eg Do girls and boys learn differently?

Eg Comparisons of how their pupils have performed compared to national average on individual exam questions can point to what each does well or badly.
7. Understanding exam marking and assessment methodologies.
8. Opportunity for specialist teachers to network
Eg Schools and teachers have a lot to share.
9. Providing teachers with subject specific inspirational material for the class-room.

b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?

Although there is general agreement that subject specific CPD is a good thing, there is a lack of coordinated delivery or funding in Wales.

The providers can be divided into firstly the Exam Boards, secondly the LEA Science and Maths Advisors, thirdly 'independent' initiatives such as those from Professional Bodies. There is little evidence of a joined up approach. Our survey showed that over a third of CPD attended was given by Exam Boards and that it was often only the Heads of Departments who attended. Also in our survey the largest number of respondents favoured that subject specific CPD should be primarily delivered by the LEAs, but in Wales the number of Science and Maths Advisers is being cut back.

In our view, as in other professional areas such as the Law, teachers should have to maintain a Certificate of Professional Competence by attending a fixed number of CPD events every year (or perhaps every 3 years), and should be encouraged to develop as individuals by qualifying for eg Chartered Teacher Status.
Provision for attending suitable CPD should be properly funded through school or college budgets, although there should be an expectation that teachers would give up some of their own time.

CPD activities should be accredited either nationally or by the LEAs.

c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?

Throughout careers.

d) Should CPD be voluntary or mandatory? Why?

Mandatory.

Unless it is mandatory then when cash is tight, then teachers will be disincentivised to attend. This would be to the disadvantage of pupils and staff alike.

e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?

Little or no funding at the moment for supply cover for when teachers attend CPD events, and low motivation for teachers to attend CPD outside teaching hours.

CPD funding available needs to be explicit beyond Newly Qualified Teacher provision, and there needs to be a clear expectation of how much of their own time teachers should be giving up.

f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?

Not every teacher has the aspiration to do Masters Courses such as in Leadership and Management (Education) that are geared towards future Heads and Deputy Heads. Wales is also investing in a Masters Course in Educational Practice aimed at Newly Qualified Teachers. However it appears to us that if leadership and management is to be included as part of a future CPD strategy there should be a minimum level (percentage of time) of subject specific CPD in the Science and Maths elements.

g) Should CPD be accredited (eg through the awarding of Masters-level credits)?

Our personal view is that CPD must be accredited to ensure quality and motivation. However we believe that there should be a minimum level of CPD required to maintain their 'Certificate of Professional Competence'.

Other comments

Comments from survey of Welsh Secondary Schools conducted in Summer 2011

The questionnaire asked headteachers/principals to comment generally on ways forward:

1. **What could be done to improve the provision of CPD for Maths & Science teachers?**

   Funding and money were significant issues raised:

   '. . . more money for CPD'

   'The School Effectiveness Grant should have a clear Science strand. Lots of focus currently on literacy and numeracy, taking attention from Science. . . . a need for practice based courses, not generic ones. . . real science courses because staff feel it's hard to find that kind of course.'

   'Welsh medium courses'

'The main difficulty is funding and release time for Maths & Science teachers..'

The nature of the current provision was also addressed:

'The provision for Maths & Science teachers could be improved by providing more CPD directed methods of delivery of the subject content. Too often courses are provided by examination boards when a new specification is introduced, these often concentrate on the content and administration but do little to help teachers with the delivery.
A good model is the one set up by the partnership of the Royal Society of Chemistry, Cardiff University and the WG. This is providing excellent free CPD for Chemistry teachers aimed at improving the delivery of the subject content.'

'... move away from single session CPD events to two-session or a series, where teachers 'try out' new ideas in the classroom, then return to discuss and evaluate'

2. What do you see as the main difficulties in upskilling non-specialist teachers?

Responses referred to the lack of time available and cost.

One headteacher approached this question by saying that we need to '*ensure that Chemistry and Physics graduates are rewarded well financially to enter teaching'.*

Another headteacher suggested the Graduate Teaching Programme be made more accessible. He cited an example of one applicant with an engineering degree being turned down for a place on a GTP '*because engineering isn't mathematical enough'.*

3. What direction should policy makers take to improve the quality of Maths & Science education in the future?

Several respondents made points about the frequent changes to the curriculum. This head stated:
'Policy makers need to leave the curriculum alone... Let us have stability in what we are required to teach.... replacing exams every five years leaves everybody stressed: pupils, teachers and parents.'

'Make the syllabus more relevant to pupil needs...'

On a more resource-led note, one headteacher suggested that
... every Maths/Science teacher should have an interactive whiteboard, with a range of suitable software to support quality lessons, and the skills to use these resources...'

Comments from the CPD Conference 'Inspiring Young People in Maths Physics and Chemistry'

Some emailed comments:
Thank you so much! The two members of staff Claire and Lilian, who attended the course last week are over the moon in their praise of the event. They both came to see me yesterday to say how much they enjoyed the course and how much they got out of the workshops. So we are delighted and hope that this is not a one off and that you will be able to continue putting in this type of CPD.

On a more mundane note - do I need to fill in any forms to claim the supply costs? I'm not sure whether I might have already done so?

But thank you again - it is lovely having teachers praise courses and not have anything negative to say.

Regards,
Vanessa Bassett, Cefn Saeson Comprehensive – Neath Port Talbot

May we just take this opportunity to thank you for the time and effort you (and all your colleagues) put into the conference. Both Chantelle and myself were extremely impressed with the varied (and packed) 2 days. Although it was a 6 hour train journey we really thought we got a number of new ideas from the conference and were also able to question experts in the field of Maths and Science.

Thank you once again for your hospitality and I can only hope that it continues for the future. If you ever need any support for the continuation for this type of conference please do not hesitate to contact us!
Kind regards
Andrew Davies, Chantelle Richardson
Ysgol Eirias North Wales

Appendix A

Teacher qualifications in Maths & Science subjects in Wales
The General Teaching Council for Wales annually publishes information about the number of teachers registered with GTC Wales by subject taught versus subject trained for the CORE subjects and Religious Education, in the secondary sector. The data is dependent on individual teachers updating their records annually with the Council.

<u>Maths</u>
The 2011 data reveals that for maths, of the 1,451 teachers teaching maths, just over two-thirds (68.7%) are trained in the subject. A further 15% do not hold an initial teacher training qualification in the subject, and the rest (16.3%) are unknown.

The percentage of specialist Maths teachers over the three year period 2008 – 2010 is showing slight improvement. However the lack of accurate information means that it is difficult to understand the size of the non-specialist teacher issue.

Year	% trained in Maths	% not trained in Maths	% subject unknown	Total teaching subject
2011	68.7	15.0	16.3	1,451
2010	67.2	14.5	18.2	1,480
2009	65.4	14.0	20.7	1,498
2008	63.3	13.4	23.4	1,481

The DfES 2006 report on secondary teachers in England that found ' ... 24% of teachers deployed to teach mathematics... are non specialists...'. It is likely that the same picture exists in Wales.

A recent report 'A world-class mathematics education for ALL our young people' (Vordeman, 2011), commissioned to look at maths teaching in England, concluded that: 'Teachers are absolutely key in determining whether a young person succeeds or fails in mathematics. However we do not have enough specialist mathematics teachers in our secondary schools and many students are being taught by people whose own knowledge of the subject is uncertain.'

Science

The picture for science subjects is less satisfactory than maths.
Only 27.8% of science teachers regard themselves as trained to teach all three science subjects effectively. A further 59.3% are non-specialists and a further 12.8% unknown.

Individual science from GTCW 2011 data, subjects as follows:

Subject	% trained in subject	% not trained in subject	Subject trained is unknown	Total teaching subject
Biology	53.8	34.0	12.2	459
Chemistry	45.9	44.7	9.4	438
Physics	41.3	48.5	10.3	400
Science	27.8	59.3	12.8	1,185

The GTCW digest 2011 has examined the subjects versus teacher qualifications across 3 years (2008 – 2010) and shows that this situation has remained fairly consistent, with little improvement.

Nessa Carson

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?

It worries me that the chemistry GCSE and A level syllabi seem to include so much that's not of use to the students either in their lives or for further chemistry study. There is so much fantastic chemistry out there that is far more fundamental - A level students don't grasp the vast concepts of energy and equilibrium that really underpin most of chemistry from then on. Also on a smaller point, I really believe the 'stretch and challenge' and 'whatever it is and discover' initiatives are patronizing and very Mickey Mouse.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?

More onus on teachers to teach, and it not to be their job to spend their lives on discipline and 'keeping the kids busy'. This wastes teachers' and kids' time, and surely puts most off a teaching career.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

At A level, I had a mathematics teacher with a law degree and whose best maths qualification was a B at A level. Many students were far more competent than she was, and there were often mistakes and downright incorrect concepts taught - I just don't think this sort of situation should be allowed.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?

This is a time for teachers to catch up with their subject, particularly in outreach, to engage kids with their lessons. I am to be consulting as a STEMNet ambassador in a secondary school CPD session soon - I think it's a great idea to bring in people from the outside and from non-school teaching.

4. d) Should CPD be voluntary or mandatory? Why?

Mandatory - but definitely not so as to take up too much of teachers' time, otherwise it's pointless.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?

Absolutely not. However I agree with separate schemes such as the RSC CChem...

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)

Not sure a national network is necessary. Or at least, if Connexions still existed to any decent extent (90% cuts in my local area), we wouldn't need one. Every school should have access to a careers service.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?

More school trips would be fabulous - for example to the Catalyst chemistry museum in Widnes - I am yet to see a child who doesn't love that place (honest). There are also a few organizations that will visit the school rather than the other way round, such as Science2U and Professor Boffin. Either way, more more more of this

David Cumbers

1. a) What is good about UK science and mathematics education?
It aims to give all acess to the skills needed to take part in discussions about the big issues in soceity. The KS3 curriculum has the space within it to enable genuine exploration of science ideas.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
There is too little hands on practical science in the curriculum, it has been pushed out by too much issues based content. Coursework remains practical in nature but the curriculum does not call for enough genuine practical investigation to warrant the time that would need to be spent to properly skill up the pupils to enable them to access the coursework and excel. Too much maths has been removed from the science curriculum (definitely from physics) and there is not enough emphasis on WHY something happens - merely THAT it does. Exam questions and mark schemes do not call for sensible working out of calculations - too frequently a multi-guess approach which builds bad habits. There is very little opportunity for pupils to build a genuine interest in exploring science that can be practically achieved in the class room - there is far too much content at KS4 to give time for pupils to get it wrong before moving on to get it right. There is no link between the subjects of science and maths - we teach many of the same concepts, but do so in different ways, using different vocabulary to describe the same ideas, or the same vocabulary to describe completely different ideas. I don't want my kids to tell me there is a positive correlation because my specification demands a directly proportional relationship! Pupils learn about data handling and graph analysis in a lesson completely divorced from bountiful examples of genuine data that they have a concrete link to, learn different methods of describing and explaining it in different subjects lessons and then are expected to excel at both in the stressful atmosphere of the exam hall. Too much of the old style science knowledge has gone - there is little evidence of

a narative that can be used to srting it all together in some semblance of meaningful order. Most modern science is impossible to properly teach in a secondary science lab - so why try? Much better to use classical science to develop a love of practical and process supported by the anecdotes and stories that make it interesting - then build a link to modern science through it. Just focusing on the modern leaves an unsatisfactory experience for all, no motivation to find out more and no skills to use if motivation has survived to lead to a HE/FE science course.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Science is important, but the increase in pressure to allow pupils access to separate sciences at GCSE level is having the regrettable effect of severly limiting the broadening choices offered to the brightest pupils at KS4. For example, those that would gain a lot personally from following an arts, or drama based course frequently find that this will not fit into the pathway offered them due to their percieved suitability for a triple science pathway when if this is not a priority for them. Not enough is done to help pupils see th elink between each subject - we still train them to be a scientist in science, an historian in history etc. We provide the barriers for them to climb before they can be an independent learner, we sohuld inatead be showing them that knowledge gained in one area can be used to help explain and understand ideas and problems experienced in many other areas of the curriculum (and/or life). Why is Stephen Fry not in charge of the National Curriculum?

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Make clear the links between the two areas - use a shared vocabulary across all specification/exam boards/schemes of work. Cut out all the extraeneous rubbish that need not be there to add context, we can do that! Pare it back to the basic facts and skills required to be a good scientist/mathematician. Require maths and science to work together - cross curricular links developed by shared coursework if such il-advised modes of "assessment" are to continue. Focus on functional uses and aplications of both subjects.

5. Other comments
I know that some of my comments may appear flippant - they are not meant as such. My typing is almost as bad as my spelling - but you have asked soem great questions and if I don't get this done tonight, you won't get answers to nearly enough of them.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Stop teacher bashing in the press. Take the curriculum and assessment of it away from politicians so that it may stay the similar for more than 3 years at a time. But, this is only as a teacher - you really need to be asking trained scientists who are not applying!

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

YES! People have no idea what teaching is about! The number of idiots that get through the interview process is truly scary and piles heaps of unnecesary stress on teachers who do their very best to get them through their chosen route in, their NQT year and for years down the line. Test for: Common sense. Ability to communicate. Flexibilty. Realisation that actually, "teacher" comes first, and "science" second - it's not just about the subject, but helping young people to a.see the opportunities available to them, and b. make the most of those opportunities.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
No, because to be a teacher you must already have the "calling" which is a crappy term but the best I can come up with. To offer any form of incentive is to attract the wrong type of individual - one who is in it for short term gain rather than the long term development of pupils.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Time spent in classrooms, the fact that they must see more than one school , and hopefully see a different type of school for each placement. Time spent getting it wrong with a suportinve (hopfeully) mentor to help them see where they did go wrong and how to avoid it next time.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
Only to allow access to less numpties. More should be allowed to fail if it would mean less long term damage to the education system than allowing mediocre folk to pass.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Only allow already good teachers to act as mentors to training teachers. Value that position and actually provide the funded time to give that teacher the time to sit and discuss issues rather than squeeze those vital conversations into an already over full timetable.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Practical ideas for science classrooms. Curriculum development. Because not all schools have the capability to provide those experiences themselves. Giving the input to training teachers means you can ensure all new entrants get it, and hopefully they will be able to spread best practice in their new schools.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Schools and universities - it's not broken, don't "fix" it.

8. h) How much of this training should be spent gaining experience in the classroom?

The vast majority.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
One year and a year as NQT seems to work fine.
1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Get up to date ideas to share. Not all of us will have KS4 or 5 qualifications in all subjects - subject knowledge is different from how to teach.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
I like the approach of talkphysics - peer support that really works. Meeting with real scientists - IOP lectures are also a good source of enough anedote to keep classes happy - and enough new science to give the tired teacher an interesting new idea to ponder.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Depends on too many variables to be specific.

4. d) Should CPD be voluntary or mandatory? Why?
Voluntary, but noted on appraisal - mandatory does not work, you just get an idiot grumping in the corner spreading bad feeling otherwise. Suggest that each person has a personal inset budget - maybe time and or financial - and must show they have used feedback from appraisal to select a sensible programme of support in any 3 year period to pass appraisal.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
No - NSLC and the funding attached to it is a very good way of ensuring CPD is accessible and meaningful and top quality. There are many modes of inset - outreach, onine, in person, national and regional centres - just wish more schools took it up.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes

1. a) How and where should we be training laboratory technicians?
Similar to PGCE, range of schools and by acreddited technician trainers.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
How to do the job - CLEAPS - common sense. Knowledge of the curriculum. How to help teachers deliver key ideas and build practicals to highlight key misconceptions.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes - same as above but with emphasis on building confidence of pupils.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
No special network, because every kids should be seen and given advice specific to them - not enough to send kids who express a wish to be a scientist to a specific science person,

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Difficult to judge. The vast majority of schools in my current experience have bought off the shelf schemes and are tying to make them work. This deskills and demotivates staff and, as most of the off the shelf schemes are poor at best, do not provide the right material or experiences for pupils to progress as they could were the curriculum tailored to them. Sadly, there is very little capacity amongst schools for staff to be given the time and resources to develop their own material - so it is an easy trap to fall into. In small schools, there are not enough staff to do the grunt work. We are lucky, we have high numbers of staff, but comparatively few of htem are experienced, have the skills needed, or the time on which to use them to best effect. No evidnce exists to show a direct link between leadership and outcomes. Neither does it for schools in general - this is not something that Ofsted can observe - even if they think they can - it's an organic, every day thing, a culture that grows and changes with the weather. Clearly a motivated HOF can do better than a demotivated one, and this will be in part due to the leadership structure of the school as a whole.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
Seeing the bigger picture and being confident in their view of it. Being able to communicate that view - but not as a management style "view of the faculty" type disaster - a proper view that is shared by all because they can see what it is, where they are and to where they need to go to let the kids see the best version of that view possible. They need to motivate older more experienced staff who are probably jaded by all the changes to the curriculum - even if they saw the next new curriculm as the best ever, they are so tired of the constant changes that they will need help to see it as such, and that will include knowing that this change is the last for a while - let folk be confident in what they are doing this can only happen if they are given time to practice, evaluate and improve on that practice without the groundrules having changed part way through that process. Oddly, it is the small changes that are the hardest to deal with - changes in terminology for example from anomoly to outlier - unneccesary, apparently tiny, but actually, on the ground, something that trips one up in many lessons. Leaders need to give people the confidnece to go into their classroom and try new stuff - to be brave, and know that if it all goes pear shaped, it's ok so long as staff and pupils learn from teh experience and make it better next time. To do that, people need to know that their is time enough to get it wrong, before getting it right. They need the resources, financial and

temporal to give people the space to think creatively, plan together, try new practicals, but equipment for new practicals - replair exuipment for old practicals - know they can find the answer for when something has not worked but really ought to.

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
See above - but make it clear that it is expected, of them, not just slavish application os school and department marking policy, homework policy, coursewoekr moderation, blah blah blah blah blah - none of which is actually useful, all of which gets in the way of folk being creative and really TEACHING.

4. d) How can leadership pathways for experienced teachers be introduced into careers?
I'm an AST - this was meant to be the leadership pathway without leaving the classroom. The role is so poorly understood and poorly defined that it is far from this in reality. I can't do the leading because the rest of the "curriculum" leaders don't see teaching and learning as important as the paperwork. Do experienced teachers want to be leaders? Should they? Are they the best leaders? Souldn't it be pathways for good leaders to become better leaders? Why not leave good teachers doing what they do well, no need to follow the peter principle just because it exists. Let managers manage and teachers teach.

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
The morale of the staff. Once that goes, there is no hope for an ethos. There is no point having a behaviour policy which would enable a positive ethos if the staff are so worn out and demotivated that enforcing it is the last of their priorities. Tradition is a strong factor, but new staff are more "proffessional" or more "corporate" and wich to spend time doing what they value which is slavish policy following rather than getting invlolved in the life of the school and community. Result - a few who do it all and wear themselves out!

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Leadership jumped on the idea of more triple groups at KS4 and more kids taking maths GCSE and A level early. Impact? More kids taking triples science, when many of them have no real wish to, results go up but at the cost of the sanity of the staff. Maths pupils dont take it seriously and have a less good set of results to take to UCAS as they do less well early. Leadership: we need more bums on seats at KS5 Impact: AS science course and Btec Health and social care Any more labs? No.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
No impact that I have seen.

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin to acquire them?

There sohuld be a shared vocabulary which should not change from KS2 to KS3 and beyond. I know the theory, but, in paractice, at present, at least with the cohort I teach to in North West London, kids have enough difficulty with simple English let alone understanding that there is a new term to describe a cherished model or piece of equipment. Especially when there is little opportunity for repetitive use of phrases to describe experiments at KS4. Planning genuine investigations can start very early, but then needs to be encouraged at all stages. Currently, by the end of KS3 all opportunity for genuine investigation is finished as the pressures to finish all the content at KS4 mean there is no time to play at finding a method, we supply "the correct answer" this is not effective. Number, and negative number, use of graphs needs to begin early, and some thought needs to be given as to when in both subjects - no point science trying to call on line graph skills in Y7 when maths are busy playing with bar charts still. Algrbraic manipulation needs to start much earlier and be practiced often - I have A level kids who can't successfully rearrange Ohms law! Cause and effect is not well understood at KS4 and could do with being firmly in place, with the language to describe it much further down the school. This links with reading patterns rather than data points from graphs, and the langage to describe and then explain the relationship. Being able to make general observations and ask the right question, or plan a series of questions to enable the understanding of a phenomena should start very early along with practising describing and explaining them. It would be nice to invent a new skill of "seeing how this links to the real world" but in a way that didnt turn back into a diet of far too much "how science works" - something that teachers coulod be expected to do as part of the learning rather than an add on, or the whole point of the lesson. Spotting bad science and fault finding an experiment - actual programmed opportunities rather than as and when is a real skill that most science teachers have lost and is so useful in real science and real science lessons.

2. b) How may the acquisition of such skills best be assessed?
A mixture of APP and something like the long investigation - but not a fake - set up, same old same old thing that is more a test of how well the teachers manipulate it. Part of the assessment should be a recognition that things go wrong, and a genuine evaluation may mean that no useful results are gained in the time available. Sometimes people should be allowed to fail - but our whole education system does not allow this - the key is having failed, the support shuold be there to enable future success.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Massive - but this is so difficult to tie down. We are a very large school and take the majority of our pupils from four feeder schools, but they then end up in 12 science sets. With these numbers, variability is huge and even with a project specifically designed to bridge the gap - it is still difficult to avoid the regression of many pupils. Some primary school science lessons are amazing - the output of the pupils in terms of experimental write ups would not look out of place if handed in as GCSE coursework. Others do not do so well. Trying to pull all those ideas together for a group and ensuring all might progress is very chalenging. The impact of being in a lab with "real equipment" is huge, daunting for many - especially with all the new terms for equipment nad procedures - a thrill for a few.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

The new KS3 went a long way to ensuring this happened, but is topped off with a beast at KS4 that still is top heavy with content, much of it unneccesary and unhelpful - KS4 should be an extension from KS3 - APP or similar should make it possible to show pupils how to progress in skills if not in content. If I taught English- I could show a pupil how to progress and evidence that progress, make a good judgement of their final grade. In science, I can do that in terms of what now really are only coursework skills - it is not possible elsewhere as no grading criteria exist for anything other than coursework. I can pretty much guess where a kid wil end up - but how can I back it up to my leadership team? Every other subject I talk to can do it, I have to rely on a skewed test to give me the proof for what I instinctively know. KS 3 curriculum is perfect as it is fact light and skills heavy. If KS4 were similar - I could breathe safe in the knowldege that as at KS3 we can spend until xmas learning how to behave, and be scientists rather than the present rush to get three ten lesson units completed by january - BAN MODULAR EXAMS! It would be so nice to know that something good is coming up in the news - CERN, Space shot, Drilling in the russina lake etc and know that we could do a week or two of exploring that without knowing that we are missing out on "vital" crap for the exam that in reality does nothign to motivate or improve sciensitst or science. There is no sensible structure that would enable this, but cutting out the amount of content would provide the flexibility to enable this.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
Learning how to write a science question followed by an explanation - you will laugh - but like it used to be! Multi guess is not effective, and neither is join the dots - boxes, speech bubbles whatever! It turns into "who can understand what the instructions are?" Rather than "Who knows what this bit of science means and why it is important we know about it?" Knowing how to cummunicate your ideas about science is far more important for most pupils than any specific subject knowlwedge - more long answers would help to justify more time spent practising this skill. Multi guess has changed the way I teach for the worse, I can't justify practicing writing explanations when in all honesty, they wont need it for the exam, and most of them will not need it in their later education or careers. Let assessment drive learning in a positive fashion instead. Open questions rather than closed - if it's genuine scientific process we are after - there are not yet any "right answers" Draw a diagram to show.... What would you do if.... All the questions we would use in class to help folk to understand are just as useful when used as summative assessments! If coursework is to continue - let it be real rather than fake.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
NO

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
When they are ready.

8. h) What evidence of learning is needed for assessment to operate effectively?
If evidence could be a video of me asking the questions and their responses, all my kids would achieve far more highly than in a written exam - not because I might cheat, far from it, I can make a quastion far more challenging and be far more insistent on a proper and complete answer than a written paper ever could. Again - instead of assessing their knowledge, we currently assess their ability to decode the question - let the English assessment be a judge of that - let me, as a gifted poser of questions pose the right question for the right pupil to let her or him display the right characteristics to feel proud in their understanding of a wonderful subject.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?

Oh - good question! In the perfect world? I want a lab in a field next to a lake up a mountain next to the science museum attached to the university, and neighboured by a factory, pharmacy, sports facility etc. I want desks that will move to form group working areas, be graffiti proof for when I cannot be in the room and some other numpty takes my kids and lets them get bored. I want the sun to shine all the time, but not on my projection screen - not NOT an interactive whiteboard. I want a really good library of high res pictures - like science photo library. I want computers that work for kids to use a scrap book style text book on - so they dont have to write more than that which is really neccessary, but can choose the bits of info that they really need to record in a way that they can access again. I want all the kit I need, when I need it, supplied by a technician who knows what I mean when I say "class set of working 6v bulbs and a power pack per group that is set to 6v max, and leads enough so that all can make a parallel circuit with 3 bulbs" I want to be able to have my A level kids free to come and refresh in a GCSE class, or teach a part of the curriculum to my nutters at KS3 - I want my wonderful Year 7 kids to be free to go and re-enthuse my jaded Y13s who are sick of the pressure of UCAS. I want scientists to come and show what they have been working on that day and not feel that I need to cut out something else for the luxuary of having taken time from the "real" curriculum. I want to have easy trips to where science really happens and know that we will make best use of it - i.e. cross curricular - history joins geog, etc. Sorry - didnt answer the question - irritiating isnt it! I want to be able to invite my primary colleagues with or without their pupils to come and play at science. I want to be next to the technology rooms so that we can go and build stuff right then if we decide we need to, I need B&Q and Tescos next door and the funds to go and buy raw materials on the spot (send the kids - they need that skill too) I want to pop across to Diamond Light Source and show the kids that science is big, dirty, cool and happens right here in the UK - not just onder the swiss/french border - I want to be able to pop out to the obervatory and instantly show the kids the breaking news story about some dry part of space. We need to be next to a canal and also on the coast so that we can take regular trips to see how the sea shore changes, rather than take Y12 once a year and cram it all in. I want to show them how the canal system works, using simple science, how it changed soceity, and geography, is rooted in history - I want to be able to call on my colleagues from those subjects to say "Hey - this is what we did today in science- any chance you could back me up?" and have them say - "Great - that fits in with what we were planning also!" Oh, for that perfect world - but can we have it tomorow - because even though I am going to work until I am 80 - I won't be around in two generations time

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
Don't understand.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
See a. above - I got carried away. Definitely not a good idea to have to teach one lesson in, and the following lesson out of a lab. Suck it up, science is an expensive subject to deliver - pay for it!

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
See a above.

5. e) What other resources and systems should be used to support science and mathematics?
I want to have a graphic artist/programmer who can sit with me in my lessons and turn my explanation straight into an animated graphic with funcitonalyit to change variables etc. Not some pre-existing one that doesnt quite fit the way the discussion went in the classroom - would that I had the time/skill/resources to do it myself.

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Why are we so insistent on measuring stuff? Did we not learn when younger that just because we measure it, it does not mean it's going to grow?! Why are not more school infrastructures made visible - kids sould be involved in the mechanics of the school - they should see the oil delivery, understand how the heating works, know why the network is permanently disfuntional - see cables and circuit breakers and the electricity meter. My parents know stuff about life and science in a way that I don not - it is to them that I turn to work out how to make stuff interesting (sometimes) what was it that they got in their education in the 40s and 50s that is missing now?

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?

I don't believe in single sex education and yet have had all boys groups for the last 3 years. It really works to improve motivation and questioning and although it is not a fiar test - their value add was much better than my mixed groups - we can be silly boys when we need to, but in so doing have managed to become thoughful, respectful human beings who listen to each other - my mixed groups in the same cohort were not so disposed, not a fair test - as I see the boys once a day and the others twice a week, but it cannot all be down to that. I do believe in setting even though the research suggests otherwise. I love the idea of teaching kids when they are ready rather than because they are for example in Year 9 - but have no evidence of it working - has anyone?

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
same as everyone else, but let parents actually understand it. I observed a lesson with a parent present. The lesson was not good. The parent thought it was wonderful. We need to ensure people understand what they are beign given so that they can understand when it is being manipulated.

2. b) How should qualifications in science and mathematics be regulated?
same as everyone else

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
By letting them have a genuine choice rather then forcing them to take separate subjects just because they are bright - bright does not always equal scientist! Why must separate equal three? Must all scientists know all of Bio Chem and Phys, can we not make a core science and add to it optional modules from a range of areas?

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Disadvantage:Schools tend to focus on the margins of each target group rather than each individual. But - without them - would no one be pushed at all?

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
same as everyone else

Tom Davies

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Changes should be smooth evolutionary changes and not abrupt short term policies

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)

the disparity between good and bad teaching

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Involve the end user at the discussion stage not as an after thought. Get industry and government to agree on common goals and stick to them

5. Other comments
education should not be a political football

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Change teaching from a career of perceived second or three degree minds to one of first degree minds. Value teachers as heroes.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
relevant A levels and tests to discover what makes a good teacher

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
good salary,good career prospects and respect

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
see b above

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
a well thought out programme involving all parties

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Relevant experienced based

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Universities

8. h) How much of this training should be spent gaining experience in the classroom?
Sandwich course with interleaved periods in schools

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?

3 years and then 2 years work based

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
see 2 b

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Sabaticals at regular intervals

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
all the time,make it integral

4. d) Should CPD be voluntary or mandatory? Why?
voluntary

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Time and workload

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
depends on subject,teacher and school

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes

1. a) How and where should we be training laboratory technicians?
as for teachers. you need good well motivated staff paid a decent living wage which is not the case at present

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
yes as part of a multidisciplinary team

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
yes

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
personally good teachers and lecturers have helped and motivated me throughout my life.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
relevant ant and necessary ones

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
By listening to their feedback and making them part of the team

4. d) How can leadership pathways for experienced teachers be introduced into careers?
talk to experienced experts on the implentation of change

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
the culture of a school what in welsh call "hwl" a sense of being part of the greater good

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Better results and happier students. Look at the government own surveys.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
As a supportive senior partner who listen and act.

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
as soon as they enter education

2. b) How may the acquisition of such skills best be assessed?
analysis based on experience allied to clearly defined criteria

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
vey as it is often disjointed and poorly co-ordinated

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
all of the above

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

ask the people who have to do the job

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
A holistic approach to maths and science should be taken

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
as little as possible with schools guiding students to GCSE and A level

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Both

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
less, less disruption

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
waht ever is needed

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
No Response

5. e) What other resources and systems should be used to support science and mathematics?
any that have an impact

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
by involving all the above in the process

2. b) How should qualifications in science and mathematics be regulated?
Yes

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
provide the money and resources

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?

targets focus on narrow objectives to satisfy only those who use the targets for their own purposes.

Catherine Dunn

1. a) What is good about UK science and mathematics education?
Science is offered in all disciplines up to GCSE in every school following the National Curriculum. The acience is relevant and applicable to life. The science is encouraged to be taught with hands on activities so pupils gain a sound understanding of the concepts.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
I teach Physics and the mathematical ability of students has declined over the years because of the nature of the specifications. Pupils can no longer do fractions, use calculators adeptly, rearrange formulae..... Mathematics up to GCSE is an essential life skill and this idea that they need to be introduced to correlations, median mean and mode when some will just need mean and the ability to work out compound interest to give an example is a real prblem. Now pupils do not understand direct proportion I get there is a positive correlation. The basic maths skills and adeptness with manipulation of formulae is just lacking.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
I would like to see some engineeering topics included that are accessible so pupils know what is involved in that type of career. Moments for distributed loads to show how moments are used in calculations. I would like to see the subject specialists working as a team so pupils gain an insight into a subject and appreciate to do well one must have an open mind and value all the science subjects. I have taught pinhole cameras for years and it was not until I helped a collleague out with a talk on perception I realised about size constancy. We all say doulbe the distance of the object from the pihole and the image size havles well then we should have two pupils stand in front of the class and one then moves twice as far away does their size change? Why not? Get pupils engaged and thinking.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
mathematics must be regarded as a set of skills that must be obtained. Check what employers want and make sure these are soundly taught. The basic mathematical skills have not been valued and these must be taught and practiced. There is too much superficial coverage and there needs to be more mental arithmetic.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
This is difficult as I teach over seas and they come here to get the practical work. I would say Germany but students tell me the practical work is lacking. China I find they are good at

maths but poor on concepts. I am impressed with the physics teacher resources from the USA and they certainly get good scientists but I cannot say I know about their schools.

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
A sound grounding in maths They can manilpuate equations without difficulty so they soon pick up the concepts as they are not held back by their mathematical ability.

8. Other comments:
We need to value our engineers and scienists. University courses that are applied should be encouraged. We need our manufacturing base back the city is gambling and look where it got us. All our atomic energy programme was folded by the gpoverment and now we are buying it from France what a reflection on the goverment of this country and the value of highly skilled scientists. Our enery providers are from overseas so how safe are we? We need to get back to running our own services.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Good technical support is essentiaql if a teacher is to be able to be efficient and give the most to teaching. Technicians need to be valued and paid more. Good technicians can ensure continuity when staff change and maintain equipment they are essential. Many hours are spent getting equipment sorted and checking it out. Smaller schools so pupils are valued and there is respect and good discipline. Teachers need to be well qualified and certainly there needs to be some CPD between training and retiring. I have done chartered teacher and I found it very very worhtwhile.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
More to the point is can they explain things do they engage pupils and do they understand the concepts. There needs to be more rigerous testing before they teach as a first class degree does not equal a brilliant teacher.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
No teaching is a vocation and it is something you should want to do it is not something to do because there is a carrot. Salaries should be professional ones. Teachers provide the doctors and need to be valued.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
The work by Black and Wiliam is excellent and much is done to see how pupils learn best and methods discussed.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
I would like to see the term back as a focussed session and then a probationary time in school would be sufficient I would think.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
I did not teacher train and did chartered teacher to gain knowledge of the pedagogy. I do think training is valuable as it gives time to develop courses and be informed about the different methods but the courses must be very focussed and top quality. Good university education departments should give a term's course and then mentor the students in a school.

10. Other comments:
Primary teachers must be either regareded and having a specialty in science and be able to teach it or all teachers need a basic science education. Many misconceptions creep in because of primary work. They do their best but it could be improved. Secondary teachers of Biology have little training and need more as the subject is so diverse. The degreee could be in ecology and then they have no biochemistry for example. Similarly engineers teaching physics need filled in on whatever branches of physics they missed eg civil need electrmagnetism!

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Keeps them up to date and enthusiastic with respect to their subject if the CPD is good too ofetn it is not.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
In scotland SSERC does this very effectively courses are run for teachers to go on and the courses are relevant to the teaching.

4. d) Should CPD be voluntary or mandatory? Why?
mandatory but it could take many forms. The specifications change and teachers deserve to be given courses on new topics.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
There are skills to be learnt eg exam marking helps with training pupils to answer exam questions correctly. Subject specific is also necessary as are the methods. Certainly when my kids were young CPD would have been tricky unless it was near by. It must be easily accessible.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
No Response

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes this is needed. Charteded teacher really helped me get up to date and someting needs to be in place. MEd is no good if the coursees are not relevant so a qualification that can be worked on in a particular subject is what is needed.

1. a) How and where should we be training laboratory technicians?
This is very lacking. I sent one on a course and he was not shown how to wire up the circuits. They need to be trained in all the basic skills so they can set up all the standard experiments. There should be a valued qualification and they should be paid a reaasonable wage.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
They need to be brought up to date as equipment changes. Since I started datalogging has come in and I just picked it up and taught myself but I then have to teach the technician.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
better to have smaller classes and a good technician and a well qualified teacher.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
There is a real problem here I do not know what to suggest but we need to do someting and I do not think career advisers work from my daughter's ex[erience. This is a rel problem that needs to be addressed as they just have no idae about the different careers.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
Needs to be seamless and pupls need to be taught topics with a different emphasis so they do not think they are repeating when a topic is being revisited to greater depth.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
No Response

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
I use thinking jotters and get pupils to write down what they think then I see what they do not understand and I have been amazed at the misconceptions.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
No Response

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
One exam before anyone leaves school so they have a qualification and a bench mark with respect to the standard they have attained. I honestly think the A" and As was good as it catered for the academic student and the one who over 2 years could gain an AS and go on to do a technical training. To get an A at A2 it should have been a requirement that an A had to be gained in all modules or at least in the AS and A2 separately and not just an average of the marks.

8. h) What evidence of learning is needed for assessment to operate effectively?
They must be competent at both practical and theoretical work.

6. Other comments:
This survey is too long I have given an hour to it and was in school to do making on Saturday. This is just what is not needed I started out filling it in but have had to give up.

Rhiannon Evans

1. a) What is good about UK science and mathematics education?
No Response

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
No Response

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
I am concerned at the number of young people leaving school not suitably equipped to enter the workforce.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Input from employers and HE needs to be embedded in the secondary curriculum

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Salaries and progression routes need to be competitive with opportunities in the corporate world and/or the world of research.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
For Primary - A or B in GCSE Mathematics/Science, for Secondary, A or B in A Level Mathematics/Science (degree level qualification to teach at 6th form)

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Maths/Science communicator courses should be part of teacher traning. Time in the workplace with employers to see the relevance of these subjects in a work rather than an academic context.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory - this ensures up to date teaching methods and subejct knowledge
1. a) How and where should we be training laboratory technicians?
In laboratories, through an apprenticeship model

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
whoever delivers this needs to be equipped with current information, online resources can be excellent but students need to be signposted to them. Some of the best careers advice can be sought from those employed in STEM industries sharing their experience.

Esther Fidler

1. a) What is good about UK science and mathematics education?
Science seems to be becoming more important in the rankings within primary education, with a leaning towards discovery rather than teaching.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
I think within Science particularly the focus in early education needs to be upon scientific skills, and becoming a 'scientific' person rather than on the knowledge. APP went some of the way towards this but it is still unclear as the SAT data sent in is based around the NC.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Religion in education, free schools, Conservative policy, shall I go on?

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
By creating thinkers, problem solvers and people with the skills to work something out for themselves using reliable methods and stick with it until it is finished.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Within Primary education, I feel they need to be teachers first, scientists/mathematicians second. There does need to be support and possibilities for good teachers to share and develop both their skills and their roles within school without becoming school leaders.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
A level in the subjects for which they are specialising. The suitability would be more to do with teaching, I would suggest time spent in a school working with an experienced teacher, we can usually spot someone who isn't made for the classroom.

10. Other comments:
I did a four year BEd, which gave me time in the classroom over the whole four years, as well as ample time to learn degree level subject and specific school based projects in my subject.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Networking primarily.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
See above, also Twitter is superb.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
I do not think there should be a time limit, although something needs to be in place to prevent stagnation.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory, to avoid the stagnation mentioned in the previous question. Some teachers do not like to change, or feel they need to.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Time and money, although these are not specific to Sci and Maths teachers, this is job-wide.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Of course, there should be planning and where finances are concerned if it is not planned for school wide it does not happen.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
It has not affected me in choosing CPD courses, I choose the relevant course.

1. a) How and where should we be training laboratory technicians?
The Science Learning Centre is very good and has many resources.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Of course, in Primary we use them all the time, they are essential when working with younger children and often when they work with a group they gain a far greater insight into what the children know.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Possibly, as things are moving on so fast. Perhaps using social media....

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Reasoning, questioning, logic, proper methods. They should begin to acquire them from birth!

2. b) How may the acquisition of such skills best be assessed?
My experience is in year 2, and I find listening and watching the best way.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
No Response

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

The curriculum needs to be flexible, in primary I find embedding science into as many areas as possible works. I am in the position to make decisions about how and when I teach my subjects and am fortunate to be able to do so.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
In Science, the APP which assesses scientific thinking rather than knowledge is a far better way in young children as their thinking will set them up for life, rather than a focus on knowing particular things.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
All around the school and grounds, everywhere.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
No Response

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
For science it would be great for each local authority to have libraries of equipment which could be loaned out to schools as some equipment is not affordable.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
A fully embedded curriculum is meaningful, memorable and ha purpose.

Jenny Gage

1. a) What is good about UK science and mathematics education?
The depth that is available to those who want that.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Science at higher levels without necessary maths - this seriously misleads students. Target driven curricula which focus on short-term goals at the expense of real learning. Lack of joined up thinking - STEM, rather than separate subjects.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Targets, as above. Making things superficially easy for students, so they don't want to engage with difficult topics, and so miss the pleasure of mastering something hard.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Focus on cross-curricular and inter-disciplinary aspects of STEM and on real learning, not just meeting targets and passing exams.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory - how else are teachers to keep up to date, grow their knowledge and practice, and generally develop their expertise.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?

Being let out of school. Good quality stuff to access.
1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Being able to ask questions and learn from the answers. Being able to learn from their own exploration. Not fearing mistakes. All part of life, and need to be there right from the start.
2. b) How may the acquisition of such skills best be assessed?
?

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Very. Pupils too often arrive thinking of themselves as not good at these subjects, when they're doing fine really. Some primary teachers give pupils an excellent grounding, others don't - greater involvement of teachers cross-phase would help.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

Provide an exciting curriculum, which isn't target and level driven. Base it on problem-solving, with interesting, relevant, appropriate problems. Give teachers the space to bring in their own expertise and enthusiasm, and to bring in topical issues.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
Almost anything other than the present system, it seems to me!

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
Should - yes. Extent - depends on what the curriculum looks like. It would be great to see, eg. ratio assessed through adapting a recipe for different numbers of people (with the real-life issue of what to do about eggs), data-handling assessed through examination of real data in a real context, etc, etc.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
Age 18, for progression to work or higher education.

Jane Giffould

These responses are from Jane Giffould, a teacher who has taught all key stages from KS1-4 in Britain and overseas. After VSO work in Kenya, as an untrained Science teacher who taught a multitude of other subjects, she then trained for Secondary School Science teaching. Her most recent teaching has been all subjects though with a fair amount of DT and Maths in a Middle School along with a short term consultation for Year 3 equivalent Science teachers in Egypt. She did supply teaching due to an ailing mother and is now looking for full time work preferably KS2 or 3 having gained a preference for Middle School work. She is a long term member of ASE, Association for Science Education with whom she has also worked as a Field Officer. In addition she is an active member of ESTA, Earth Science Teachers' Association and in the past has been a member of DATA, Design and Technology Association.

1 General questions

1) Science and mathematics education in the UK

a) What is good about UK science and mathematics education?
They exist and are considered as priority subjects although unfortunately Science can go by the board to some extent when schools concentrate on levels in Literacy and Numeracy.

b) What aspects of UK science and mathematics education need changing and how may they be improved to et the challenges of the 21st century?

c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)

- The problems of being dictated to by government ministers who seem to have very little knowledge of current education and the needs of society.
- The dumbing down of vocational subjects. How did Britain earn its Great? Look at the inventors and entrepreneurs of the agrarian and industrial revolutions that helped put Britain on the map. These were people working with vocational skills.
- The ebac which, if not so worrying, would be laughable. It is nothing like the IB which I respect as covering a wide range of subjects and demanding a lot from the students.
- The league tables as being no more than an exam passing fad but not actually looking at the educational needs of society or the students.
- Primary schools concentrating on Literacy and Numeracy to the deficit of all other subjects.
- The divide and rule of forcing Academies and Free Schools whether they are wanted or not.
- The excessive cost of further and higher education which puts people off extending themselves. eg: my son, a bright lad, who refused to even consider uni as he did not want to get into debt.

d) How can a science and mathematics education system best meet the needs of employers and higher education?

- Education and employment need to get together to see what is needed. This needs to be done at local level as well as at government level.
- Students need an education that will lead to employment.

- Employers need to review the Science and Maths that they use, they may well be surprised at the amount involved.
- Similarly Education and Higher Education need to get together to see what is needed so that time in HE is not wasted catching up on what has not been done, back in 1967 my uni course had a catch up Maths and Physics block.

Other comments:
I note that this study is just looking at the 'pure' subjects of Science and Maths. Yet to be effective in the economy these need to be applied. Hence the study could be more effective if Technology and Engineering were included to encompass the whole of the STEM sector.

2) Science and mathematics education internationally

a) Name three countries anywhere in the world where you feel ‘high-quality' science and mathematics education are to be found? What are the hallmarks of this ‘high quality' science and mathematics education?

- Finland. Due to respect for highly educated teachers.

b) What specific aspects of other countries' high-performing education systems should we be learning from?

- Maybe consider whether education is considered a privilege or considered a tedious bore that one has to do whether one likes it or not. Attitudes towards education can have an effect on the final outcome. Does education lead to employment? Students work and perform better if there is a known reward such as employment at the end. Or to quote a Year 8 student of many years ago: 'I will be going on the dole'. Hence education had little appeal to him.

Other comments:
It depends what is meant by a 'high performing education system'. My personal opinion that high performing means that it educates people for a wide range of jobs, a plumber is as important as a nuclear physicist. Neither should be expected to do or even understand each other's jobs but all should respect the need for both. Thus the high performing education system will produce high quality academic graduates along with high quality vocational people who need not have been to uni to get their skills.

2 Teachers (and the wider workforce)

An education system can only be as good as the teachers within it. But for many years now shortages of science and mathematics teachers have been recorded in England and Wales and the situation elsewhere in the UK is not entirely clear. Problems have been reported both in recruiting sufficient trainees and retaining qualified teachers.

Please answer these questions without feeling in any way constrained by current or proposed mechanisms in place for recruiting, training and/or professionally developing science and mathematics teachers.

1) Teaching as a career

a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?

- Teaching needs to be made attractive.
- Who would willingly go into a class of 30+ snotty nosed brats who have no wish to learn anything, are out to get at you and will threaten 'My dad will do you in'. Yet this is how education can be presented in the media and there is many a teacher who can confirm it.
- What about the time a teacher spends on/at work. It is not a 9-5 job. Assessment, preparation, parents evenings etc goes on until the late hours of the night as well as the weekend, so the loss of social and family life. Long holidays although appreciated are not a substitute.
- Financial problems in schools cause cutbacks in many areas including cover which is now done by teaching assistants rather than qualified staff. Penny pinching does not enhance the quality of a job.
- Government intervention which has become a permanent fixture is not conducive to making a job attractive. The government appears to enjoy telling teachers what and how to teach irrespective of the fact that teachers are qualified and the government people in general are not.
- Proper time for proper CPD not just a school imposed twilight session which is useless for all but is made to look like teachers are getting CPD. Subject teachers need to continuously upgrade themselves on their subjects. Belonging to a subject organisation and attending subject meetings/courses/conferences is one way to get excellent CPD yet many schools will not let their teachers out for this and claim they cannot afford it. (Hence why long time ago I was always 'sick from eating too many mince pies' in the first week in January so that I could go to the ASE conference.)
- Current lack of jobs does not make teaching an attractive career. I am meeting many teachers, also looking round schools, who are not finding jobs, plenty of these are NQTs who have not found a job 8 months after qualifying.
- So to make teaching a top career choice there needs to be: well behaved children who want to learn in class along with a system that automatically removes and sorts out those who do not fit in; more in-school time for preparation and assessment; enough finance to do the job efficiently; have the government respect the fact that teachers are qualified to do the job and let them get on with it; quality CPD accepted, expected and respected; guaranteed work at the end of training. Which all adds up the question 'Do we value the education of our children so as to provide for the long term balance of the economy?'

2) Initial Teacher Training

a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

- Primary candidates should all have good GCSE in Sciences and Maths.
- Secondary candidates should ideally have a STEM related degree, especially teaching AL. (I speak from experience having low grade Science ALs followed by an industrial management degree with some Science and Maths. I did various catch up

courses but would have benefitted from the in depth training of degree level to do the teaching up to GCSE Physics that I was doing.)

- However being good at a specific subject does not mean that one can teach it. Sometime being mediocre has the advantages that one then understands the problems of the weaker students and can address these whereas those with high level academic achievements do not always comprehend those who are stuck.

b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?

- Inducements should include all those items included in the final point for 1). There needs to be the guarantee of a good job without too many financial constraints where one is respected for the quality of one's work and is allowed to get on with it without interference along with ensuring the CPD is good and relevant.

c) What is good about initial teacher training programmes in science and mathematics in the UK?

- Am insufficiently up to date to comment.

d) What changes to these programmes (e.g. philosophy, content, or emphases) are needed?

- Am insufficiently up to date to comment

e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?

- Ensure that the same basics are taught throughout.
- Ensure that all topics of the curriculum are covered so that, for example, those with a Physics degree, will also be competent and confident at teaching the Earth Sciences section of the curriculum.
- Same assessment for all.

f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?

- Training needs to include both pedagogy and subject matter to ensure that trainees are up to date on both. This is particularly important when considering that teachers often have to teach beyond their own specialism. Hence for an undergraduate course the subject matter needs to cover the school curriculum with a specialism depth in one or two areas. For PGCE there needs to be sufficient coverage of subject matter to ensure that the range of specialisms in the class can cope with the whole of the curriculum. The training needs to incorporate classroom practice at regular intervals. (I was satisfied with my PGCE where we did 2 ½ days per week in school. I tended to then slope off the pedagogical aspects as I just had to work with my Year 11 class! or maybe would be covering for someone else in the school. But then I had the advantage of having taught for 2 years in Kenya on VSO before doing my PGCE. I also had the advantage that my then husband was doing his training at

Institute of Education and I got to know people there and would share some of the sessions whilst they came to find out about my teaching practice)

g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?

- Teacher training needs to be based in a Higher Education background to ensure the academic subject areas are available. The former teacher training colleges had the advantage that there was a concentration on the teacher training aspects, however they would not have had quite so high an academic level. Thus a school of education within a university covers the pedagogy aspects and has access to the subject areas. At the same time there need to be schools affiliated to the university who will take the trainee teachers for their teaching practice. These schools should work together with the university in order to have a definite programme for the trainees rather than trainees being dumped in a school and expected to get on.

h) How much of this training should be spent gaining experience in the classroom?

- Classroom experience is very important and can be a make or break for some trainees. It should constitute at least a third of the time. However how this is done depends on the rest of the course and the needs of both the related schools and the trainees. As mentioned above I appreciated the continuous ½ week for every week as this was more of a drip feed plus I was also experienced in full time teaching and I then got some full time supply at my teaching practice school. However those who have not experience full time previously will need to have some full time experience before qualification.

i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?

- This is obviously dependent on whether the course is for undergraduates or post graduates.
- The one year for post graduates should be sufficient so long as they have the right subject knowledge prior to their training. If not then another 6 months of catch up subject knowledge would be helpful.
- For undergraduates there would need to be at least 3 years in the breakdown of 2 years subject area to 1 year teaching skills. This would be the same for primary and secondary teachers with primary getting breadth of subject knowledge as they cover all subjects and secondary getting depth of subject knowledge.

3) Continuing Professional Development (CPD) for teachers

a) What are the benefits of subject-specific CPD for science and mathematics teachers?

- Subject specific CPD is important to ensure that teachers are kept up to date on their subjects as well as particular skills such as practical work/visits/industry links etc.

b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?

- Teachers need to be aware of all the facilities for their CPD. They need to know about their subject organisations, such as ASE, ESTA, DATA, ATM as these organisations contain the expertise and access to expertise. They also run journals to keep people up to date as well as conferences and twilight sessions.
- The SLCs are important for Science teachers in that they provide a wide range of courses.
- Other organisations and industry provide courses for which teachers should be made aware.
- Local Authority courses used to be useful along with the advisors for information and advice. Unfortunately over the last 20 years different government 'initiatives' have downgraded the Local Authority facilities by removing schools from their care and hence removing the income for helping schools.

c) At what times throughout their teaching careers and with what regularity should teachers undertake subject- specific CPD?

- Teachers need regular subject specific CPD as the subjects evolve over the years along with methods of teaching those subjects. At least one day a term would be useful. On top of this would be longer, perhaps one week courses each year where teachers could go into topics in greater depth. It would be good if we could look to Australia and New Zealand that provide upto 1 year every 10 years of sabbatical to enable teachers to follow up studies in real depth.

d) Should CPD be voluntary or mandatory? Why?

- CPD per se should be mandatory. What is done in the CPD should be voluntary as each teacher is aware of their own strengths and weaknesses and hence where they would benefit from CPD.

e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?

- The major obstacles are finance, time and school management acceptance that teachers do need to have subject specific CPD which is not just the school generated twilight activities laid on by school management
- Financially schools have cut back enormously on CPD because they claim that their income has decreased whilst costs have gone up, hence they cannot afford to have teachers out.
- Teachers are not necessarily happy about the cover that they will get when they are out. Now they do not even get a supply teacher but have to depend on the teaching assistants, who should be helping 'little Johnny' to do their teaching for them. (As a supply teacher for whom there is no longer any work I am fully aware of this. I am also aware that not everyone was happy with supply teachers. However when a school has its own list of regulars who know the children, are regarded as part time teachers by the children and who are known to teach rather than supervise, then this is another matter. I speak as one whom the children considered as part of the staff of one school.)
- Time is of an essence in education as with the current push, push, push a lot has to be covered in a short amount of time. Hence Management are often not happy to let

teachers out for CPD. Hence they are slow in approving the CPD and then it is too late, especially when it is related to the complexity of the Impact Awards.

- Not all management, especially those who are not STEM oriented, are aware of the necessity of keeping up to date with subjects.
- Overcoming is a different matter. Finance, awareness and attitude are major factors. The Impact Awards offered sufficient finance to cover a teacher. However many people were not aware of them and when trying to get the paperwork done to cover one was too complicated (I know from experience) If subject CPD was made mandatory and expected on an Ofsted report then school management might be more willing to do more about it. Timewise this perhaps could be done en bloc for a department. Perhaps the whole department out for a day such that there would be timetable adjustments for the day or to be done at such times as off-time table days that some schools have. Attitude is a major factor. Long time ago I remember the 'blue book' being in the staff room such that we could choose courses for the year and we were encouraged to do so. That time is long gone I fear. It needs to come back.

f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?

- Perhaps one could not be considered for leadership roles unless one had shown one had made use of subject specific CPD, after all how can one lead a department unless one is up to date in the subject? (Was recently talking to a staff member at a school where the member of management with an overview of Science had no interest in Science!!) However it should also be shown that the CPD done was then used as part of the teaching. Otherwise people could go on courses, enjoy the lunches and leave it at that!

g) Should CPD be accredited (eg through the awarding of Masters-level credits)?

- Accreditation of CPD is a good idea in that it would give recognition of CPD and would encourage people to use their CPD for further qualification. However as in f) the accreditation should only be given once the CPD has been shown to have been used to the benefit of the teaching. Currently the CSciTeach (Chartered Science Teacher) as awarded by the ASE requires a certain amount of CPD to be shown to gain the award.

4) The wider workforce

a) How and where should we be training laboratory technicians?

- Laboratory technicians need to have accredited training provided within easy reach of their place of work. Due to the nature of their work and the level of their pay it is unlikely that a long course would be accepted, hence modular style would be probably more appropriate. Local Further Education Colleges would be likely to be the most suitable type of place for daytime training unless schools were available during inset days as can happen at the moment. Registered Science technician, RSciTech is now being introduced via the ASE as a suitable status to which technicians could aspire. This will require a certain level of training and expertise.

b) What CPD needs will laboratory technicians have and how will these best be accommodated?

- Regular CPD is essential for an effective technician in order to keep up to date on matters concerning: curriculum, health and safety, new methods of preparation, administration, …..
- These could be done on site for a large school, at a hub school or at the local further education college.

c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?

- Teaching Assistants have been an integral part of Science and Maths classes for many years depending on the school and students' needs. (I remember a TA with a secondary class to help a student with special needs back in 1989)
- It is useful for the teacher if the TA has an understanding of the subject being taught, especially when it is a practical subject. They need training especially in the practical area. They also need training in when not to help those students in their care. (From my own experience in DT I found that certain TAs would hang over the child and do the work for them thus not allowing the child to learn. I had to keep finding jobs for them to do so that the child had to get on with the work. One TA, who was with a partly autistic lad seemed to think he could not manage. Actually when focussed on the subject he was good, so good that I gave him the job of changing the blades in the power saws. I knew that he would keep to routine because of his autism and would not think outside the box. If he got stuck he knew the routine was to ask me. The TA, who did not understand practical work, could not comprehend that this student could be trusted to work on it on his own.)

d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)

- Careers advice and classes are important in schools. Obviously these should have someone with a knowledge of STEM related careers. I feel that a national network of careers advisors is essential for the economy of the country. If students do not know the diversity of careers available then they will not go for them. As STEM subjects are core to the economy hence students need to be alerted to what they can do. Careers advice should not be just for Year 11 but should be an integral part throughout education. In primary it would not be careers advice per se but would be included in subjects with mention of careers relating to the topic. (eg: in a year 3 lesson on rocks I introduced the idea of a geologist as a person who works with rocks. This could then be extended when looking at the uses of rocks such as coal hence coal mining and coal miners.) As education progresses so the idea of actual careers could be worked into it. (At an EBD special needs school I was in charge of careers and from Year 7 onwards we had a careers lesson once a week where we learned about the wide range of jobs that could be available. Further up the school we then did visits to local companies to see what sort of jobs were available and what they would need to do them. My students loved the visit to the vet where my long suffering cat was given a health check.)

3 Leadership and ethos

Leadership and ethos are complex concepts within education, but are considered to be significant in affecting the overall performance of individual schools and colleges, and the education system as a whole.

Much less is known about the leadership characteristics of those science and mathematics teachers who successfully introduce innovative teaching and learning practices. This implies a culture of initiative and collegiality for developing, as well as delivering, the curriculum.

However, systematic evidence is also lacking in respect of the effect of such leadership on student performance and progression in science and mathematics.

a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?

- If STEM teachers are leaders then this will enhance the cause of STEM. Often STEM teachers will embrace other subjects whereas other subject teachers will eschew STEM subjects claiming non-comprehension of them. Thus an organisation with STEM leaders is more likely to have a balanced view on education. eg: a Maths oriented headteacher who was willing to give a try to teaching Year 8 ICT compared with an English oriented headteacher who appeared scared of coming into the Science labs (although I did get him to photograph the CSE group with their hot air balloons on the staircase.)
- As the economy needs more STEM oriented commerce then to have school leaders as STEM based will bring over to the populace that these are important subjects needing consideration and uptake.

b) What kinds of leadership skills should science and mathematics teachers be able to acquire?

- Leadership skills need to include: a vision for the future; a need to work with others outside the normal school environment; team work; listening and acting on what has been said not just doing one's own thing; working with other subject areas in a collaborative manner to show the links between subjects; gaining respect from colleagues inside and outside the school; the likelihood of being right; ready to admit errors and then act on them; be adept at administration; have up to date knowledge of what is needed to be known whether it is the latest in health and safety or what Ofsted are likely to require;

c) How can school and college leaders encourage leadership among science and mathematics teachers?

- promote a wide range of CPD covering subject and administration areas to ensure teachers have a wide range of capabilities;
- push teachers on further qualifications such as CSciTeach, working towards threshold etc.
- encourage leading visits out of school;
- emphasise working with such organisations as Education Business Partnerships
- point out the importance of having a STEM voice on committees;

- offer places on the governing body;

d) How can leadership pathways for experienced teachers be introduced into careers?

- have a school policy for career development for all teachers showing the options open to them;
- working with the SLCs to provide suitable courses for leadership in the STEM subjects.

e) What factors are most responsible for creating the ethos of different schools and colleges?

- strong leadership where the leaders are respected not feared;
- leaders who care about those for whom they are responsible, staff and students rather than their own pet schemes;
- leaders who say and mean the word 'we' rather than sticking to 'I';
- weak leaders bring down a school, I have seen this happen when a strong well respected leader was eventually replaced by a weak leader whose main word was 'I'.
- weak leaders generate poor behaviour in students, long time ago a lad in my class, who was caned even though he was not the perpetrator of the problem, said he was glad of the caning because it showed there was some discipline in the school rather than none
- leaders who stick to their word rather than prevaricate

f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?

- Leaders who are ready to review what is needed to provide the best for their students will be aware of the importance of STEM for all along with enhanced STEM for those who will go high with it.
- If the ethos of a school is good then it is likely that the educational quality is good.
- Leaders need to be inventive and investigative and ready to explore rather than go with the general flow. They need to be ready to query the dictats laid down by the government if they do not consider then as to be for the benefit of their students. Vocational skills are important along with the backing Science and Maths they should not be pushed aside due to the whims of a government but used to prepare students for life after school. TES of 10 02 12 has an article on this referring to the Engineering Diploma.

g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?

- I have noted over my years in teaching that governing bodies vary enormously. I have spoken to governors who have no idea what they are meant to be doing but it looks good on their CV and I have known others who are very hard working with the aim of having a well structured school that runs efficiently.
- Many schools will allocate subject areas to different governors. Again this varies from the governors who have no knowledge or interest in the subject areas they have been allocated to those with a keen interest and willingness to help.

- There is a difference between help and interfere. Those governors who offer to help with maybe their specialist expertise are welcome. Those who have not been in the classroom since they were at school and who therefore have to know better are not welcome.
- Governors who are employers in industry should have some idea on the use of the STEM subjects needed in industry and hence could be very useful in affecting and effecting the policies of a school.

4 Skills, Curriculum and Assessment

Acquiring the right scientific and mathematical skills and knowledge is a key component of an 'ideal' 5-19 education process. Teachers teach to a relevant curriculum and enable learners to acquire useful knowledge and understanding, which is then assessed at a critical point in time to certify what a young person knows and can do in these areas.

a) What skills are particularly important to young people's progress in
(i) science and (ii) mathematics, and when should they begin to acquire them?

- STEM subjects need capability of gathering data including measuring, then using the data with deductive reasoning to generate results and conclusions.
- This requires the manual skills of practical work along with decision making as to what practical work should be done.
- Practical work generates a need for risk assessment, awareness of safety issues and the ability to act with these.
- Use of IT and the internet is now important whether in letting the computer take readings and graph them or an investigation for facts. It also provides the opportunity to do experiments virtually to see what would happen if…………
- Generating questions and then finding methods to answer them.
- All these skills should be started from the start of school. Even 20+ years ago I saw Year 1 children who were competent at doing a maths survey on pets to make pie charts. I have had a Year 1 class who were excellent at doing the risk assessments for every trip that we did. They thought up things I had not considered. The same Year 1 thought up 50+ Science related questions to ask a teacher who was climbing Mt Everest and then sorted out which 3 had priority and where they would find the information for the rest.

b) How may the acquisition of such skills best be assessed?

- Assessment runs the risk that for summative assessment at the end of a topic the student can mug up the facts and skills to pass the test and then forget them afterwards.
- Assessment tends to rely on recall which at times can be a useful skill and for a range of skills needs to have the knowledge so deeply embedded that they become intuitive, such as when the pilot brought his aircraft down safely in the Hudson river after a bird strike. However this intuitive recall is unlikely to be ingrained in the students at school level for many skills.
- Skills can be tested by paper testing however for practical skills this is then testing a knowledge of the skill and not the skill itself. Practical skills can be recorded with a tick sheet to show that students have acquired a range of skills eg: using a microscope correctly,

lighting a burner safely etc. However this can present an endless list to be ticked. It is then necessary to pick out the most important skills to be noted. But this has the problem that other skills are then ignored.

- It has been stated that the best form of assessment is multiple choice questions (TES, 10 02 12). As a former multiple choice question writer and editor for GNVQ I would beg to differ. It is very difficult to produce questions which are rigorous and accurate enough to test the range of students at whom they are aimed. They can confuse the brighter student who reads more meaning into the question than is actually there. They provide the answers rather than finding out if the student actually knows the answers. It is possible for someone who can barely write to, by chance do well in a multiple choice test (Kenya 1973 a student who could hardly write did well enough in the end of Primary exam to pass on to Secondary) This form of assessment does not assess the practical skills which are essential in STEM subjects.
- It is better to assess the use of a range of skills in a practical situation to show an understanding of when those skills should be used. This would include giving the students a problem or a project and seeing how they tackle it. However this then becomes subjective when there can be various ways in which it can be tackled.
- Assessment needs to show that the student can use the knowledge and skills (s)he has gained.

c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?

- The transition generally provides a bit of a set back due to the students changing their environment and having to settle in to a new environment with new teachers, often a completely different teaching style and structure of the school day. As this follows the summer holidays there is also the long break in continuity. However once settled the students should be back in 'normal' mode. It is perhaps not a good idea for secondaries to try and assess levels before the first half term if they want to have a more definite result.

d) How should a curriculum be structured so that:

i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science;

- The whole school curriculum needs to review where topics can be taught across different subjects to allow more applied work. eg: for Maths work I have used aviation 1:500 000 charts for students to 'plan flights' which incorporates scales, distance measuring and geography whilst in application of concepts.
- Time needs to be available to cover practical work which necessarily takes more time than paperwork.
- There needs to be acceptance of applied work throughout, this is valid in all subjects, not just STEM subjects. eg: for a better understanding of the Tempest we were constructing the island as a 3D model.

ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning?

- There needs to be a less prescriptive curriculum and more trust in teachers knowing what they are doing. What is good practice in one place does not always work in another due to a different environment, a different culture and different students. Topics to be covered can be listed and then left to the teacher to decide the best methods considering the classes they are working with.

iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives:

- Again a less prescriptive curriculum. Topics covered lower down the education ladder need to be those that will be suitable for all whether they move on to work, further education or higher education. They need to provide them with a base where they can live their lives productively eg: understanding the basic electricity to be found in a home and dealing with faults, health and care of the human body. As they move up the education ladder they need to be shown how different directions in life require different skills. They can then try those skills to help them decide the direction in which they will be going.

iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

- Again a less prescriptive curriculum. There needs to be time to incorporate interest factors such as new discoveries and advances. It is useful to include a section relating to recent discoveries so that students can see that Science is a living subject which is always moving on, not just in a straight line but in a diverse fashion.

e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

- Formative assessment is important to find out what has been understood and what needs re-doing, possibly in a different manner. This is the assessment to help with learning. How it is done is varied. It could be just a teacher overviewing a class and jotting down what needs revising. It could be by reviewing the written work to see where improvements are needed.

f) To what extent can/should science and mathematics be effectively assessed through other subjects?

- It would be interesting to see how STEM could be assessed through other subjects. When having fun with a year one class I felt that students asking whether 200 in Hungarian would be 2 x 100 or 20 x 10 showed a good grasp on number concepts, they had worked out up to 199 on their own.
- The main difficulty would be formal assessment especially when working between different teachers.

g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?

- Final school leaving only. And that should be as a school leaving certificate to show that the levels reached in certain areas which cover sections from the whole curriculum not just a few academic areas. Along with this would be internal assessment for the remaining subjects worked on to show that the students have a rounded education not just the public exams. (To a certain extent recommended by A Little in TES 10 02 12)

h) What evidence of learning is needed for assessment to operate effectively?

- The evidence depends on what is being assessed. Practical work might be showing a particular skill which could be signed off as evidence. A construction project could benefit from a photograph to show the finished product or even a series of photographs to show the development of the project. Problem solving could be enacted in front of a class or a student could explain something to the class. In Year 4 a Lithuanian girl with very little English managed to explain some Maths to the whole class by putting the numbers with suitable symbols on the board showing that although having problems with language she could still manage the maths. There is no one way for assessment and gathering of evidence.

Other comments:
The problem with assessment is that it encourages people to teach to the test and so narrows down the education provided rather than allowing it to naturally diverge and expand into areas of interest and usefulness.

5 Infrastructure

Infrastructure refers to the nature of the learning environment in which formal teaching and learning take place. For the purposes of this exercise, picture an 'ideal' learning environment of the future (in one or two generations' time, for example) which has all the resources and support systems in place to enable the best possible teaching and learning in science and mathematics.

a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?

- Science and maths are an integral part of our lives from birth to death. We are all learning all the time. School is merely a concentration of learning. At the age of 2 my son was learning to count as he laid the table for 3 people of the family. He might not have known the word 3 but he had the concept of 3 in order to have the correct number of knives and forks. As students progress through school they need to realise that they are learning outside school as well as inside. Hence there is a great benefit of trips to see Science and Maths in action. When at primary, a very long time ago, my class had the pleasure of a trip to the aircraft carrier, Ark Royal due to the father of a class member being the captain. We learnt about the Science and Maths needed on the ship, seeing that these subjects were part of the big wide world. Visitors coming from the outside world into the school can help as well. Industry links and STEM ambassadors are an excellent way of bring inside and outside a school together.

b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (e.g. primary, secondary, middle, all-through schools)? Why?

- There are pros and cons for both more and less diverse types of educational institutions.

c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?

- Facilities for practical work are essential for both science and maths.
- Links with other subjects are important especially when looking at subject applications.
- External facilities are useful to see the use of the subjects as part of the world.
- Equipment both specialised and everyday is needed for the practical work.
- Everyday equipment can make the work more meaningful. A cross subject topic such as volume had a much higher comprehension level if done with everyday items such as milk bottles down to very small containers of a few ml such as found for sauces with some supermarket ready meals. Access to water then generates the understanding that 1 litre remains 1 litre irrespective of the shape of the container. Cereal boxes make superb pin hole cameras. A range of food boxes are good for comparative weights. The list of ideas is as big as a supermarket!

d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?

- Cross subject topics are very useful and have been mentioned in 4f and 5a. Every subject can be linked to Science and Maths. eg: covering a History lesson on Tudors I turned the classroom into a warship that was running out of water. The students volunteered a homework of getting fresh water out of sea water, they had just done evaporation in Science. Music is mathematical which is why I got top marks in Grade 5 theory. The more cross subject topics the better, life is holistic, education should be for life and not for league tables.

e) What other resources and systems should be used to support science and mathematics?

- The subject associations such as listed in 2.3.b provide and have access to a world wide range of resource along with conferences and other sessions. They need to be used.
- Plenty of industries are offering resources. These obviously have to be used with care as they need to be checked for suitability and to ensure that they are doing more than promoting the industry.
- The internet has access to a multitude of resources which again need checking for suitability.
- Industry visits and ambassadors as in 5a.
- Publishers who provide complete schemes, although these do need checking, especially with the ever changing initiatives produced by the government.
- Learned Societies such as IoP, SoB, RSC all produce excellent resources as do a number of other academically based organisations.
- There is plenty out there. Some of it is reviewed in TES.

f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?

- More flexible timetabling would allow more integration between subjects and the possibility of having sessions suitable to the topic being taught along with time for practical work.
- An understanding by all staff that cross curricular work is a norm rather than special.
- An understanding by Ofsted that there is not a standard lesson plan which must be adhered to.
- An understanding that there is more to school life than Literacy and Numeracy.

g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (e.g. should there be single sex classes or schools)?

- I believe that different studies at different times in different places and with different predominant cultures have shown different answers to these questions. However I cannot recall any specific one of these. Some students work better in single sex groups where they are not distracted by the opposite gender. Other students work better when they feel competitive against the opposite gender. Gender differentiation can enhance the image of stereotypes eg: girls for Biology and boys for Physics or girls for cookery and boys for engineering. It depends on the school and local cultural environment as to what will be best for each school.

6 Accountability

Those who are responsible for science and mathematics education within schools and colleges should be accountable for their performance.

a) How should science and mathematics in a 5–19 education system best be made accountable to

(i) students;

- Students need to know that what they are being taught is applicable to them both in the present and in the future rather than a set of stuff they have to do because the government said so. The same applies to the assessment which they have to go through. So they need to see the STEM subjects as relevant to their everyday lives with the chance of opting to specialise for their future careers.

(ii) parents/guardians/carers;

- Parents/guardians/carers need to be sure that the STEM taught is going to help the students be able to cope with life, after all that is theoretically what education at school is all about.

(iii) higher education;

- Higher education needs the students to have a good firm grounding in STEM to be able to cope with what it has to offer. It needs to agree with the specialised subjects that would be taken prior to entering higher education to see that they will be relevant and that they will not need to provide catch-up courses.

(iv) employers;

- Employers need a wide range of STEM however they all need their employees to have a good basic grounding in a comprehension of STEM. They need to have an input into what is taught for basic and for specialised levels to ensure that their future employees will be able to deal with circumstances as they arise and will not need catch-up courses on the basics. They need to know what is being taught.

(v) taxpayers;

- Tax payers want to see value for money from education. They need to know that STEM subjects are an essential part of the curriculum for students to be able to then become economically worthwhile employees who can contribute their fair share of taxes as well as developing the economy of the country. They should be aware of the options available and how they are used to the benefit of the students and hence the country.

(vi) ministers?

- Ministers appear to think that levels and qualifications are the be all and end all of education. They also seem to think that academic qualifications are the only viable ones. The ministers initially need some education in the benefits of a well rounded education where students have a good basic STEM background which they can apply in a range of situations. They need to work with employers and higher education to find out what is actually needed. They need to understand the high importance of STEM in its whole to be a base for an economically viable education. They need to learn how STEM integrates well with all other subjects. They need to consider how exam marks do not necessarily say that much.

b) How should qualifications in science and mathematics be regulated?

- STEM qualifications need to show that students have an understanding of the subjects and can apply them. There need to be a range of qualifications covering the range of requirements by employers and higher education as well as the capabilities of the students. These qualifications would be best at a national level rather than different boards competing with each other. Just one set of the range of qualifications rather than multiple copies of nearly the same thing by different boards would help bring the cost down whilst ensuring that all qualifications were comparable.

c) How can we ensure that all students can access the science and mathematics courses they wish to?

- Firstly their needs to be a tie between 'wish' and 'need'. Students may not be aware of the best courses to do to enable them to be suitably qualified for their adult life. There needs to be an excellent well resourced career service available nationally with links to every school and college of further education to ensure that students can find out about careers and the requirements of those careers. Then they will be able to have a better judgement of the courses they would like to do.

- Following from this the STEM departments also need access to the well resourced career service so that they are aware of the best courses to provide for their students. These will naturally vary over the country depending on the intake level of students and the local work requirements.
- Schools then need to assess the best selection of courses for their students and ensure they have the requisite staff and facilities to run them. Cut backs in the STEM areas are not good for any educational establishment that wants to show that a high turnover of its students go into employment.

d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?

- Performance targets provide an easy way to see where to go next. However the level to which they are set can be too high and unachievable or too low and so not worth the bother. In addition they can be too many and so unachievable or too few and so not sufficiently challenging.
- They can have the effect of narrowing the field of view as the aim can be just to achieve that/those targets irrespective of anything else. Thus a lot of interest factor can be lost. This is the same as teaching to the test.
- Compulsory provision of performance targets has one trying to find something when perhaps in that area it is not relevant. And so they are a waste of time.
- Those related to STEM could include the aim to master the basic skills in the subjects.
- Having to put them each time on a student's work, knowing it is unlikely that they will be read and used is indeed a waste of time.

e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?

- The quick fix that governments like is to use exam results as a measure of performance. This does not tell that much except maybe the intake of the students. Not surprisingly Grammar schools tend to therefore get a high performance level. Exam results give an indication of the ability of the school to train their students to pass exams. They do not show how well those student will then be able to deal with their adult lives. My O Level results look good because I have Latin. However subjects such as metalwork and woodwork would have been much more useful in my life. The latest initiative of eBac tells us nothing except that some schools are now fawning to the government to push students for academic subjects that are not necessarily of much use to them.
- A much better long term measure of performance would be to look at the further education, higher education and employment levels of the students after they have left school. Not just the first year but perhaps every 5 years for the next 25 years. I may have got Latin O level, but I am now unemployed. Whereas my son spurned A Levels and uni and now runs his own business. A school whose students continue into further/higher education and then continuous employment would appear to be providing a better and more suitable education than one where unemployment levels are high.

Other comments:

- Cut backs in such areas as careers service and ranges of courses available may provide a short term savings but will also provide a long term economic down turn due to the basics for stability having been removed. Investment in the future with such areas as careers and economically viable education which lays out the importance of STEM will provide the base for a stable workforce to build on. A stable workforce then helps the economy even more by not claiming large amounts of benefits.

Roger Green, St Paul's Girls' School

1. a) What is good about UK science and mathematics education?
Recently (the past 4 or 5 years) there has been an increase in the number of students taking maths beyond GCSE after a disasterous few years at the beginning of the millennium

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
The place to start is at the primary stage; get this right and the improvements filter through the system in the fulness of time. However, sticking-plaster improvements need to be used further up the system

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
The fact that so much of the technological world around us requires mathematical and/or scientific skills (not to operate but to understand and to develop further) means that it is essential that our science & mathematical background education is strong. Everyone reads the 'papers' whether online or via tv etc and we are constantly bombarded with statistics and 'facts'. We must be able to interpret what we read and have a questioning approach. Science & maths also develops problem-solving skills which employers and higher education require.

6. a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?
Korea Japan China These countries along with probably many others are developing economically and are beginning to dominate the world's focus. They seem to be ahead of us mathematically and this is evident when we have families from these countries come over to work here in the UK and their children take up school places. They are invariably ahead mathematically, and we can see this with international competitions at school level as well (such as the Mathematics Olympiad.

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
We should look carefully at their style of teaching and the content of their curriculum/syllabuses.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Undoubtedly payment is the primary problem. If a mathematician can earn a lot more money elsewhere (e.g. in the world of finance) then it is likely that most will be tempted to work there rather than in teaching. The figures speak for themselves! Secondly status. By that I mean that if teachers are not respected by children (or even their parents) then a large proportion of teachers will leave the profession; why have the hassle? Thirdly the payment and respect seem to be inversely related to the age-level at which teachers are operating. By this I mean that status of a professor is higher than a secondary school teacher which again is higher than a primary school teacher. However, if we have our poorest paid teachers in the primary sector we may well end up with the poorest science/maths teachers operating in this sector. Yet this is possibly the most important sector of all; turn off a child at this level through uninspiring or incorrect teaching and you have possibly lost that child from the subject are for good!

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Teaching should be a graduate profession. Ideally there should be at least 1 maths specialist in a primary school (like a music or art or perhaps PE teacher), which means a Maths/Physical Science graduate! Teaching in secondary schools is dealt with using specialist teachers who should have a degree in their subject (or strongly related subject).

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
There SHOULD be inducements because there is already a shortage of GOOD maths and science teachers. There is only one inducement that is likely to attract the desired personnel - financial!

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
I don;t know what current programmes comprise, but I do know that the most important requirement is hands-on experience in teaching and to have experienced teachers (with well-over 20 years' teaching in the classroom) as mentors/tutors, and NOT people who have perhaps spent 8 to 15 years teaching and then moved out to teach potential teachers

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Use experienced teachers as advisors. Perhaps use the pool of retired teachers as mentors etc. Of course this will cost money!

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?

A problem with full-time courses is that the students have to pay. It's better to get them into the work place and pay them as a part-time teacher and have part-time courses to supplement their teaching experience.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
In all types of schools, primary/secondary, state/academy/independent. The more institutions helping out the better.

8. h) How much of this training should be spent gaining experience in the classroom?
Most of it!

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
The length of time for primary & secondary should be the same. If the student is working part-time at a school, the course should last 2 years.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
By looking at your own experiences and others' you begin to develop your own style of teaching and see other ways of teaching topics which help the students you are teaching.
2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
They should be encouraged to join a professional institution and interact with like-minded people. Often the main stumbling block is the cost (perhaps £100/year) and this should be shouldered by the school, since they will be reaping the benefit of such membership.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
No

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
There may be a case for teaching assistants who work alongside teachers, but only if there are students who require special help. Otherwise classes should be small enough for teachers to cope without teaching assistants. Class sizes are a real problem at primary level and they need to be halved!

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Any kind of centralised network is useful and this is probably best done by the specific specialised professional institutions such as IMA etc.

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?

A strong leader can be both very helpful or detrimental to the development and quality of education. Leaders who can build upon teamwork and make all feel they are contributing to the development and quality of teaching within the subject are most likely to be successful

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
Some maths and science teachers need to be in positions of senior management so that the overall management of the school appreciates what is really necessary in these areas.

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
Parental background.

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
The understanding of number is the most important of all skills and this should be developed as soon as a child enters primary education

2. b) How may the acquisition of such skills best be assessed?
There are many ways in which skills can be assessed - both formally and informally. Experienced teachers can make sensible and reliable judgements but they are likely to be biased if such judgements are then used to place schools in league tables etc. We all know exams work, to a certain degree, but we also know, for example, that the pupil obtaining the highest mark in an exam is not necessarily the best at that subject in the class.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Any transition phase is very important - it can make or break success in a subject.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

A curruculum is a framework on which to hang specific topics etc. Teachers work in different ways, often responding to the needs of the students in front of them. There should always be room/time to develop topics down avenues which do not feature on the curriculum. There is always more than one way of doing anything and this should be properly understood by leaders and parents, to give teachers the flexibility to help their students develop.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?

Since we have a change from primary to secondary, perhaps a national assessment is sensible at that stage. We currently have GCSEs, AS and A level exams, and this is too many exams in consecutive years. The A level exam is required as there is another change of establishment at this age.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Both in school, because there are social development of the student to consider as well as experimental work which is often better done with others, and out of school (perhaps from home via internet?)

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
Less. There should be more standardised approaches offering all the same possibilities. Children develop at different times and to miss out at say 11 because a child has not reached their full level of competence at that stage (eg. Grammar schools/secondary modern) is not fair nor does it allow for the true development of that individual in the sciences and/or maths.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
There should be specialists in ALL schools. ALL SCHOOLS should be good schools!

2. b) How should qualifications in science and mathematics be regulated?
Exam boards should NOT be profit-making organisations. Examiners should NOT be teaching the board they examine unless there is only 1 exam board/exam paper that students can take

Beth Hawkins, Science Museum

1. a) What is good about UK science and mathematics education?
In most part encourges the realisation that the subject are important in our lives - it is not all text book anymore.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Even more links to application of science and math and the wider reach of the subjects. Science and Math are part of so many other subjects and weaved in to so many different careers. But this really does not come through classroom education, which makes it feel as if it is stand alone.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)

Managemnt control of schools. Currently a very uncertain time. Not that it was an answer, but subject leaders with regions and boroughs could give advice/ strong direction. These positions are slowly slipping away and more focus is on leadership and management. Subjects seem to be lost.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Good basic grounding and understanding for everyone. I do not think this is just about core content. Everyone needs their education to show that science and maths are not to be 'scared' of. They are pillars of society along with English literacy. With appreciaction of science and maths, and the opportunities that they bring, we best support employers and HE.

5. Other comments
Moving to more content based curriculum which has been suggested is worring - not because we should not teach basics, but that should come through advocting different pedagogies to reach the needs of our young people today. Society and life is very different and education has to keep up.

6. a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?
China - sucessful industry, and economy USA - seen through innovation UK - Research in UK world regarded and we attract student to study and train here are HE level.

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
Making better use of technology in our classrooms - eg China

8. Other comments:
I feel we have the right philosophy about science and maths, but our application is poor and we are not listening enough to the needs of our younger generation. We need to use tools that will keep us more in touch with changing access to information, and provide skills that will tool us for the future, not to allow us to become stagnant.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Greater emphasis of professionalisation of teachers. It is a great profession, but not regarded in same way as others such as accountants, lawyers etc. We need to consider why this is the case.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
A good subject base knowledge is essential, beyond A'level qualification I feel should be compulsory. But a good teacher is not just about academic knowledge - the worst teachers I

have worked with had 1st class degrees! So much curriulum knowledge for the classroom is far away from degree level knowledge. I feel diagnostic tests would be better applied as part of the final qualification process - not to select.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Financial inducements do attract - but if the career is one that is better rewarded professionally and longerterm financially, an initial inducement should be put in to helping to keep good teachers in the profession. Annual 'rewards' to keep good teacher in the profession, would be an incentive to come to the profession - rather than getter it all up front. It is like leading the horse to the water, but we have to do more to help them drink.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
That we do train and give some context for teaching, and that we give time for students to learn the profession in a supportive environment.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
Teaching is nearly all about application, being in a classroom with a class of students. There is too much adademic study in ITT courses, writing assignments/ coursework is a huge added pressure when you are learing to find your voice and confidence in the classroom. ITT should be more about how to do the job well. To be inspired by the profession - and not be streched to do everything in a training year. If CPD was compulsory for teachers through out their career (as it is for accountants, doctors etc) this academic content could be brough in through out a career - and not just at the start, when emotions are already stretched. In all honesty, from my own experience, my ITT year was mainly about getting through the day with classes of students who seemed to battle against my teaching. Going back in the evening to then write an essay, was by far the most stressful year my whole career. We need to find to develop good teachers - not wear them out before they start!

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
An agreed ITT curriulum across UK and unite different ITT training initives. Bring focus to sucessful pedagogies - not just content and educational theory.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Content (It is very hard to be a good practivctioner in all subjects) Pegagoical techniques and tools to engage and inspire science and maths - if ITT studenst can see the wow and potential in science and maths - they will pass that on to their students. Learning outside the classroom - links in the real world can help studenst see that science and maths are subects for them and that is not confined to the classroom.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Schools and colleges Universities Science/maths institutions - lead from the front Science centres/ musuems (they have expertise in science and mathematic engagment and communication for all audiences, and this should be brought into the classroom)

8. h) How much of this training should be spent gaining experience in the classroom?
80% - as much as possible. You can't learn to teach from text book (or the internet!) The only way to be confident and effective teacher is to practice and expeience it. But regular time to take time away from the classroom, to grow and devlop, share ideas and learn new things should be integrated along the way.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
I trained in 1 year (a while ago now!), but 2 -3 years with maybe differing levels of qulaification along the way (again like doctors, lawyers, accountants etc.)

10. Other comments:
I have a very strong belief that tecahers deserve greater respect for their profession. I am embarassed to admit this in this survey, but I am never proud in meeting new people that I am teacher, I find myself saying 'oh, I am just a teacher'. Training to become a teacher was the hardest year of my life, and now working with people who are taining to teach, their life is so much harder than it was for me. Finding who you are as a teacher and getting ideas to use in the classroom is so much more important at the start of your career. I learned theory during my PGCE - but to be honest, it was all meaningless until I had a class of pupils and could take time to reflect. When trying to keep a class of 30 15 years quiet - you really don't reflect on Piaget!

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Invaluable! New ideas, new content knowledge, curriculum changes just to start with are things you need to keep you a good effective teacher.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Firstly, I have to admit I have a strong belief that CPD should be compulsory for teachers and a part of their profession (sorry to say it again, but like other professions!) Every tecaher should be alloted a number of days a year to attend triaining and this should be part of school and staff culture. At least some CPD should be conducted off school site, some should be onsite with departmental teams.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Every year teachers should be given the opportunity to take time out for subject specific CPD.

4. d) Should CPD be voluntary or mandatory? Why?

Mandatory. I have said this before, but it is important to be uptodate which subject and pedagogical developments. It is important for the profession to be seen to be skilled with ongoing skill development. If mandatory, teachers could loos teaching status if they do not keep up CPD requirments - controversal, but true of other professions.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
School and wider curriulum adgendas/ exam board changes all take up time and resource for CPD. CPD should be a school wide focus and headteachers need to understand the requirment for subject specific CPD. Government with wider adgends, often bring a need for other CPD, which often leaves little time for personal development and subject CPD.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
In some cases yes, other no. The two are always related. The needs of the teacher and the position of the teacher with in the school should drive this.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes,it is always good to know you are getting somthing for you hard work - but may not be a driver/motivator for evryone.

8. Other comments:
I left tecahing to do a masters degree in science education, and I learned SO much in that year. I had never been exposed to any other the 'current' thinking or the ideas and resources that were avaialble. I had thought that I was a on the ball up to date teacher, but so much did make it through to me. To be fair the internet was still not commonplace in schoolor at home, but still, my eyes were opened. I wrote my MA dissertation of the effective CPD and the professionalisation of the teacher, and through experience, I have seen how much the teachers gain from time out from the classroom to gain new ideas and to meet other science teacher. It does bring so much for the teachers, who inturn will bring their new ideas, and renewed energy back to their students. The best way to reach students will always be through their teacher.

1. a) How and where should we be training laboratory technicians?
Specialist training for educational technictions. ASE and science learning centres deliver this well

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Regural upadtes in new techniques, new ideas, Health and saftey as expected. Often technitions work alone or with 1 or 2 at most in a school. Best accomdated either as online CPD and an annual course.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?

I believe there is a role. It is hard to teach a class of 30 students, especially when doing lab work and also facilitating strugglu students in maths. Role would be to support students in applied work and to be an additional support to the teacher to personally reach evry child in the classroom. Trained externally - science learning centres and in school.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Everyone in some aspect should be - but not a great answer I guess. My experience has been that many teacher do not know what careers aer related to science and technology unless they research this for themselves(I for one was one of those teachers who do not know the full portential of STEm in careers until I stepped away from the classroom) Teachers need support with this, and a network of advisors would be good, obviossly there are organisations that already do do this work and more programmes that should how STEM is relevant to young peoples lives with out being to 'in your face' are often more sucessful.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Yes, this is very important. STEM is everywhere in our lives and to confin it just to the classroom, is misleading.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
I can't see why it would.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
All schools should have 'lab' environment for science including primary schools. To restrict science investigation because of basic facility is not good. Even if some facilities can be shared with secondary schools that would create a better science start in education. For both Science and Maths greater acces to computers and technology in the classroom, will start to make better links to the society that we live in. We do live in an increasingly digital society and this should be used in the classroom, not only to engage students, but also to skill them to be technologist for the future.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
Science and maths are creative subjects, but often not perceived in this way by students and often not schools. To bring science and maths into media, ar, fashion, music etc it will bring the relvance to young lives more explicit.

5. e) What other resources and systems should be used to support science and mathematics?

I have already talked about technology, but use of game and media in these subjects is hugly engageing, and can bring a lot of knowledge delivered in a way that can be more accessible to studnets.

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Teaching schools could be an excellent opportity to test and try new ideas and share best practice. We can measure by seeding inititive and measureing omapt though the tecahing school communities.

Chris Harrison, King's College London

1. a) What is good about UK science and mathematics education?
Science has, until recently, been a core subject and so has value within the school and with parents. It has strong traditions built on the Nuffield work in the 1960s and 70s and tries to incorporate application of knowledge. It attempts to teach Science for All while still providing good background science training for those who need it for a career.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
The National Curriculum along with the high accountability drive in schools has shaped science and maths into a body of knowledge to be given to students rather than the emphasis being on developing skills, ideas and understanding. Transmission mode of teaching is still prevalent and this hampers dealing with misconceptions, helping young people consider controversial issues and true investigative work.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
he style and methods of assessments support a transmission mode of teaching.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
By developing skills as well as providing knowledge

5. Other comments
Inflexibility in the school day means that science is often crushed into hour slots and this mitigates against investigative and project work.

6. a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?
New Zealand

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?

More teacher assessment and less standardised assessments. Better links with technology and the inclusion of biotechnology

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
More collaborative team approach to teaching where planning and evaluation are given as much importance as being in the classroom. Professional learning is at the centre of what teachers do and so adequate time, willingness by SLTs to release staff and finance to allow this.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Has worked with young people Degree and 2 A levels in maths or science for secondary. GCSE grade B in double science for primary teacher. Suitability better decided by interview rather than test.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Financial inducements help but some tied into the first few years of teaching may be useful to stem the loss of NQTS and early career teachers

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Many are research-informed - PGCEs, Quality and experience of lecturers is high. Good working relationships with partner schools to ensure support of trainee.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
There must be a strong focus on misconceptions work, assessment for learning, creating the dialogic classroom and subject knowledge (particularly through practical work which had been declining in schools over the last 20 years).

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
More sharing of resources. More opportunities for PGCE tutors to meet and share ideas and train one another.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Longer courses that feed into the first three years of teaching to ensure that ideas introduced i the ITT year can be supported as practice develops and evolves. In this way you get both sustained and strong teaching but also develop the capacity to evaluate and hone skills and ideas which teachers will need in the future.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Universities with partnership schools. Its dealing with the principles and how these can be applied in the different schools that trainees need to experience and not be supplied with one method that fits the school that they are in.

8. h) How much of this training should be spent gaining experience in the classroom?
About half in the first year, 75% in the second and 90% in the third year. So a 3 year PGCE and not one year as now but teachers paid a reasonable salary throughout the 3 years.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
3 years post degree for secondary 5-6 years including degree for primary Paid throughout the training period on reduced but reasonable salary

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Can be tailored to meet needs.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Through ASE and Science Learning Centres.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
A minimum of at least 5 days subject specific or learning specific CPD every 3 years.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory. Otherwise SLTs will not release teachers to do it

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
SLTs - see above Communication - Teachers do not always get information on CPD courses

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Definitely

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
If teachers demonstrate that they have been reflective and evaluative in their use of the ideas of the CPD within their practice

1. a) How and where should we be training laboratory technicians?
At Science Learning Centres and through ASE
2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?

Both subject knowledge and on innovations that demand they prepare materials differently (such as CASE)

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes. There is a need to support teaching assistants in how to support collaborative learning and dialogic classrooms. Trained at Science Learning Centres.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
We certainly need this. It is currently poorly done in schools. Teachers need CPD on this too.

Elizabeth Hope

1. a) What is good about UK science and mathematics education?
All students are involved

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Make teaching the career. At present the better teacher you are the quicker you can increase your salary. This is done by moving out of the lab into a role of "Head of yeat" and so on

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Dramatically higher than they are at the moment especially for primary.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes but expect them to be repaid if the teacher leaves the profession also expect private schools to contribute.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
University where extra knowledge can be acquired and practical trialled. if biologists are teaching physics they have a lot to learn.

8. h) How much of this training should be spent gaining experience in the classroom?
Half

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
At least a year

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
New equipment a decent amount of time is needed for familiarisation

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Journals not facebook

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
More early on

4. d) Should CPD be voluntary or mandatory? Why?
Voluntary, much CPD is pointless don't encourage more

8. Other comments:
Heads should be critisiced in Ofsted rep[orts if they fail to organise CPD for their staff

1. a) How and where should we be training laboratory technicians?
Colleges of further education

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Group meetings in nearby schools

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Something that could be done on the internet with a dedicated team

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
1)The ability to read, observe, think, recall and describe.Acquire them from an early age but do not call them science till at least eight. ii) Think, silence is needed for this activity

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Very

The focus here is on assessment but students would be greatly helped if teachers corrected their written work instead of assessing it. I coach many state pupils and their teachers only assess work. This is also ture in my grand childrens primary schools

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
yes

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
The institution doesn't matter but a quality course well structured that any reasonable teacher can follow from 8 to 16 should be produced AND not frequently changed. It should not include repitition

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
I think you would knopw if you had excellent teaching so don't worry about measuring it. Getting a thorough course which allows teachers some flexibilty to follow their or their students interests

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
Try cohorts by ability

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
More thought should be given to how students are experiencing their science education at the moment it is slow, lacks rigour and is repetitive. It now takes 11 years for a student to learn less science than they learnt in 5years in 1970. I am surprised anyone wants to teach it has become so boring.

2. b) How should qualifications in science and mathematics be regulated?
Have only one examination board and completely remove commercialisation from the provision of public exams. This would save money and hopefully slow dumbing down.

6. Other comments:
Do not ask teachers what they would like to teach ask employers, college lecturers etc

S Hunt

1. a) What is good about UK science and mathematics education?
Science is accessible to all, is relevant to the learner and helps them make informed decisions as a member of society.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Science curricula need an element of stability. Core topics remain in place over a long period (10 years or more) with an opportunity to update (knowledge and pedagogy) on an annual basis. This will allow for a more stable teaching programme andenahnce the teaching each year. large scale curriculum changes should be less frequent than 5 years to allow for embedding, practise and reduction in teacher stress.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
1) It is not normal to have students of any age to sit for 5 hours a day in an enclosed space without talking. Learning classrooms are more like prosons than a place where life skills are developed. The learning space needs innovative thought and change. 2) Learning through real life scenarios and contextualisation makes it relevant. eg Scuba diving as a multi disiplinary scientific subject taught 'on the job.'

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Skill and knowledge development are combined with enthusiasm and relevance to society and self. Well demonstrated career paths demonstrated from what is being taught.

5. Other comments
Set the scene for science and maths - Why do we need them? What role they play in our lives? The consequences of no scientific and mathemtical nowledge. How they will play a part in my future career eg nurse/checkout assistant/lorry driver/mechanic/linguist/priest/musician/receptionist/waitress, waiter/entrepreneur/bus driver/engineer etc

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Scotland: High quality teacher training and continuing teacher development after qualification. Canada: Inquiry based sceince education as a matter of normal teaching.

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
See 2a CPD: Scotland IBSE: Canada
1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
1) Appropriate student learning behaviour in the classroom 2) Reduced class sizes (20) 3) No need to reinvent the wheel to design each lesson taught and resources. 4) A less onorous weekly work commitment eg good work life balance. 5) Less marking homework /less homework. 6) Less admin 7)Respected salary. 8)Continued Subject and Pedagogical Developement as a matter of right after qualification. 9) Supported career progression. These are in order of priority.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
No Response

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
If the end product / teacher role is right no incentives would be neccessary.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
No Response

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
Encouragement of practical science skills and inquiry based approaches is needed.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Set exams in subject knowledge, pedagogical approaches and practical delivery.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
No Response

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
No Response

8. h) How much of this training should be spent gaining experience in the classroom?
The majority!

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
Depends on the student not the course!!!! Training at individaul pace and ability is needed not pushing everyone through the hoops at the same time.
1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
1) It ensures a base level of information required to teach that subject. 2) Keeps the teacher up to date with their subjects advances and its method of delivery 3) Creates/maintains enthusiam for the subject and its teaching, keeping the teacher engaged and positive about teaching. 4) Makes the subject come alive in the classroom engaging the student and facilitating their learning. 5) Better subject knowledge and enthusiasm brings about better attainment. Better attainment will hopefully increases career prospects leading to a happier life with a good standard of living.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
1)Attend a minimum of 3 external CPDs per year (one in subject knowledge, pedagogy, assessment or student monitoring) PLUS 2) Have in school demonstrations of best practise and increased subject knowledge. 3) Reflective practise encouragement. 4) Constructive feedback from colleagues on a regular basis who have taken part in their lessons.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Every term teachers should have the ability to attend an external CPD led by an expert in that field. These CPD providers would be on a registered approved list of providers to ensue quality.

4. d) Should CPD be voluntary or mandatory? Why?
Would you ask the same question of Doctors? Of course keeping up to date with knowledge and skills should be madatory.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Teachers find it difficult to leave the classroom because 1) Senior Management do not support CPD and therefore make approval difficult. 2) Financial constraints - Make it a requirement that they must attend at least one and hopefully 3 CPDs a year. Give the schools a ring fenced budget (use or loose it at the end of each academic year) 3) Onerous admin - simplify the process 4) Disruption of the classes on the CPD days - do them en mass on designated training days/holidays 5) Extra prep time to leave cover lessons and then to mark those lessons on return. See 4. 6) No encouragement to use newly gained knowledge/skills - programme in place that HoD is fed back to and useful info/skills passed on or used to enahnce the scheme of work.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes and No! Increased knoweldge, ebthusiasm and skills should be linked with increase in assessment. Leadership within subject specific courses would be an optional CPD choice.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
That would be a good incentive. You need all Masters to be able to accept accredited courses throughout the country.
1. a) How and where should we be training laboratory technicians?
In a lab! With great respect! On a regular basis.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Subject knowledge eg Biol/Phys/Chem. and then Microbiology, radiation etc Skills Health and Safety Good lab practise Progression

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Technic support and smaller classes would be better than teaching assistants!

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
I have never seen one person be able to advise well on all aspects. Some goos Careers video clips would be better. Especially those that destroy misconceptions eg Forensisc science degrees allow you to become a forensic scientist!. You need A levels to become a nurse!

5. Other comments:
This survey is too long and doesn't inform you how much more there is to complete!
1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Practical and Inquiry skills are especially important for science and scientists.

2. b) How may the acquisition of such skills best be assessed?
A practical series of exams or a terminal practical exam. Assessed in house and/or externally.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
A year 7 teacher should be aware of what topics have been covered at KS1 and KS2. However, each primary school will have taught the content to varying levels, which makes the transition a bit of a farce. In real terms a Year 7 teacher should engage their students in practical science which includes a revisit and reinformecment of the knowledge which should have been gained at primary school. Annecdotely and from experience year 7 students are excited by practical science and are engaged and focused. You can see their interest and focus reduce in year 8 and 9 for a percentage of the class. The question for science is not about the importance of transition between primary and secondary science, but the drop off of appliocation from year 8 onwards.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
i) teacher more practical science in teacher training courses. More CPD on subject and skills. ii) Some preferno practical. This is not to be encouraged surely. Guidance is what is needed. iii) We can not learn everything at school. Continued learning is a life long thing. Perhaps a school leavers sceince club for adults? iv) open projects based upon students

own interests. eg extended project at AS/ Open Uni style self tution short course included AS/A2 and even triple science.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
Doing not just writing! Allowing the student to think independently.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
Geography, Religion, Maths, D&T, PE, History, Literacy, Art, Home Economics etc all have apsects of science and maths which are already assessed as such. Don't confuse assessment with learning or understanding. What benefit would asessing in different subjects give? Get the subject content, context and pedagogy right first. Consider and research a variety of assessment methods and gain evidence over their effectiveness on stimulating understanding and application and being able to compare abilities nation wide.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
Year 8, and then after to childs ability.

8. h) What evidence of learning is needed for assessment to operate effectively?
Factual recall. Application. Application in unfamiliar contexts. assessments allowing comparisons between indiviudals to set an attainment level eg Grades A*-C etc

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
As much outside the classroom as possible to engage with the real world and true life.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
No it will not benefit from more diverse - why should it? It is just more confusion for the parent, child and teaching profession. It is the standard of school and curriculum that is important.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Out door learning in the environment and work place. more experts brought into the classroom or visited. More hands on science.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
No Response

5. e) What other resources and systems should be used to support science and mathematics?

Outdoor spaces/work place visits/friendly expert/science in the news video and newspaper clips / challenges

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Science: More technician support / increased hands on practicals / more enthused knowledgable teaching / less curriculum volume / more outdoor learning / more visiting experts

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
There is much research on this!!!

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
No Response

2. b) How should qualifications in science and mathematics be regulated?
By a public sector body not the government both for curriculum setting and assessment. This is not an area for meddling to get votes or profiteering.

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
Less courses and obligatory study.

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
No Response

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
Performace of teachers/students/schools are all linked. Although it is the students performance which is judged as the overall measure of success or failure by parents, students, Ofsted, Senior management, industry, HE establishments. Student performace depends on a pleathora of reasons ranging from nature and nuture to the teaching and facilities.

Howell G Jukes

What is good about UK science and mathematics education?
I did an "A" level course in Pure and Applied Mathematics in the mid '60's. I had an inspirational teacher and a tightly drawn syllabus to work to - and I achieved an "A" grade in

the subject. UK science and mathematics education is only good if these high standards have been maintained.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
The play of very young children should be so designed and directed that they absorb concepts of number, size, weight, speed etc. without having to consider these as abstractions: the separation of the overall experience from the "mathematical properties" of the experience should possibly be left until later in the child's development. It is of paramount importance that the bringing about of mathematical insight, and the aiding of pattern-perception, should be the items to be concentrated upon. The availability of support modules downloadable from the Internet will be an invaluable resource for a future teaching programme.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
The politicisation of the teaching profession, especially since the 1960's, has been an absolute disaster. The attempts at "social engineering" that have resulted have signally failed. Students' different ability ranges, and different capacities for abstraction, may require the employment of different teaching methods. One has the distinct impression that the "one size fits all" dictum has gotten far too strong an influence on current teaching methods.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Sciences and mathematics should first be taught as practical subjects. The progression, from the practical and fundamental to the abstract and theoretical, should be a gentle one - and should depend upon the student's revealed ability. A judicious mix of pure and applied mathematics should enable the requirements of employers, and academia, to be satisfied.

5. Other comments
Research into the fundamental psychological processes whereby mathematical concepts become established should be undertaken as a matter of urgency: it is obvious that either there is insufficient knowledge in this field, or that the present body of knowledge has not been fully transposed in teaching methods.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
China, South Korea, Russia

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
The consistent winning performances of the Chinese in the Mathematics Olympiad needs some explaining. Do pictograms give the Chinese an advantage in "non-verbal" thinking? Are mathematical concepts better formulated via the differing "thought fields" of these languages?

8. Other comments:
We should accept that, on present evidence, many other countries are more successful in teaching sciences and mathematics than we are in the UK. Professional researchers should, accordingly, be despatched to these countries to study their teaching methods.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
The status of teaching itself should be raised to the level achieved in the '30's, '40's and '50's. Significant salary premiums for the teaching of these subjects should also be introduced - although it is fully recognised that this might be exceedingly difficult politically.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
"A" levels (i.e. "A" levels as they were in the '60's). Aptitude tests for both teaching, and science and mathematics, should be instituted.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
The absolutely vital importance of these subjects to our economic and social future should be fully acknowledged; with all the necessary inducements being offered to ensure adequate take-up.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Internet-based courses, similar to those offered by the Open University. Each student/teacher would then be enabled to progress at his/her own pace.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Universities Mathematics of Science Faculties. This is necessary because of the high-level of understanding that must be gained in the subjects themselves, and in the methods whereby this knowledge is best imparted.

8. h) How much of this training should be spent gaining experience in the classroom?
One imagines a considerable amount; since the subjects appear to be beset by problems associated with the acquisition of the body of knowledge within each subject, and with the difficulty of imparting that knowledge effectively.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)

The standard of career advice available when I went to Grammar School (early-mid '60's) was truly lamentable. Nowadays, however, internet-based support in this field should be capable of remedying this.

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Leadership qualities have a vital bearing on effectiveness in all fields of professional endeavour. The resistance to the recognition of this is, itself, a major problem.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
Inspirational personalities, capable of enthusing a broad range of students and pupils, are to be prized; but leadership skills can be taught. It seems necessary to point out, however, that class sizes should be sufficiently small to enable real relationships to be established between the teacher and his pupils.

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
The basic enthusiasm has to be present in the teacher. Leadership implies the ability to encourage leadership qualities in others - and this applies to school and college leaders.

4. d) How can leadership pathways for experienced teachers be introduced into careers?
Surely all teachers of experience will already have expressed aspects of leadership within their own careers.

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
I'm afraid (that is to say that I am aware that it may be considered "politically incorrect") that it must be recognised that the creation of "esprit de corps", via the encouragement of competition on the sports field, engagement in music and drama events and productions, the encouragement of "pride in the uniform", and the building of, and adherence to, a body of school and college traditions, are all vital tools for the creation of a positive ethos for any academic institution.

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Leadership has great influence in these matters. The creation of sporting heroes is comparatively easy: the creation of mathematical and engineering heroes is also possible - the ethos of the institution being instrumental in this. Every attempt should be made to ensure that these endeavours are considered "cool".

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?

Governing bodies, insofar as they are peopled by people of experience, and sense of duty, can obviously be influential in ensuring that the teaching professionals are reminded of the importance of high performance in the fields of science and mathematics.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Everywhere.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
The importance of these subjects should be capable of being highlighted whatever the institutional structure.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Computer facilities would obviously enable pupils to ask any question, at any level, in furtherance of their scientific and mathematical knowledge.

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Performance targets have been so universally mis-used (and not only in the educational field), that the greatest care should be taken in their use. It is my experience that enthusiasm and commitment are not easily subject to evaluation via such regimes.

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
Records of the career paths of ex-pupils and students are the best means of indicating the success of the teaching methods of the institution.

6. Other comments:
I am a little mystified as to why the Royal Society should ask a Welsh farmer for his opinions on the subject of education! But I am aware of the dire position of the teaching of mathematics and science in our schools and colleges, and of the adverse comparisons with the performance of other countries that have been highlighted in recent years. I have recorded my opinions as an indication of the great importance that I attach to the questions addressed; although I must stress that they are the opinions of a non-educationist, and a non-expert - but an enthusiastic reader about all things scientific. It is to be noted, also, that I have always been extremely grateful for the knowledge of the sciences and mathematics that I managed to acquire. I also have great pride, by association, concerning the considerable achievements, in the fields of science and engineering, of my more diligent school colleagues. Howell G Jukes

Chris King, Keele University

1. a) What is good about UK science and mathematics education?
The breadth and balance of the current curriculum - giving all pupils a background in 'scientific literacy' that will be very valuable to them and also giving the scope to develop thinking and investigational skills, as well as the background necessary for A-levels.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
As science advances, the science curriculum balance will always need adjustment - but hopefully not by losing the breadth, balance and investigational aspects of the curriculum.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Government pronouncements on the training of biology, chemistry and physics teachers - thankfully, most of my teacher education colleagues still train science teachers with specialisms - ie, teachers capable of teaching broad science at KS3 level with specialims beyond that. We also need to maintain teacher training for geology teachers - which is an 'at risk' area - with an allocation of only six per year, at present (and seven vacancies so far advertised this year).

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
By inspiring young people to take science to the highest levels - through which, if taught effectively, they will develop the thinking skills that will equip them well for employment and HE

6. a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?
Korea, Japan and Taiwan - each of these countries has a quarter Earth science in their compulsory science curriculum.
7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
Some of the best Earth science teaching is based on curriculum development projects of the '60s and '70s in the USA - in which practical activities are used to exemplify the teachers and 'bring it to life'.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
In juridictions where most excellent teachers are found, teachers have high prestige and are remunerated very well. It is sad buut true that where other career choices pay better - people are not willing to put themsleves through the mill of being a full time teacher, when there are easier options.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Secondary science - two science A-levels and a degree in a recognised schol scienc esubject - biology, chemisty, physics or geology; also GCSE Maths and English. Some trainees in the past with thirds have become excellent teachers, whilst some much better qualified, have failed.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Financial inducements are likely to be the most effective - particulalry in the new 'high fees' environment.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
In most - the broad science background offered, along with specialist training - together with the strengthening links with partnership schools - in ITT programmes with strongly maintained partnerships.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
Most ITE lecturers (and I weite as Chair of the Midlands Scienc eConsotrtium of ITE Science Lecturers) - consider they are doing an excellent job - sometimes despite the system.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
By inspecting teaching rather than paperwork (ITE lecturer teaching of trainees and trainee classroom teaching)

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
OfSTED evidence has consistently shown that institution-based ITE courses are more effective than all other routes - so these should be suported and enhanced.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
The current PGCE balance with 1/3 of time in an ITE instution and 2/3 of time in school seems to be working well. However, we always struggle to find enough high class science teaching placements in schools. Schools should be encouraged to take part in teacehr education much more - to ensure more high quality placements.

8. h) How much of this training should be spent gaining experience in the classroom?
2/3

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
the one year Subject Knowledge Enhancement (SKE) courses followed by one year PGCE courses provide trainees with excellent skills and backgrounds - suggesting that all traines would benefit from such courses.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Where the CPD is of high quality - not only is its impact profound, but also it should be the expectation of every professional to be educated in this way.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Through hihg quality CPD - that is recognised as such in their career plans.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
All teachers should have an annual CPD input (in similarity with the Scottish model) - with options for broader CPD development through MEd modules.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory - as in Scotland - but policed more effectively than it is north of the border - so that the high quality of the CPD is monitored and maintained.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Finance is a major issue - since science teachers have become so used ot accessing 'free' CPD through the Strategy and Scienc eLearning Centres, theat schools have become unwilling to pay for CPD. Teachers would also value CPD much more highly of there were an effective accreditation system linked with it.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Some shoul dbe linked to broader strategies, but some should be linked to the normal professional development of a science teacher.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
There should be a range of accreditation mechanisms, including Masters-level credits (Masters-level credits would not be appropriate for some shorter CPD courses - but these shoudl also be accredited, if at a lower level).

1. a) How and where should we be training laboratory technicians?
The training of technicians through Scienc eLearning Centres has been very effective and highly regarded, by both technicians and their schools.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?

Technicians need CPD in in the management and administration of their own workloads, but also in contributing to science teams in school and in supporting new 'cutting edge' investigational and other practical work.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes, providing they are subject trained. 'General' teachign assistance have proved to be of lower value than scoemce-trained TAs, who undertand that their role is to develop the thinking skills of pupils and not just give them the answers.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
If this were provided direct to science teachers through CPD - then it would have more impact, since pupils would value the careers input (if up to date and substantive) more than that of a 'career adviser' stranger.

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
It is critical for young people to develop thining and investigational skills - and lessons should be geared to this purpose.

2. b) How may the acquisition of such skills best be assessed?
By much higher quality questions than those currently being asked in many GCSE science papers.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
No Response
4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

Investigational practical work should be assessed effectively. Fieldwork should be mandatory - and therefore an expectation of all pupils undertaking science. Teachers judgement is being skewed by the demands of the GCSE assessment system - by asking questions requiring higher level thinking skills - science teachers will be encouraged to teach for the aquisition of such skills

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

Incoulding ranges of questions - including taxing higther level questions to stretch all students, including the more able.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
It is unlikley that science coulnd be assessed effectively elsewhere.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
16 and 18

8. h) What evidence of learning is needed for assessment to operate effectively?
Evidence that students have gone beyond recall, and therefore are using higher level thinking skills.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Optional lunch time clubs have proved effective in enthusing students, and should be supported. Many schools require homework, but it is of low quality, when higher quality homework can be of greater value and be more inspiring.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
No Response

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Well-equipped science labs are crucial.
4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
No Response

5. e) What other resources and systems should be used to support science and mathematics?
All labs need good ICT systems

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Support at the highest management levels for well-planned science fieldwork to be run at intervals during the school careers of pupils.

Professor Diana Laurillard, The London Knowledge Lab, Institute of Education.

Professor Rose Luckin

Professor Richard Noss, Director Technology Enhance Learning research programme, The London Knowledge Lab, Institute of Education.

Professor Aaron Sloman, Dept. of Computer Science, University of Birmingham.

Professor Mike Sharples, Institute of Educational Technology, Open University

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Professor John Slater, Director of Development, Association for Learning Technology (ALT)

Seb Schmoller CEO, Association for Learning Technology (ALT)

Joint response to the Royal Society's call for views: Vision for science and mathematics education 5-19.

This response has been prepared by a consortium of the leading Technology Enhanced Learning (TEL) research labs in the UK, in collaboration with the UK's Technology Enhanced Learning research programme and the Association for Learning Technology (ALT).

Summary
We welcome the opportunity to contribute to this Royal Society project. Our response highlights the following key ways in which science and mathematics education could be improved:

- Learning technologies offer unprecedented opportunities to improve learning outcomes for all learners.
- We need to harness the opportunities that such technologies present. Students need to **construct and reflect** on mathematics and science; chalk and talk 'delivery', even if on a whiteboard rather than a blackboard, is not enough, and may be inneffective.
- Learning technologies need to be introduced to all teachers along with an increased focus on pedagogies that exploit digital tools and resources for active learning about science

and maths. Such technologies are also effective for supporting communities of practitioners and for CPD.

- Technology can provide an effective mechanism for both formative and summative assessment and is currently under-utilized for this.
- Problems that apply more generally to education must be solved in this wider context and not localised to specific subjects.
- Science and mathematics must be celebrated and teachers across all subjects must be encouraged to take pride in their expertise in their chosen field(s).

General questions

Whilst of course we welcome this endeavour by the Royal Society we are disappointed that the remit of the project does not sufficiently address the important role that learning technologies can play in education in all subjects, including science and mathematics. The UK is a world leader in research that explores how technology can support learning and truly to maximise the success of science and mathematics education in the future, we must harness the opportunities that such technologies present. We note that the working group membership does not currently include such expertise and we believe that the group would be strengthened by including this expertise (Question 1b).

There is a need and opportunity to engage young people in ‘personal inquiry’ into scientific and mathematical topics so as to give these topics personal meaning and engagement with their lives. That could mean topics that directly affect them (such as fitness and diet), or ones that pique their interest, such as global warming or the effects of pollution on animals. New personal technologies can enable young people to carry out structured investigations – to enhance their understanding of scientific method, and their positive attitudes to science and scientists. Including and beyond young people a central issue is how to enable people without advanced scientific training to engage in the science that affects their lives. This can be achieved through informative media (e.g. BBC) linked to ‘learning journeys’ that engage people in curiosity-led learning about scientific topics and engaging people in doing active ‘citizen science’ – to benefit scientific understanding and to engage young adults as participants in active science. In mathematics, the challenge is to unlock some of the exciting mathematical doors that are embedded in our everyday lives – and to create computational systems that allow mathematics learning to become experimental and experiential in ways that were simply impossible before the advent of digital technologies (Question 1b).

We are concerned that the UK is not changing sufficiently with the times. It is as scientists mature that their worth becomes apparent, so we do not yet know if we are still developing the same level of scientific capacity as was the case say 10 to 25 years ago. Teaching of both science and mathematics need to be more inspirational. Cultural change and the underpinning support infrastructure must celebrate scientific endeavour and success. Science education is still very traditional and does not take advantage of the potential offered by technology in the way that practising scientists do in their professional work. Teaching methods need an update and must be seen to be “real world” and relevant to future careers. There needs to be more personalisation to improve every individual's attainment and more active learning to improve the motivation to learn science and mathematics (Question 1b and c). It is important to avoid localising general educational problems to science and mathematics (or any other subject). These problems can only be truly solved by seeing these issues within this wider context (Question 1c).

Current discussions of computing education focus far too much on the needs of computer science degrees and IT employers. Although these endeavours are important, this focus is too narrow. For a science and mathematics education system to best meet the needs of employers and higher education, we need a coordinated system in which young people are engaged in building, testing and critiquing models - as a scientific and mathematical activity. The kind of computational thinking involved is important for everyone. It isn't only computer scientists who benefit from computational thinking. So much of the natural, artificial and social world makes use of complex information processing systems. We must focus more on computational needs of research across disciplines, including psychology, neuroscience, psychiatry, biology, epigenetic processes, evolutionary processes, medicine and the complexities of social and economic systems. With the topic of this call for views in mind, we would also stress educational processes here, e.g. what information processing allows a brain to support powerful mathematical and scientific reasoning capabilities? Currently there's practically no support for any of this in schools, so people have to start learning at university, which is (a) too late and (b) not something that most university teachers can teach as they are products of this same outdated system. In a recent study of how people interpret computer outputs in their workplaces (Hoyles et al) researchers found that many people were completely unaware of the systems that underpinned their working lives. People need to understand the ideas behind the computer models that are working behind the scenes to gain a sense of empowerment and job satisfaction. Essentially these are the new literacies that people need to be workers and citizens of the 21st century. (Question 1b; Question 1d)

'High-quality' science and mathematics education can be found in countries such as Russia, Finland, Germany, Luxembourg, Japan. Key elements of success here include (Question 2a; Question 2b):

- Preventing narrowing too early.
- Ensuring scientific and mathematical literacy are seen to be important for all.
- Ensuring universality: maths and computing are for more than just CS and IT.

Teachers (and the wider workforce)
To make teaching a top career choice, we need exciting and challenging postgraduate courses leading into education. These could, for example, combine research on educational techniques and learning mechanisms with learning about the best available forms of teaching, thereby contributing to the evidence base for sound decisions about policy and practice. Clearly communicating such interesting opportunities might help to attract some who currently go into other fields. Teaching, including mathematics and science, needs to be viewed as a high status profession. (Question 1a; Question 2e)

For admission to initial teacher training, degree class is much less important - being a teacher requires special aptitudes which take time to develop. Mathematics teachers must understand what a mathematical proof is, why proofs are required in mathematics and that the same result can often be proved in different ways. They must be able to diagnose intelligent but incorrect thinking in a very bright students (e.g. coming very close to a correct proof), to avoid killing the potential of bright learners. (Question 2a)

Learning Technologies and Computer Science need to be introduced to all teachers in a way that changes attitudes, plus an increased focus on pedagogies that exploit digital tools and resources for active learning about science and maths. There is almost no focus on special needs - dyscalculia guidance has almost disappeared, and many teachers do not even know about it. The teaching of programming is now just beginning to take off again, as a result of the work of the ComputingAtSchool (http://www.computingatschool.org.uk/)group and others. But the process must not be controlled (Hi-jacked) by educationalists whose main aim is to get more good students into CS degrees and into jobs with IT employers. The need for computationally educated thinkers is just as great and just as urgent in a wide range of other academic disciplines and walks of life. Unfortunately most people now discussing what sort of computing should be taught don't understand that (Question 2d).

The quality of science and mathematics initial teacher training programmes could be improved by making the STEM teachers more of a community of practitioners experimenting and learning about how best to teach their subject. We believe that very bright teachers must be given far more freedom to be creative and to push their learners in directions that suit them, rather than constraining them to fit into a national curriculum that is inevitably a based on compromise. (Question 2e)

Science and mathematics teacher training should take place in institutions where science and mathematics research is happening and in schools. Institutions should be encouraged, or even obliged to introduce potential science and mathematics teachers to the ways of thinking of some of the most advanced and creative researchers, e.g. as guest speakers. (Question 2f). We also need to attend to teachers of other subjects who do not reinforce numeracy in the same manner as they do literacy (Question 2 Other comments).
Keeping up with major aspects of the development of a field is essential for people teaching that field. We noted earlier that teacher training should provide access to the ways of thinking of some of the most advanced and creative researchers. Access to high calibre, inspiring scientists could also help. We should not underestimate the value of web-based video channels such as the Royal Society's own for this. This would ideally continue throughout a teacher's career. The most successful CPD will include a significant peer element. Good practice of any subject needs to be shared and Learning Technology based CPD provides a major possible route. Make the STEM teachers more of a community of practitioners experimenting and learning about how best to teach their subject (Question 3b). The National Centre for Excellence in the Teaching of Mathematics (NCETM) "shows a way forward in terms of creating a community of teachers who are" (https://www.ncetm.org.uk/.): The National Centre for Excellence in the Teaching of Mathematics (NCETM) aims to meet the professional aspirations and needs of all teachers of mathematics and realise the potential of learners through a sustainable national infrastructure for mathematics-specific continuing professional development (CPD). The NCETM provides and signposts high quality resources to teachers, mathematics education networks, HEIs and CPD providers throughout England. At the same time, the National Centre encourages schools and colleges

to learn from their own best practice through collaboration among staff and by sharing good practice locally, regionally and nationally. (Question 3b)

The wider workforce of support staff need to be trained to be flexible, for example, we should not underestimate the importance of IT support staff who need to have wider horizons than simply the standard business applications and systems that tend to be embedded into school-based practice. This issue has done a lot of harm (Question 4a). Teaching assistants remain important and could benefit from training in the workplace where learning technologies can provide vital distance learning opportunities and offer quality assurance. TAs provide key support when they encourage learning to talk about what they are doing (Question 4c).

Teachers need to persuade learners about the importance of science and engineering in the wider workforce. This is a job for all of them. They need to be role models (Question 4 - other comments).

Leadership and ethos
The words "role models" cannot be stressed too much - whether the models come from governors, head staff, staff or somewhere else. The more that role models that believe that maths and science are important the more likely will the pupils follow suit.

Skills, Curriculum and Assessment
In Maths some key aspects are missing in the curriculum: an appreciation of how to interpret numbers/statistics including at various levels; common ways of representing data (exploratory data analysis); back of envelope calculations more underpinning for subsequent CS: examples that include complex logic, more binary, sizing problems, common CS algorithms, sources of error. All of this is universal and should be included at all stages. A good teacher will not discourage learners from getting things wrong, because often that's a deep part of learning why something is right. Computer Science is also very much part of Maths and Science and needs to be treated as part of STEM (Question a).
Recent trends and developments in technology as well as a rise in social and collaborative networks have generated an increasing interest in the use of technology as a support for formative assessment. Examples include the use of e-voting systems (Hanley and Jackson, 2006), learner e-portfolios (Kimbell, 2008, Tolley et al.), diagnostic testing environments which offer adaptive, ipsative assessment data for teachers and students over time (Winkley, 2010, Ripley, 2007, Bull and Kay, 2007, Zapata-Rivera et al., 2007), use of handheld devices to capture data (Bennett and Cunningham, 2009), activity logs, timestamps, version tracking, target-setting (Jewitt et al., 2010), self-guided learning (Sainsbury, 2009), learning journals, and so on. Less well-developed, but increasingly emergent, are new forms of e-assessment, which take into account opportunities for technology-supported peer, collaborative, and self-guided learning (for both teachers and learners) using online social networks and read-write technologies such as web 2.0. (Luckin et al., 2008, Elliott, 2007) as well as for increased parental participation (Lewin and Luckin, 2010) via distributed learning networks. (Question b) Technology can support transitions between different elements of the education system (Question c).

Infrastructure

Labs remain necessary but can be supplemented with virtuality. Instead of hoping to re-fashion schools, we now have the opportunity to design computer-based laboratories that can support personalised and shared inquiry within and beyond the classroom (Pea et al., 2011; Mulholland et al., 2011). Mobile devices including smartphones and tablets have become scientific toolkits, combining cameras, environmental sensors, compasses, voice recorders, and position locators with powerful multimedia computers. Networked through high bandwidth phone connections they can enable simultaneous distributed inquiries across many locations. This process of distributed inquiry needs to be managed, so as to enable productive learning through proposing of new inquiries, investigation, analysis, collaboration, and debate. (Questions 1d and e)

Accountability

Science and Maths should be made accountable through the same accountability structures as the rest of education. This is not an SC&M problem. (Question a)

We welcome the opportunity to contribute our views to this consultation and would be happy to provide further detail or oral evidence to the working group. For more information, please contact Professor Rose Luckin [Professor of Learner Centred Design, The London Knowledge Lab, Institute of Education.].

Further colleagues who have provided input to this response include:

Professor Richard Noss, Director Technology Enhance Learning research programme, The London Knowledge Lab, Institute of Education.

Professor Diana Laurillard, The London Knowledge Lab, Institute of Education.

Professor Aaron Sloman, Dept. of Computer Science, University of Birmingham.

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Peter Jan van Leeuwen

1. a) What is good about UK science and mathematics education?
Some of the teachers

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
No science and maths teaching before the age of 7, a waist of time for the system, and the children need to learn other stuff at that age!!! No GCSE exams for the brighter students, a lot of time spend on exam training, not on the exiting stuff. Both my two boys, aged 14 and 16, are/have been bored by the slow pace up to the GCSE exams, almost completely killing their interest in science especially!!! Less web-nased learning. Both my boys missed a good structure, only when I did bring in a few reasonable revision guides (hard to find, way too colourful) they start liking science again.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Starting science and maths education too early, and the GCSE exams for all, see answer previous question. Also the small number of A level subjects.Again, get rid of the GCSE exams, do something sensible in those years to free time for more subject at A level. Finally, the web-based learning. It is messy. A well-structured book is so much better, see previous answer.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Good inspiring teachers. Don't start too early (see above), no GCSE exams for brighter students. Not too much web-based learning, where are the good old books? (see answers question b).

5. Other comments
In the end, it all stands or falls with good teachers. They have to be well structured and enthusiastic, and open for questions from the children. Finally, beware of 'teaching experts, rely on experienced science teachers and scientists. Same for maths.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
The Netherlands (own experience at University there, but it is degrading), Germany and France. No distracting exams at the age of 15, well structured lessons.

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
See my answers for question b)

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Good salary Good support from schools, esp. regarding 'difficult' children

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Primary science and maths teaching (i.e. to children aged below 7) is counterproductive. Please don't do that!!! Secondary: BSc science and/or maths, and ability to think well structured and teach that to children.
2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Better salary

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
No science teaching to before 7-years old, see above. Also, abandon GCSE's for the brighter students, and teach them only by 'A-level qualified' teachers.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Some basic understanding of what to learn when, what belongs to which age group etc. For instance, we know now that some organisational skills only develop after the age of 18, so don't force them onto children of 16/17!

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
No real preference, but the teachers at these institutes should fully understand their subject.E.g. that science and maths are creative subjects, that equations are short-hand notation for a whole world of ideas and concepts.

8. h) How much of this training should be spent gaining experience in the classroom?
Hard to provide hard numbers, but a consideral amount, with the best teachers...

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Keep up to date with new stuff, so to keep enthusiastic.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Once every 2 years (?)

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory, you have to be able to engage in the new science/maths and keep children entusiastic.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Not necessarily.

8. Other comments:
The instructors have to be of really high quality.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
I don't think so...
4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Such a network might be a very good idea indeed.

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Enthusiasm, enthusiasm, enthusiasm. Year 7 and later. No science without maths.

2. b) How may the acquisition of such skills best be assessed?
Tests that inform the teacher what the children have learned and did miss, to guide further teaching.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
No GCSE's for the brighter students, please, see previous answers, get rid of this difference.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the

specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

i. A mistake made in GCSE's is that theory and applications are mixed up contineously, leaving pupils confused. first treat the basic material completely, than treat one or two applications in depth.,

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
Explain to children why they are assessed, not to judge them, but to figure out where to put extra efford.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
No a good idea in my opinion.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
No GCSE's for brighter kids, see e.g. german system.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
Make distinction earlier, see previous answers on first page.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Good well-structures books to learn from.

5. e) What other resources and systems should be used to support science and mathematics?
Not too much web-based learning. It's is chaotic.

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
No single sex schools or classes, that was something from at least 50 years ago. It is so damaging for normal behaviour.Boys and girls should learn that it is completely normal to talk to eaxhother without sex-related issues playing a role. The UK youth is a bit weak at that, to say the least...

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
It's also about ability and hard work.

Dave Leese

1. a) What is good about UK science and mathematics education?
How science works if it is taught well. Good background knowledge from all subjects

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Needs to be focussed on current science in the real world to engage students

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Restriction of post-16 budgets in schools

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
University courses with years in industry. Industry sponsoring bright A-level students, possibly mentoring them?

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
Small class sizes, trusting teachers on exams

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Money, good systems in schools to control behaviour, thorough professional development

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
2ii Enthusiasm for subject and time spent in schools before applying as technitions or as teacher support staff should be looked upon favourably. Time spent in industry should be looked upon well

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
I think inducements work. Perhaps it would be better to move teachers who hit performance management targets up the pay scale faster than giving lump sums just after training.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Time spent in classrooms. The ones that try and force teachers to do MEd's are not necessarily the best. The ITT programs should be viewed as extended induction programs.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?

More real world teaching, lesson analysis of historial educational papers from when evidence based education was not really practiced

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
OFSTED type monitoring. ITT providers should be paid on the quality of the graduate they produce, not the qualtity. Extra funding for courses that provide high quality teaching. Teachers could be followed up by the unis after 1 year etc.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Ideally full time because it shows the comittment needed to be a teacher

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
University do a reasonable job, but tend to be overly academic. Good schools could be paid to train teachers and they could get support from unis for part of the course.

8. h) How much of this training should be spent gaining experience in the classroom?
As much as possible. It is only when you get into a classroom that you realise if you can do the job or not.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
I see no reason for courses that are longer than 1 year. I think it is an advantage if teachers do not go straight from university degrees to teaching. A career other than teaching is an advantage first, it can be anything though, working in a call centre to being a research scientist or an accountant.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Confidence in subject delivery and content. Being able to address pupils misconceptions and answer questions as well as possible.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
If STEM teachers do not keep up to date they cannot move up the pay scale. Doctors have to be revalidated and show they have kept up to date. Why not do this with senior staff (on UPS) or those in management poitns? You should have a personal development plan that can be used a part of robust performance management.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Action research projects shold be undertaken by people looking to move onto UPS or into management. This shows a dedication to the job and a willingness to improve. CPD early on in your career can boost confidence and improve practice. It should be an ongoing process
4. d) Should CPD be voluntary or mandatory? Why?

It should be mandatory to a basic minimum (changes in assessment and curriculum) beyond that it should be voluntary. Leaders should want to improve their practice and that of the people they are in charge of - it is what they are paid to do to a degree.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Knowlege in schools and a lack of robust performance management. If performance management targets are not met, they may be just recycled onto the next set of targets. There is training there, you jst have to be motivated to look for it.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes. Leaders should be able to do research to improve their practice, and diseminate practice across their own school and within school partnerships..

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes. A non university "vocational" diploma or masters level qualification could be generated. The quality of CPD should be assessed by OFSTED.

1. a) How and where should we be training laboratory technicians?
In the prep room, and at places like the science learning centre for techs that are really keen. Good techs make the world of difference in a science department.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
They need basic lab skills and ideas they have should be listened to!

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Difficult to answer. Teaching assistants are not teachers. Teachers should be able to provide cover lessons that are of a suitable level for teaching assistants to cover. People helping out SEN pupils need a set of answers.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Train up STEM teachers. It could be part of progression onto UPS. Ever school should have someone with some experience in this area.

1. a) What impact do teachers’ leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?

No concrete veidence is around as far as I am aware. Get people doing small projects nationwide to look at this. Most STEM teachers have some form of higher degree and should be able to cope with this. Good communication and strong leadership is needed.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
Communication skills and planning

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
Use a robust performance management system to identify people who are motivated and suitable.

4. d) How can leadership pathways for experienced teachers be introduced into careers?
Via meaningful robust performance management. Excellence should be rewarded

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
Consistant application of sensible rules decided by senior management. All teachers apply the rules. Positive culture within the school.

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
The DoE have a bigger role by introducing things like the English Bacc. Courses get cancelled because of decisions like that. The quality comes down to consistance of message from leaders. Evidence is difficult to descibe without naming names.

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Literacy and numeracy start from a very young age. Without these things science and maths are unobtainable, as is most of the school curriculum.

2. b) How may the acquisition of such skills best be assessed?
Test on leaving primary school. Pupils should be able to read and write at this stage. If they cannot, for whatever reason, they should be given extra lessons in secondary schools so they can access the curriculum at a later date

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Secondary schools expect literacy and numeracy from primary schools. Any shortfall is not really addressed

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective

pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

i schools should already be able to do practicals. OFSTED should look at this ii They should already do this iii through how science works. Teaching context is very important for the majority of pupils who do not take science beyond GCSE iv These should be incorporated into lessons as necessary. Information can be diseminated via staff meeting. There needs to be no great change in curriculum for any of this to happen. Curriculum changes only benefit textbook manufacturers

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
A wide variety. A practical test (coursework) of some sort should be kept. It is important pupils understand the value of experiments. Pupils are assessed using tests at the end of modules/courses so this is the best form of assessment to practice during the course.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
11 and 16, and before going to university at 18.

8. h) What evidence of learning is needed for assessment to operate effectively?
Teacher assessment in the intervening period (between exams) as part of a robust performance management system. Teachers found to be over and under assessing need to be able to correct their mistakes via CPD.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
In a classroom and at home. Sites like the Khan academy may show something of the future.

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
National curriculum should dictate that it makes no difference what route you take.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Functioning labs with good technical support.

5. e) What other resources and systems should be used to support science and mathematics?
web based resources. Exams could be done entirely via the web and monitor pupil progress.

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
Private schools seem to favour teaching pupils in single sex classes (as well as having small class size). This may be historical, or may be, via evidence. Pupils should be able to sit GCSE exams early.

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
In general, performance management!

2. b) How should qualifications in science and mathematics be regulated?
GTC if that still exists

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
National Curriculum shoudl dictate what is taught everywhere

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
League tables will always have their critics but appear to be a simple way of looking at school performancce. It just comes down to what you put in them.

M Lev

1. a) What is good about UK science and mathematics education?
what is good is there is an established network of teaching.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
education needs to be more inclusive and focus on interest rather than individual.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
the polarity of the current network fails with lateral movement in everone other than genius

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
looking forwards while keeping an eye for lateral movement is paramount to success

5. Other comments
teach them young and have them for life

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
japan - much better than here - they have focus. france - much better than here - they have lateral east europe - they have inspiration to think

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
we should have open minds ourselves before we try to understand others

8. Other comments:
the fact we do this is a start to addressing the fact we have, over the last 40 yrs, closed our minds

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
in order for it to work the teachers need testing the same way the pupils do, repetition is boring and an example of anti-science

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
a national test for teachers would help - ie make it a positive choice rather than a failed choice

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
no inducements as it attracts a cop out culture, exactly those you wish to exclude

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
unsure -

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
unsure -

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
teachers held responsible for outcomes and if they demonstrate success - rewarded

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
teacher exams throughout career - courses dont work

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
pre-school; school; university

8. h) How much of this training should be spent gaining experience in the classroom?
classroom experience should reflect on outdoor experiences - particularly in young.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
no course - exam plus interview . money saved spent on getting kids outdoors and peer reviewing children's work from teacher plus feedback

10. Other comments:
teach children with utmost respect and see that every one of them is a mini Einstein

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
CPD misses the point

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
that is their responsibility - assessments should come from analysis of children's work judging teachers by results of kids should be regular and constant and evolving - the ability of a teacher to bring a current idea into the classroom, showing the kids - life - as it happens , is exactly the purpose of doing things this way.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
there should be a group of external teachers that work with teachers assessing their ability to acheive above throughout their career. When a teacher reaches that level they should be rewarded handsomely and made into assessor.

4. d) Should CPD be voluntary or mandatory? Why?
it should work the way i explain it - only way to involve kids at cutting edge from start.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
there are no assessors at moment - what there are is school inspectors

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
a teacher should be a leader, if they fail the assessor should highlight how to talk to children without prejudice

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
as teachers develop they should be rewarded regularly - both with one off payments and with certificates.

8. Other comments:
teachers who can inspire children from the lowest socio-economic class are the most valuable to the system

1. a) How and where should we be training laboratory technicians?
scottish and english system divide here - scotland, in keeping subjects broad, limits this -

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
that depends at what stage you teach kids lab work. it should start as early as possible and in conjunction with outdoor activities - example - is this soil acid or alkaline could be taught to a four year old if done well

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
they control trouble - makers and are not necessary in ever classroom a teacher that can control their own class should be rewarded positively rather than one who can't negatively

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
the assessor should provide the link between universities and schools

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
you are confused as you believe good scientists make bad leaders. the best scientists should be in university they should talk to the assessor who in turn talks to the teacher

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
they should learn through assessor and become one if possible

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
a career path to high level university teaching

4. d) How can leadership pathways for experienced teachers be introduced into careers?
they are the assessors

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
geography, location based development creating visible results for children is paramount

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
there is no structure - the network is polarised - we do not select for best minds - we fail

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
the governing body should serve as a marker of standard and success

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
keeping an open mind is key, standardisation kills that

2. b) How may the acquisition of such skills best be assessed?
assessors and exams for teachers not children

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
if you have not got it right at start - forget it - any teacher who shines above that should be the starting block of assessor function in others

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
clearly there are broad outlines but I think that currenty system is so badly wrong you ask these questions in first place - a child of five can understand photosynthesis if taught well

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
test the teacher from the output of whole class taking note of how well they perceive different children's progress as significant as any result based confirmation. this is less true of mathematics where you have a point in assessing things the way you do.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
maths should come later - opening minds first - any subject well taught can do that before exerting pressure on the child with individual performance

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
they are fine where they are

8. h) What evidence of learning is needed for assessment to operate effectively?
the assessors opinion and , of the assessor, the university contact of the children he meets of assessor

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
that depends on geography of school

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
no

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
it should be made possible that university experts meet young children to talk about projects both they and child done. that way you have created a future interest.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
good question - children should be exerted physically while learning outside classroom. Climbing hills can be the best biology, chemistry lesson ever

5. e) What other resources and systems should be used to support science and mathematics?
assessors of teachers performance

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
involve parents

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
it works better apart after males become sexually interested but it is not possible to separate, by that stage you should know who is worth investing in anyway.

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
already discussed

2. b) How should qualifications in science and mathematics be regulated?
as above

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
they can't

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
assess teachers up till entrance exams - if they fail to get child performance right then scrutinise

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
in order to bust the existing system one examining board should exist

6. Other comments:
a reduction in passmark for any exam is therfore not bad as you mark according to position within group - hard exams better - more challenging which is, the spirit of science anyway.

Alex Lucas

1. a) What is good about UK science and mathematics education?
MEI maths course - integration with industry, using real life questions. Great course!

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Need to encourage more enthusiasm at younger ages - this may require secondary school teachers who teach "Science" to be given specific help in the best ways to discuss and demonstrate ideas from Biology, Physics AND Chemistry (these teachers often come from a degree background in only one of those topics). I think there is a societal opinion that science is boring - this needs to be improved and I think this is essential! Big Bang Theory, Numb3rs, Brian Cox and Attenborough all help but there's definitely room for improvement here. Most of the senior positions in my old school (Headmaster, Head of various societies/careers etc) were non-scientists, and alongside the lack of prominently positioned scientists within the MPs this gives a feeling that to become a scientist relegates you to a lab. Obviously this isn't the case, and continuing to study maths/science should be seen as a valuable skill and quality for an individual! It would be useful if students were to be given a declaration: ... in Maths, that teachers are aware of how tedious it is to endlessly repeat similar exercises in order to be able to fully get to grips with particular mathematical ideas/identities, but that it is necessary to be able to work fast and notice them further down the line. My classmates and siblings have always bemoaned such exercises, with no idea as to why they are necessary. ... in science it may also be useful to declare that what the students are being taught is a simple model, and that next year/in x amount of time, we're going to make it more complicated/look at a more appropriate model. My peers and I were constantly fed up in Chemistry in particular, when we were taught one thing one year, only to be told that was all wrong the next etc (why would you continue to pay attention if you felt that likewise this would also be a "lie"). It's perfectly acceptable and, in fact, what science is

about, to start with simple models and improve them to get the best picture of the situation - this fact does not need to be hidden at school. I am currently aware of my brothers' current education (they are 7 and 5 years). Though they will engage actively with me in doing some basic equations at home - rudimentary algebra in fact "I have this number, let's give it a name, I'm going to call it x" they apparently don't respond particularly in class with the teacher. Their teachers have started to think they aren't that good at maths, whereas the impression I get is that they are bored with addition and multiplication now that they have "got it". I only have anecdotal evidence of course, but it was the same with me when I was at school. If not pushed to the next level, some students get bored and either become uninterested or stop bothering to pay attention. Maybe streaming at much younger ages would help, though of course you may still struggle to notice these quiet types. Pointing out interesting questions or points at an early age may also help children to accept or think about particular topics when older. For example, subtraction being taking away a number or adding a negative number (you could discuss the number line here); squaring a number and observing that both positive and negative numbers square to a positive number ("I wonder what sort of number we'd need to square to a negative one?"); look how I can add my numbers in any order I want, that's because addition is commutative but don't worry about that term at the moment etc etc.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Lack of good quality scientists coming out of schools and the reduction of funding for scientists at higher education will severely effect science research and innovation in this country, which I believe will drastically effect the economy further down the line. No longer having to take at least one modern foreign language at GCSE level is not good for the education system. Language teaches many skills the most basic of which is to communicate with people from foreign countries. I don't think it encourages an accepting multi-cultural society, and I think it is quite embarrassing for this country.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
At the very least produce people with basic numeracy skills. Giving people an understanding of what it means to be a scientist (i.e. developing better models and not ALREADY knowing everything) and how to look at problems analytically.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Higher salary, more chances to gain other prominent positions within the school (head of dep, head of 6th form etc), a less rigid curriculum and teaching system. Obviously an alternative way to think about the purpose behind this question, is to ask how we can get more trained scientists and mathematicians, so that even keeping the same percentage of which becoming teachers, means we have more people wanting to teach. The answer to this would be in better funding to learn sciences/maths in higher education, a coolness factor in being a scientist?

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Have a degree in a science or mathematics course.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes - we need to kick start people enjoying and continuing in science and maths and if that requires better teaches attracted by inducements then yes. This wouldn't need to be a permanent thing, I would expect the intake of students to science/maths to be able to stabilise at a higher level after a while.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Courses that provide good examples of how to explain and demonstrate science to those who are required to teach Biology, Chemistry AND Physics but who have come from a background of only one of these.

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
Equal opportunities to become Heads/Head of 6th form etc compared to humanities teacher.

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Without leadership and ethos there is drab education and hence little encouragement for students to learn or be interested.

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Knowledge of theories and models, not perfect answers.

2. b) How may the acquisition of such skills best be assessed?
Knowledge of theories and models would not need to be assessed and would be difficult to do so anyway (unless if including an essay question about it).

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
My old teacher used to complain that she had to basically reteach basic methods of addition and multiplication to her 11 year olds, because some of them had been taught an easy way of getting the right answer, but which wasn't encouraging the students to think about the process correctly (the term LeapFrogging comes to mind, but that may not be correct). This held back all of the 11 year olds, boring those who knew the right way to think about the Maths - this transition of some individuals effected everyone. The impact is high.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students’ school careers?
NOT at primary school. If teachers feel the need to work towards an such an assessment they could make shortcuts in teaching the children easier methods to get the right answer, whilst missing the point about how/why. Children at primary school are effected by the stress of such exams, and may decide they cannot and will never be able to do particular topics, just because they got a bad (or lower than their peers) mark. Within a school it would be appropriate for the teachers (or governors?) to check that everyone is being taught along the right sort of lines. This may also stop teachers focusing on subjects likely to come up in exams and abandoning other subjects in addition (I don't want to consider how many times I learnt about the Tudors and Romans and little other history). Testing from 14 years would be appropriate, with end of year exams within school to get the children used to taking exams and without intense pressure on the teachers.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
In well-equipped labs, with trips to other facilities such as telescopes or Universities (where researchers could talk about what work they do) etc elsewhere.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
If not all schools in one area can afford decent well-equipped labs for all their students, then have a lab that all the schools in the local area can bring their students to for a few lessons a week. This may be for particular sorts of science lessons requiring unusual/expensive equipment.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
More interacton with researchers and professors in local Universities.

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Advantage: the idea of performance targets Disadvantage: the consequences of teachers aiming to fulfil 'current' or short-term performance targets, without having to think about/being encouraged to think their students being capable/interested further down the educational line.

Chandra Mehta

1. a) What is good about UK science and mathematics education?
It fosters and enhances students to think outside the box developing problem solving skills.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?

There is a great need to ensure the students are confident win the basic skills needed to progress on to higher levels.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
All teaching is now mainly geared to pass exams and more pressure is placed on the teachers to ensure their pupils pass. There is little time to explore issues when they come up. The attitude that is fostered in the pupils is just to do enough to pass exams.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
We need input from employers to help in making informed decisions on the essential requirements for employment pertaining to Science and Maths. The curriculumn should reflect this.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Singapore, India and China. The general population is confident in the basic skills in these subjects which allows them to produce confident Scientists and Mathematicians.

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
The fact that they ensure the basics are in place to grow from.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Society in general does not value education and the teachers do not have the respect that other professions have. The value placed is directly prpportional to the wages one earns. As teacher's do not earn and have fallen behind many professions in their earning potential it will not attract the best into the profession. Most bright pupils are following media studies and other popular cultural careers as most pupils can't see job prospects with these subjects and will not pursue these careers.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
THey should have a degree in these subjects.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Extra pay for those training to teach these subjects .

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?

Intducts the teacher in the practice and helps in the organisation and delivery of these subjects.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
We need to foster the ability of the teacher enthuse pupils into their subject.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Recruit the best students from university, give them the tools and the finance to inspire the next generation of pupils.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
It should be more vocational as opposed to sitting in a university. There should more chalk face teaching so that they know what they are getting into.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
It can be in the educational establishment where these subjects are taught and prehaps a day release course at universities . This would better prepare the teachers .

8. h) How much of this training should be spent gaining experience in the classroom?
As much as possible. Perhaps 80% of the time should be in front of the class.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
one year

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Keeps one uptodate with developments in their specific area of expertiese.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Through organisations such as stem, and royal societies.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
In the summer months when exams are over.At least every year to ensure they are up to date.

4. d) Should CPD be voluntary or mandatory? Why?
Voluntary but should be encouraged with enhance payment or accredition to Masters level to ensure they are done.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Too much paper work in the class room and generally in the running of educational estabilshments.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes then it would be valued.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes this would allow teachers the recognition that they have done these courses to enhance their knowledge.

1. a) How and where should we be training laboratory technicians?
They should attend the sessions with teachers to ensure they support the teachers in delivering the subject matter.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
They need support in finding the equipment required setting up and even helping in delivering projects.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Teaching assistants are essential for students with learning difficulties and may need to attend the sessions with the teachers so they are aware of what the teacher is trying to accomplish.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Stem is good start but a national network would be even better.

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
The leadership needs to understand that to deliver these subjects successfully the would need to provide adequate resources in therms of time and finance to ensure the teachers can deliver the curiculumn successsfully.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
The ability to negotiate. The ability to work with others. The ability to market their department within the establishment.

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
They need to listen to the teachers and provide the support required to prepare the teachers for leadership roles.

4. d) How can leadership pathways for experienced teachers be introduced into careers?
See above

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
The way the college markets itself.

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Science and Maths are potrayed as cinderella subjects with little value placed on them. Leadership have no problem saying "they are bad at maths" . This implies you do not need these subjects to become leaders and hence undervalues these subjects. Resources are cut and courses are cut without any negotiation and purely on financial basis.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
The governing body seem to be toothless and go with the principles suggestions based purely on financial impact . They therefore have little influence on these subjects.

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
They need a sound knowledge of science and maths. they should start in primary school.

2. b) How may the acquisition of such skills best be assessed?
Through exams and practical tasks.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
Crucial. Pupils tend to lose their enthusiasm for these subjects as the class sizes are large and there is no opportunity to develop individual skills.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
All the above could be achieved through themed project across curricula. in odrder to enthuse students

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
Projects. Tests and assignments. Practical tests.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
at least 20% of the curriculumn.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
at 11 and at 16 and 18

8. h) What evidence of learning is needed for assessment to operate effectively?
exam marks, projects

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
both in school and outside school

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
Students need change haveing 5-10 educational establishments are not the most condusive to show children that they are at a different age.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
subject specific labs as they tend to focus on the specialist area of study.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
using kitchens to teach science or sport fields would enhance the learning experience.

5. e) What other resources and systems should be used to support science and mathematics?
IT and external visits

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
See above. The measure would have to be pupil performance and uptake of these subjects.

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
No. mixed classes produce balanced views

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
pass rate, uptake of the subjects

2. b) How should qualifications in science and mathematics be regulated?
they need to be more rigourous with timed exams and greater scrunity of project work.

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
Provide more subject specialist teachers

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Gives numerical evidence of performance Restrictive and leads to a precribed curriculumn.

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
Yes. Number of students progressing

Carol Nesham, St Mark's Primary School

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes, see 3e and learn how to work from their teacher

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Yes- a national network easily available on a website and with email links with featured careers and broader info about the people who do them- there was an excellent display at the Eden Project a few years ago featuring one of the key architects which showed lots of aspects of his life as well as his work

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
A keen leader of a subject enthuses others and increases the profile of the subject. Also a leader (eg head) who is keen has a great inluence. At our school the head is very keen on Science and Maths and has driven our bids since 2006.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?

The same as any other teacher

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
See 4A

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
See 4A

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
Same as 4A- govering bodies can be very inluential and practically helpful- our chair of govs is a retied Science teacher and has helped in class and run clubs and generally supported with wildlife area- a lot of legwork and research

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
It is vitally important but the more diverse the experience of children at feeder primaries the more time and opportunity is wasted at secondary level. One answer may be seen to stream straight away but this does not seem fair when a perfectly able and potentially keen child may simply not have had the same learning opportunities as a child from another school

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
I honestly find this now

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
No Response

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
Science can be assessed to some extent through Literacy and vice versa and very much through D&T

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Both

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
See Skills curriculum and assessment 4. I strongly feel that it will be a huge benefit in some school and not in others and this worries and saddens me

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
At primary level it is more everyday so the usual learning environment with the addition of extras (visits, visitors, special equipment, outdoor learning) to engage is fine

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
Not facilities but links with DT, Art, Literacy, ICT enhance teaching in all areas

5. e) What other resources and systems should be used to support science and mathematics?
See CPD ideas

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
No Response

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
My class (of Y2/3/4) have recently had a closing gap between genders in Y2 Sat results and most recently results were the same. Interestingly, half of last year's cohort was in a YR/1/2 class and the resulst overall were the same across the genders so this suggests that the mixture of ages and genders is working successfully. However in a larger school I used to operate single sex mixed ability threes and could see huge benefits in this

Richard Newbold, Tunbridge Wells Grammar School for Boys

1. a) What is good about UK science and mathematics education?
9E/F from KS3 National Curriculum Some Module 3 work from GCSE Chemistry Some of A Level Chemistry

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Return to more demanding KS3 and KS4. Greater pace and expectation. Return to longer lessons to enable proper practical work and thought about experimental results.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Continual dumbing down.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Training for thought coupled with rigorous examinations.

5. Other comments
Context driven science with the exclusion of scientific rigour appears to have taken over. The latest offering from the ASE "Wikid" is appalling.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Massachussets, Hong Kong, Singapore

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
Give me a few plane tickets and some time off and I might be able to tell you.

8. Other comments:
IGCSE seems better than GCSE science

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Improved status aand pay as working in the city is so much more lucrative.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
A Levels and degree. Give old 'O' Level papers to assess current knowledge.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Free training and a bursary for living costs.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Thoughtful classes and workshops in college (for me at Goldsmiths)

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?

Better training for teachers in school that takes PGCE; proper supervision of in school raining to ensure some takes place and that PGCE students aren't used to fill in gaps in teaching staff

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Key list of skills to be delivered, with monitoring by an external government body.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
PGCE; ensure philosophy behind pedagogy is covered and that student teachers have time to think before being dropped into classrooms.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
University followed by school placements. Gives theory and ideas time to develop as well as practical experience.

8. h) How much of this training should be spent gaining experience in the classroom?
About half.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
One year.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Generally not as much of a waste of time as other CPD, can be relate to ideas that make a difference to tlearning and teaching.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Reading relevant journals, sharing best practice.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Throughout, continuously.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory to enable teachers to have the time to assess their practice.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Cost, distance. Bring CPD to schools by employing a County or area based system (just abolished here!)

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Some.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Would be good to se it accumulate to give something.

1. a) How and where should we be training laboratory technicians?
Getting to the point where this will need to be done at a college/ university.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Continual CPD throughout career, some in College as day release.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Tohelp disabled and EAL pupils.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
General careers service and teachers.

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Some interms of pupils making good choices. Some as eciding who to employ. Some as in choosing scheme of work approach.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
Same as any other

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
Improve status of Science/maths compared with soft subjects.

4. d) How can leadership pathways for experienced teachers be introduced into careers?
Provide good quality planned CPD that moves from clasroom to head with all steps between

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
Intake and parents, a little from leadership team.

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
pupils willingness to work hard affects everything.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
minimal apart from aiding financial management

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
reading and comprehension listening mathematical / number handling manipulation of apparatus

2. b) How may the acquisition of such skills best be assessed?
formative and summative assessment combined

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
usually knocks them back a bit but usually found their feet by Christmas. Small but significant problem for two year KS3, minimal for three year version.

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
A minimal National Curriculum, removal of league tables. Reduced tick box culture, i.e. no more APP.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
Continual formative coupled with some summative as exams are important to pupils life choices.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
Unlikely as most non scientists are not scientifically literate, e'g geography regular confuses pupils over gobal warming/acid rain/ozone layer.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
16/18 seems okay as late enough for most late developers to have come through.

8. h) What evidence of learning is needed for assessment to operate effectively?
Need mixture of practical , written and analytical skills. the former could be assessed by teachers over the course or by exam but definitely not by GCSE ISAs.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
mostly in schjool, occassionally via TV/internet but most pupils are ill-informed about world around them

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
mixed, some schools that value science will do well others (the majority) will push it even further back

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Well designed and equipped laboratories, with sufficient equipment, including fume hoods.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
IT facilities are very useful.

5. e) What other resources and systems should be used to support science and mathematics?
Outreach from professional bodies bringing equipment into schools, e.g. "Spectrometer in a Suitcase" from teh RSC.

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Better labs - inspect and provide a RSC kitemark or equivalent.

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
Boys behaviour improved by girls but girls more likely to be quiet if larger numbers of boys.

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
Independent monitoring body not controlled by government

2. b) How should qualifications in science and mathematics be regulated?
Professional bodies

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
Make it mandatory from 11-18 that all schools teach subjects with a mximum class size of: 11-16: 30 L6 20 U6 15

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Can focus mind on key areas; just focus on that area

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
Place in world tables

Sarah Parsons, Harper Adams University College

1. a) What is good about UK science and mathematics education?
• That it is compulsory. • Multiple levels of GCSE are available: e.g. different tiers for mathematics, Additional Mathematics, Functional Mathematics, Double award science and Individual science subject. • There are many really excellent, inspirational and hardworking mathematics and science teachers.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
No Response

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
• The following comments are made from the perspective of being a lecturer in mathematics and theoretical mechanics, and also a provider of mathematics and statistics support in higher education (at Harper Adams University College). Factors which affect success in mathematics and statistics learning is an area of pedagogic research in which I am currently interested, and, in particular, the effect of learners' self-confidence (or self-efficacy) on their learning and achievement. I believe that it is beneficial to create classroom cultures which help to foster students' self-confidence as well as teaching students the skills and knowledge that they need. It is often harder, and takes longer, to build someone's self-confidence than it is to teach them specific skills and knowledge, but this self-confidence is vital for their future effort and achievement. In Parsons et al. (2009) it was shown that there was a statistically significant relationship between students' own self-confidence ratings and their achievement in mathematics, both by Kruskal Wallis tests and Multiple Regression analysis. In Parsons and Croft (2011) the sources of self-efficacy, and mediating processes, as proposed by Bandura (1997) were cross-referenced with the experiences of undergraduate students learning engineering mathematics as described during semi-structured student interviews. Bandura's self-efficacy sources were: enactive mastery experiences, vicarious experiences, verbal persuasion; and physiological and affective states. The mediating processes (those which work out the effects of self-efficacy) as proposed by Bandura were: cognitive;

motivational; affective and selective processes. Burton, L. (2004) described teachers' and pupils' understandings of what self-confidence is and it's effects on learning mathematics. Teachers viewed confidence more in terms of actions (such as putting up hands), whereas pupils defined confidence more in terms of how they thought and felt about mathematics, for example whether they felt they could do it or not. The pupils listed positive classroom characteristics which they considered would promote self-confidence: overall it was a more collaborative environment (especially favoured by girls, compared to boys who tended to be more competitive than girls); a discursive environment; teamwork; a light-hearted approach; and a relaxed classroom where you are not afraid to make errors. Pupils also listed the teacher characteristics which they considered help to build confidence: to explain well; not rush; know what they are talking about; and to be sensitive to pupils who are struggling. Graven (2004) on the other hand investigated the confidence of in-service mathematics teachers, and viewed confidence as essential for ongoing CPD. Garfield (1995) and Garfield and Ben-Zvi(2007) listed key principles for learning statistics which included: students constructing knowledge; active involvement; that learning requires practise; confronting misconceptions; and the benefits of using calculators and computers to explore and visualise data. All of these principles could also be applied to learning mathematics. References
Bandura, A. (1997). Self-Efficacy: The Exercise of Control. New York: W. H. Freeman and Company Burton, L. (2004). Confidence is Everything – Perspectives of Teachers and Students Learning Mathematics. Journal of Mathematics Teacher Education, 7, pp.357-381. Garfield, J. (1995). How Students Learn Statistics. International Statistical Review. 63 (1), pp.23-34. Garfield, J. and Ben-Zvi, D. (2007). How Students Learn Statistics Revisited: A Current Review of Research on Teaching and Learning Statistics. International Statistical Review, 75 (3), pp. 372-396. [On-line]. Available from: http://scholar.googleusercontent.com/scholar?q=cache:UFEHTcVjhYgJ:scholar.google.com/&hl=en&as_sdt=0,5 [Accessed 23rd September 2011]. Graven, M. (2004). Investigating mathematics teacher learning within an in-service community of practice: The centrality of confidence. Educational Studies in Mathematics, 57 (2), pp. 177-211. Abstract [On-line]. Available From: http://www.mendeley.com/research/investigating-mathematics-teacher-learning-within-inservice-community-practice-centrality-confidence/ [Accessed 22nd September 2011]. Parsons, S. J., Croft, A. C. and Harrison, M. C. (2009). Does students' confidence in their ability in mathematics matter? Teaching Mathematics and its Applications, 28, pp. 53-68. Parsons, S. and Croft, A.C. (2011) Engineering students' self-confidence in mathematics mapped onto Bandura's self-efficacy. Engineering Education, 6 (1), pp. 52-61. [On-line]. Available from: http://www.engsc.ac.uk/journal/index.php/ee/article/view/165 [Accessed 24th September 2011]. • Mathematics and Science are often viewed as unfashionable subjects. • Today's modern technology is changing teaching and students expectations of teachers. A higher standard of handouts and resources can now be produced than was possible a few decades ago, and I think has become expected. It is hard and time consuming for teachers to produce new handouts, especially when they may not be IT enthusiasts or efficient at typing. Extra support for teachers for the production of high quality resources would be beneficial. As technology evolves it is likely that such resources will unfortunately always need some updating, at least to remain compatible with current versions of software and hardware.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Good salaries, pensions. Sufficient time on the working day for marking and preparation. Good practical support for teachers (for example assistance with porducing resources). Career progression opportunities.

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
ii) parents/guardians Written as a parent Regular information on pupil's progress to their parents seems a good starting point for accountability. This can be in terms of school reports and grades, and also end of topic test results. Parents can also look at the work in children's exercise books and the marks given for homework. When things are going well accountability seems a less important matter, and in general parents and guardians are probably happy to leave the school or college to carry on as they are doing. However if things are not going well then I think that this is a very difficult area. In my own experience when I have had concerns about a particular system or teacher it has not been easy to know how to go about raising my concerns, how to raise the concerns in a positive way, or to receive feedback about what has been changed or addressed. If an extreme case were to arise, for example, if there was a real problem with a teacher being incompetent, or of professional misconduct, then there would be conflicting principles to be observed. The school and the individual teachers have a need for such sensitive information to be kept confidential and dealt with within the school. Whilst at the same time parents with genuine concerns have a need to know that their concerns have been listened to and how these concerns are being addressed. If a school were to take a 'sweep it under the carpet' approach, this would be in my view unhelpful to all parties: to the school in that the areas in need of improvement do not get addressed, to parents who feel that the communication with and the response of the school have been unsatisfactory, and to the pupils whose education will continue to be adversely affected by the problems. It is in my view very difficult to create a system which is both transparent and accountable to parties outside of the school whilst maintaining appropriate confidentiality.

Geoff Petty

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Teachers need to use evidence based teaching methods such as those in 'Evidence Based Teaching' Geoff Petty; 'Visible learning for Teachers' John Hattie Embedded Formative Assessment Dylan Wiliam

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
teaching methodology because it has more effect on student attainment than any other factor we can change. See John Hattie Visible Learning

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
better teaching

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Singapore, Taiwan, Japan Teaching methodology

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
teaching methodology

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
better career ladder

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Visible Learning John Hattie says this has no effect on teaching quality. His work summarises meta studies which are the most authoritative source of information.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
More emphasis on factors that affect achievement most, teaching methods tutorial monitoring etc

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
see just above

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
one centred on pedagogy because this has the greatest effect on achievement

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
raised achievement of students, but only if they are followed by Supported Experiments say research reviews my Timperley for example. See www.geoffpetty.com on supported experiments

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
continually 30 hrs a year

4. d) Should CPD be voluntary or mandatory? Why?

mandatory as it affects achievement so much

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
poor senior management who can't prioritise

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
yes

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
yes

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
they have little effect as presently used according to reviews of research

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
They have impact when they focus on teaching and learning only. See Visible Learning John Hattie.

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Research review evidence shows they have great impact if they focus on teaching and learning.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
focus on teaching and learning

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
formative assessment , summative has a detrimental effect usually see Dylan Wiliam's work

8. Other comments:
The above factors hav much less efect on achievement than teaching and learning. Important to prioritise.

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Little evidence they work as well as supported experiments style development. An Improvement focus trumps measurement of attainment as a means of improving teaching. Inspire don't measure.

Sue Pope

General questions

1) Science and mathematics education in the UK

a) What is good about UK science and mathematics education?
Primary science is a particular strength evidenced by performance in international comparisons such as PISA and TIMSS. This is partly because of the greater emphasis on science in the primary curriculum. Something we don't want to lose given that attitudes towards science are formed early (e.g. Tytler's review in Australia)

b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?

The principal change required is in relation to teaching approaches, which need (in mathematics at least) to include far more opportunities for students to grapple with problems that challenge them to use and apply the mathematics they know, sometimes in unexpected ways. These problems should include the kind that require the use of simple mathematics in complicated contexts. A greater emphasis on reasoning should also be introduced.
Our assessment of mathematics learning should also reflect the curriculum changes described above. More will be written about this below.

Given the high stakes performative culture in which we find ourselves – assessment is the key driver. We need to ensure that exams assess what we value. The recent changes to GCSE mathematics (with an increased emphasis on problem solving, mathematical thinking, functional mathematics and quality of written communication) and GCSE science (to better reflect curriculum changes which emphasise how science works, science and society and scientific enquiry) need to be given chance to work.

c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Assessment and accountability that is fit for purpose. Education that nurtures the development of positive attitudes and dispositions towards science and mathematics, thus ensuring scientific and mathematical literacy for all young people. This is necessary for specialists who will have to work in multi-disciplinary teams and communicate their work to a sceptical populous.
d) How can a science and mathematics education system best meet the needs of employers and higher education?
By ensuring all young people develop mathematical and scientific literacy whether they are consumers, technicians or experts.

2) Science and mathematics education internationally

a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?

b) What specific aspects of other countries' high-performing education systems should we be learning from?

Other comments:
It is worth looking at the work in New Zealand on preparing their National Curriculum. Statistics was integrated into mathematics and it has achieved a high post-16 participation rate. In Australia a review on STEM and ways to increase participation and engagement was undertaken by Tytler. The need for nurturing positive learner identities from a relatively early age was seen as key to success. In Massachusetts a long term, large scale curriculum development initiative focused on the development of higher order thinking skills. Like England, Massachusetts has seen a big improvement in TIMSS, but without such a large decline in attitude. (See Ruthven 2011 for more on this).

Teachers (and the wider workforce)
An education system can only be as good as the teachers within it. But for many years now shortages of science and mathematics teachers have been recorded in England and Wales and the situation elsewhere in the UK is not entirely clear. Problems have been reported both in recruiting sufficient trainees and retaining qualified teachers.

Please answer these questions without feeling in any way constrained by current or proposed mechanisms in place for recruiting, training and/or professionally developing science and mathematics teachers.

1) Teaching as a career

a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Positive press about teaching. More support for teachers doing their job e.g. classroom assistants, technician support to produce and manage resources in both mathematics and science, funding for CPD including further study.

2) Initial Teacher Training

a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Ofsted is clear that the vast majority of HEI based routes into teaching have rigorous procedures in place for selecting ITE students. The reality of the job is the main reason for wastage – the job is physically and emotionally demanding. It is not unusual for student

teachers to work 60-80 hours a week to keep afloat! All HEIs expect applicants to have spent time in school, and for primary to have substantial experience of working with young people.

To raise the bar and insist on more than grade C at GCSE in mathematics and science for entry to primary ITE would prevent some very capable people becoming teachers.
It would be worth encouraging people with A level (or equivalent) in science or mathematics into primary teaching so they might become the specialists of the future.

For secondary the subject knowledge enhancement (SKE) courses have enabled a large number of committed and capable teachers to become science and mathematics specialists. There are insufficient graduates alone to supply the number of teachers required so it is crucial that this provision continues. Typically students who complete SKE courses are graduates with at least A level or equivalent and some relevant experience in mathematics, physics or chemistry. The fact they spend about a year studying the school subject from an advanced perspective means that they can easily hold their own with a graduate who has a minimum of 50% in the discipline and are often more committed to the profession.

b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
A wide range of people become excellent teachers. The current model of substantial bursaries for the most qualified graduates is ill conceived and has no evidence base. No one should have to pay £9K in fees to become a teacher. The country needs good teachers and just as many health professions have free training so should teaching.

c) What is good about initial teacher training programmes in science and mathematics in the UK?
Evidence from Ofsted suggests that HEI based ITE programmes are rigorous, of high quality and represent value for money. Student teachers spend the bulk of their time in school and providers are challenged to ensure that the school experience is as good as it can be. Where strong partnerships exist, student teachers benefit from excellent mentoring and schools enjoy new ideas and the opportunity to reflect on their practice. In addition many partnerships include special arrangements for CPD and preferential rates for post-graduate study. All HEI based routes focus on developing critically reflective practitioners whose principal focus is on children's learning and development.

d) What changes to these programmes (e.g. philosophy, content, or emphases) are needed?
Many schools are under a great deal of pressure to meet performance targets and therefore are unwilling to participate in ITE programmes. It should be an expectation that all schools work in an ITE partnership.

At primary there is limited time to develop subject knowledge in the wide range of subjects in the curriculum. Consideration could be given to how in a one year PGCE more time might be devoted to developing knowledge and understanding of subjects and their pedagogy.

Some routes into teaching do not offer a secure grounding in theories of teaching and learning and child development. This is a serious weakness. All ITE should include theoretical, as well as practical, elements.

e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Ensure all routes are associated with a HEI and that student teachers get substantial experience in at least two contrasting schools (or settings) and have to engage with education as an academic discipline eg theories of teaching and learning, studying literature on pedagogy, critically reflecting on their own practice, developing competence with a range of teaching approaches which engage all learners.

f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Both full-time and flexible routes need to be available to allow for different circumstances. However it is valuable for students to feel they are part of a cohort with fellow students to share experiences and learning.

Note that most school placements need to be undertaken as a continuous block. However it is possible to get some valuable school experience on a part-time basis. Many programmes have a phased introduction to school (one or two days a week at HEI, while the rest of the week is in school), building up to full-time placements.

g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
ITE is best conducted both in school and HEI. The opportunity to take time out, reflect on experience and recharge batteries before embarking on a placement in a contrasting school can really help to maximise learning during ITE. It can also help students to stick with the course as there is additional support outwith the school.

h) How much of this training should be spent gaining experience in the classroom?
Currently 24 weeks out of 36 are spent in school during a secondary PGCE year, and 18 weeks out of 36 are spent in school during a primary PGCE year. This seems about right. Although many would say there is insufficient time to lay the foundations for subject specific pedagogy in primary even for the core curriculum.

i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
Currently students have one year to meet the expectations on a PGCE course. Those who study part-time have longer. Whilst a longer time would be beneficial, it’s unlikely to be affordable. What needs to be introduced is an entitlement to CPD during the early years of teaching. IN FE teachers are expected to spend a certain amount of time each year undertaking CPD. The same is true for teachers in Scotland. It would be good to see the same provision in England.

3) Continuing Professional Development (CPD) for teachers

a) What are the benefits of subject-specific CPD for science and mathematics teachers?
There is considerable evidence that subject-specific CPD for teachers of science and mathematics makes a positive benefit. From the ‘Effective Teachers of Numeracy’ research (Askew & Brown, KCL) which showed the most effective teachers in primary were ‘connectionist’ teachers and that this was strongly correlated with having completed a 10 or 20 day course in primary mathematics to emerging evidence from the post-William’s review MaST course, extended CPD in which teachers have time to develop their own knowledge and understanding of mathematics, to try different approaches in their classrooms and to work with colleagues on developing mathematics in their school really makes a difference for learners.

In secondary SKE courses for non-specialist teachers of mathematics are a way of widening the pool of specialist teachers and improve the experience of learners. Such courses need to be funded with ring-fenced funding if all schools are to benefit and develop the pool of subject specialists.

MEI work with HEIs to deliver accredited teaching A level mathematics CPD. Again these extended course have an impact on participants’ confidence, knowledge and understanding and their classroom practice.

A comprehensive review of mathematics CPD was undertaken for NCETM (REC-ME).

b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Teachers should be encouraged to join a subject association, or their school should join. Teachers should be supported in joining a subject association and have access to local branch activities. They should also have the opportunity to attend subject association conferences, funded by their school.

Reading the TES and the subject associations’ journals and other publications help teachers keep up to date.

c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
All teachers should undertake CPD each year as part of their normal practice.

d) Should CPD be voluntary or mandatory? Why?
It would be good to see CPD as an expectation for all teachers, as in FE or Scotland. Schools should have the funds to enable this to happen.

e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?

Expense, time, regional availability. Schools are very reluctant to let teachers 'miss school'. Teaching is a demanding job and after school or weekend CPD puts considerable pressure on teachers' home lives.

f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Whilst this may be desirable, it shouldn't be exclusively so. Subject-specific CPD is beneficial for students.

g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Accreditation should be available for all extended CPD, although teachers should be able to choose whether or not to complete the necessary academic work. CMathTEach and CSciTEach require teachers to have completed a Masters (or equivalent) and be a member of a subject association, and these could be used to encourage completion of academic work. Schools could consider additional rewards to teachers who have gained CTeach status.

4) The wider workforce

a) How and where should we be training laboratory technicians?
Lab technicians should be trained in school and college on a day release basis or similar

b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Lab technicians need to know and understand the science for which they must prepare resources and be fully conversant with health and safety legislation.

c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Very definitely. Teaching assistants can help to ensure that all students get the most out of the lesson. They can collect specific assessment information. They can work with a small group on a particular task. Specialist TAs in mathematics and science should have a better of understanding of the content and the school's policy in respect of teaching key ideas. Therefore they can give more appropriate targeted support which builds on previous learning experiences when learners are struggling.

d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Every teacher of science and mathematics needs to be aware of STEM careers and raise awareness of these careers through their normal teaching. This is explicit in the current secondary science national curriculum. There are valuable websites to support with this (stemcareer and mathscareers) and examples of how these might be used in teaching would be helpful. Careers advisers also need to be aware of these sites, as do parents/carers.

STEMNET allows teachers to access local industrial/business users of mathematics and science and all schools should be encouraged to make use of this valuable resource.

Leadership and ethos

Leadership and ethos are complex concepts within education, but are considered to be significant in affecting the overall performance of individual schools and colleges, and the education system as a whole.

Much less is known about the leadership characteristics of those science and mathematics teachers who successfully introduce innovative teaching and learning practices. This implies a culture of initiative and collegiality for developing, as well as delivering, the curriculum. However, systematic evidence is also lacking in respect of the effect of such leadership on student performance and progression in science and mathematics.

a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Subject leaders for science and mathematics have the potential to ensure continuity and progression across the whole school's provision. A strong leader will work with their team to ensure a shared vision for the subject that aligns with the school's aims and involve them fully in making it happen. Giving them freedom to work in ways they are comfortable yet challenging them to exploit new approaches that may enhance learning.

b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
As well as generic leadership skills, teachers of science and mathematics need to understand how best to secure learning and optimise progress for all learners, so they can support their team to become as effective as possible,

c) How can school and college leaders encourage leadership among science and mathematics teachers?
School leaders can encourage leadership by giving them time and space to lead, supporting their development of leadership skills through training and involvement in whole school projects, alongside careful negation of realistic development targets.

d) How can leadership pathways for experienced teachers be introduced into careers?
There are already plenty of opportunities for teachers of science and mathematics to move into leadership/management roles. May senior leaders in school have mathematical or scientific backgrounds.

e) What factors are most responsible for creating the ethos of different schools and colleges?
A shared set of values and expectations that are consistently enacted by the entire community including students, teaching and non-teaching staff. A commitment to the

development of the whole person as well as academic achievement. A belief that all can achieve and have a valuable contribution to make.

f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Senior leaders have a vital role to play in ensuring that science and mathematics are valued in school. The STEM pathfinders project (SSAT) found that as well as enthusiastic teachers of science, mathematics, D&T the senior leadership needed to be fully supportive and enthusiastic advocates for mathematics and science eg they never say ' I was never any good at maths when I was at school'. Governors can be encouraged to link with particular curriculum areas and subject leaders may find it valuable to have the critical friendship of a governor.

g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
Governors have a vital role to play in shaping the ethos of a school. Governors can take on the role of critical friend to a particular curriculum area, supporting subject leaders in realising developments and also ensuring that governors are fully conversant with developments in the subject and any aprticualr resource or CPD needs.

Skills, Curriculum and Assessment
Acquiring the right scientific and mathematical skills and knowledge is a key component of an 'ideal' 5-19 education process. Teachers teach to a relevant curriculum and enable learners to acquire useful knowledge and understanding, which is then assessed at a critical point in time to certify what a young person knows and can do in these areas.

a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
The ability to solve problems is the most important and most highly valued mathematical skill. Problem solving skills should be explicitly taught from the start of mathematics education. The range of techniques addressed should include the use of simple mathematics to solve problems in complicated contexts. As part of the problem solving programme, a clear emphasis on the use of reasoning should be evident.

Students also need to develop a questioning attitude towards phenomena and data – why does this happen? Is this explanation plausible? What other explanation might be appropriate? How does this new knowledge fit with what I already know?

Students also need to develop confidence in their own abilities to do and understand mathematics and science.

b) How may the acquisition of such skills best be assessed?
Mathematical problem solving is hard to assess because it cannot readily be demonstrated by learners within the fixed amount of time usually allocated to public examinations. By its

nature, the problem solving process may take considerable time. However, since this is the most valued mathematical skill, the difficulty of assessing it should not mean it is not part of public assessment. On the contrary, there are very strong arguments for changing the style of these assessments so that they can include assessment of problem solving. Assessment of reasoning fits more readily into conventional assessment; note, however, that assessment of proof in A level Mathematics has caused awarding organisations immense difficulty.
In the Mathematics Pathways project proof was successfully incorporated into longer pure papers. The decision to continue with a six module A level for mathematics in which assessments are never more than 90 minutes makes it difficult to incorporate items that require considerable thought, problem solving or proof.

c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Progression is a major issue between primary and secondary phases. In science the experimentation with everyday objects tends to stop and children have access to laboratories. Unfortunately the amount of practical lab work is not as great as it might be due to anxieties around behaviour and health and safety. The former may not be such an issue if there was more practical work. Science teachers need to be confident about the use of practical tasks, supported by technicians who can manage resources effectively. Teachers also need to be skilful in drawing out the scientific principles from practical wok, connecting with previous learning and challenging potential misconceptions.

In mathematics the use of teaching aids may reduce significantly in the secondary school. This is a mistake, students need mathematical models to support and extend their mathematical understanding. The use of ICT as an exploratory tool for understanding complex ideas in mathematics should be more prevalent in the secondary school, although evidence suggests that it isn't.

Spreadsheets can be used to model realistic scenarios such as budgeting for an event or exploring properties of number.

Having subject specialist teachers can be both daunting and exciting for children. Secondary teachers can benefit a great deal from visits to primary school to see how science and mathematics is taught and to recognise that children don't come as a 'blank slate' ready for a 'fresh start' to secondary school, but need teachers who value their prior experience and want to build on it.

d) How should a curriculum be structured so that:
i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science;
ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning?
iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives:
iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

The curriculum needs to avoid too much prescription, as it may make it difficult for teachers (particularly non-specialists) to know what is important. It needs to make expectations in terms of both process and content clear. Whilst there should be flexibility for teachers to adopt whatever pedagogic approaches they prefer, the curriculum should set out an entitlement of experience for example around practical work, extended tasks, experiences which link different aspects of the curriculum, experiences which draw on modern day applications or the rich cultural and historical roots of mathematics and science, opportunities to develop communication skills both spoken and written.

The curriculum should set out a clear progression which is informed by research. Breadth, depth and interconnected ideas are to be encouraged.

e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

The most effective assessment is assessment that validly assesses the intended curriculum. This will often require assessment instruments that are different from the most conventional types (timed, written tests, multiple choice tests). In mathematics it is vitally important that mark schemes should be used that permit examiners to mark responses more holistically than the conventional M1A1 approach. For example in GCSE QWC marks are awarded for the quality of communication in an entire response.
Teacher assessment should be informed by a rich evidence base comprising individual and group work on a mixture of short and extended tasks. In primary schools where the teacher spends most of the time with one class of children, it is possible to build up a detailed picture of strengths, achievements and areas for development across the entire curriculum. Encouraging children and their parents/carers to take an active role in assessment by drawing to the teacher's attention achievements beyond school, and contributing to discussion about attainment and next steps, can only help to secure the best possible progress for each child. In secondary school children should be encouraged to take responsibility for their own learning, and through the use of e-portfolios (say) draw to their teacher's attention relevant work from across the curriculum. For example a student may have undertaken a project in PSHEE which involved raising money for a charity concerned with pollution. In developing campaign material s/he may have undertaken research into the science of pollution going beyond what was covered in class. Again involving parents/carers may be beneficial.

Helping children understand what they need to do to make progress in terms of the subject (rather than you're on level 3b to get to 3a you must….) so that children are able to talk about what they can do and what they want to be able to do.

f) To what extent can/should science and mathematics be effectively assessed through other subjects?
This is a second order issue compared with the need to ensure that assessment is valid. By getting children to take responsibility for their own learning, so they recognise confident use of mathematics and/or science across the curriculum (note that this is more of an issue for

secondary). However, where mathematics isn't taught by the class teacher in primary, problems can arise as teachers may not be fully aware of individual needs and therefore miss opportunities across the curriculum to develop understanding.

g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?

The number of stages at which public examinations are used should be the smallest that can be managed. It is highly doubtful whether it makes good sense to assess our young people in each of Y11, Y12 and Y13. Many students take public exams each year from Y9 to the end of compulsory schooling. Entries may be followed by retakes in an attempt to improve performance for school accountability measures. It is an appalling waste of public money to be entering and re-entering students for public exams (made available by private enterprise). The culture needs to change so that students only enter exams when they are likely to do as well as they possibly can.

Tests for pupils at the ends of key stages should be low stakes internal assessments, not the kind of high stakes tests that were used following the first introduction of the National Curriculum.

If a national system of testing is used before the age of 16 it should be on the basis of national sampling so individual students and schools don't get results but an overall picture of standards in the country is maintained.

h) What evidence of learning is needed for assessment to operate effectively?
Theoretically, any kind of evidence, including ephemeral evidence may contribute to effective assessment. This needs to be encouraged in schools where, particularly for mathematics, there is a tendency to rely on timed written tests

However, for examinations leading to qualifications it makes sense to require all evidence to be gathered under controlled conditions. The future will surely be on line assessment. It is important that this doesn't narrow the range of opportunities for candidates to demonstrate understanding.

Infrastructure

Infrastructure refers to the nature of the learning environment in which formal teaching and learning take place. For the purposes of this exercise, picture an 'ideal' learning environment of the future (in one or two generations' time, for example) which has all the resources and support systems in place to enable the best possible teaching and learning in science and mathematics.

a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?

There should be well resourced classrooms/laboratories with sufficient space for children to be able to work individually or in groups and the teacher to move about easily monitoring the work. There should be sufficient storage space for equipment and resources, some of which should be freely accessible to learners – including calculators, computers, digital cameras, data loggers etc. The entire school and its grounds should be available for use in learning and teaching science and mathematics. The school should have a 'maths' trail' which children contribute to and adapt, so it is suitably interesting and challenging for all learners whatever their age and stage. Links should be built with the local community so vistors form thiose who use mathematics and/or science in their work can be a feature of the curriculum as can reciprocal visites to their work places.

Teachers should also consider how local community amenities such as museums, libraries, churches and other places of religious worship can be exploited in the curriculum. Google Earth makes it easy to use maps and satellite images of the locality and comparisons with other parts of the county, country, continent, world…

b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (e.g. primary, secondary, middle, all-through schools)? Why?
Whatever the school, mathematics and science need excellent leadership and management, drawing on the strengths of all members of the team and working towards a shared vision for learners in the school.

c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Secondary schools need well-appointed laboratories so that all children can undertake practical science experiments in safety. Computers need to be available for the collection and analysis of data. They should also be available for studetns to research information.
In the future one can imagine every student having personal digital technology as a matter of course. Hopefully, teachers will be able to display all the students' screens at once to facilitate shared learning.

d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
D&T may well have facilities that are appropriate for working with food in both science (investigating the effect of different proportions of salt, sugar, yeast in bread) and mathematics (adapting recipes). The library is likely to be a valuable space for all subjects. PE can be used to generate data and investigate projectiles (say). Dance can be used to explore aspects of geometry including transformations and symmetry.
.
e) What other resources and systems should be used to support science and mathematics?
Clubs for students where they can explore recreational aspects of mathematics or debate current issues in science are valuable as ways of raising the profile of mathematics and science in school. After school events for parents/carers and children can help reinforce home-school links and help parents/carers to understand how science and mathematics

education has changed and why. This is important in both primary and secondary school, although often something primary schools do more regularly.

f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
The ease with which the school recruits and retains teachers, and post-compulsory students opt to study mathematics and science are indicators of excellent science and mathematics. All schools need to prioritise quality teaching accommodation and support (eg technician, TAs) to secure excellent provision. They also need to facilitate access to CPD for all teachers.

g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (e.g. should there be single sex classes or schools)?
The evidence is not conclusive. Some schools have found stage not age grouping works for them. Others have found that single sex teaching in mathematics and/or science works for them. The difficulty is that with any initiative, being involved in the initiative tends to have a positive impact!
One argument for single sex teaching is that girls who like science may be less prone to succumb to negative stereotyping.

Accountability
Those who are responsible for science and mathematics education within schools and colleges should be accountable for their performance.

a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
Teachers need to be trusted to do the best job they can for their students. National sampling should be used to monitor academic standards rather than testing entire cohorts – a remarkably expensive think to do.

A system of cross-school moderation would help to raise confidence in teacher assessment.

b) How should qualifications in science and mathematics be regulated?

Qualifications should be better regulated than they have been to date. There has been a collective failure to require awarding organisations to deliver valid mathematics assessment. The interests of awarding organisations have been dominant; these have been served by allowing awarding organisations to continue to produce conventional examinations, with traditional approaches to marking. A significant shift is needed to ensure that examinations assess what the mathematics education community and users of mathematics qualifications value. Such examinations would place much greater emphasis on the central skills of reasoning and problem solving. An effective regulator would require that awarding organisations actually deliver assessments with greater emphasis on these features. To do this would require the regulator to acknowledge that different subjects may need different kinds of assessment.

The recent changes to GCSE needs to be given time to work. Evidence from the evaluation of the mathematics linked pair pilot suggests that teachers are beginning to make changes to their practice in order to prepare students better for the new item types. The regulator needs to act on external concerns should it transpire that an awarding organisation is failing to comply with the regulations and produce assessments that are consistent with its specification and sample assessment materials.

c) How can we ensure that all students can access the science and mathematics courses they wish to?
It may be unrealistic to expect all schools to make all courses available. However it should be possible for consortia of schools to do this. Also with changes in technology it should be possible for students to access on line resources and support, as for further mathematics. CPD needs to be available to teachers so they can develop their skills to offer courses for which they lack the necessary expertise, confidence and/or experience.
d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Performance targets have distorted the curriculum experience for young people at every stage where they exist. At key stage 2 children can spend up to two terms in Y6 learning no new mathematics and just practising for tests. In secondary including English and mathematics in the five A*-C GCSE count has resulted in many schools adopting strategies to 'bag the C'. This often means early and repeated entry to GCSE, in some cases with multiple awarding organisations! The DfE analysis published at the end of 2011 makes it clear that most students under perform by a grade in GCSE mathematics if they take it in Y10. Because students are led to believe that a grade C will do, they often lack motivation to 'improve their grade' at retake, not realising that for some university courses a grade C will not be sufficient.

e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
It is helpful to be able to access information about schools. However whatever information is reported becomes that which is most highly valued, whether or not it should be. There does need to be some attempt to include measures of progress, a school that achieves 95% A*-C with an entry cohort that is all level 4 or better in Y7 is doing very differently to a school that achieves 50% A*-C with a cohort in which just 60% have achieved level 4 on entry. CVA was not about having low expectations, it was about recognising the diversity in schools.
There also needs to be built in some measure of participation rate post-16. At the moment 11-16 schools are not accountable for what happens when their young people leave, and consequently tend to be more likely to 'bag Cs' without considering how well prepared students are for progression.

Mathematics needs to be done. Whereas GCSE early entrants for English will continue to develop their skills across the curriculum, mathematics is little used across the curriculum so early entrants' skills may atrophy. Particularly if they are allowed to stop studying mathematics once they have grade C.

Other comments:
I am a member of the general council of the Association of Teachers of Mathematics. This is a personal response as the time available did not allow sufficient time to collate members' opinions.

Hopefully more time will be allowed in any future calls for evidence.

John Poultney

1. a) What is good about UK science and mathematics education?
Very little

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
We need to decide why each pupil is taught this subjects and what we want them to get out of them. This will be different for various groups of pupils. We need to make sure that the high ability pupils are enthused and challenged by the curriculum and the way it is taught, while the low ability pupils are taught things that they see as relevent to their lives. In essence we need a differentiated curriculum - science for future scientists and science for the citizen. The same soes for maths. Only when the curriculum is relevent will pupils engage with it.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Science and Mathematics should be the lead subjects in developing pupils' thinking skills. They are not. Too much of education is for the school and the way it is assessed and too little for the pupil. We must develop the thinking skills of all pupils and especially the more able ones as a priority. Multiple choice and short answer exam questions do the opposite; they develop recall and memory rather than deductive, evaluative or creative skills. It it these later skills that we need as a society - recall is less an less important in the age of information technology - we can look up facts easily, but understanding them, producting meaningful conclusions or producing new knowledge is much harder.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
In maths we must focus on two areas - basic skills for everyone and more advanced mathematics for a smaller group. Currently a grade 'C' GCSE really just says that the pupil knows something about some aspects of mathematics. It could also be argued (given the low raw marks needed for a grade C) that such a pupil is more likely to get a maths problem wrong than right. We need basic skills for everyone. I would argue for a set of new qualifications in basic mathematics that should be compulsary in schools. The pass mark in these exams should be extraordinarily high - 95% but the topics simple and basic. Perhaps a

first level would be integer addition and subtraction taken in year 3, integer multiplication and division in year 5, decmals and fractions in year 6, percentages in year 7, simple statistics in year 8. Only once all these basic tasks have been mastered should more advanced concepts in GCSE (trig, surds etc) be attempted. In science we must move away from recal and the bias to biological science. We need to develop thinking skills and for pupils to have a better grasp of physics.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
As an NQT coming from 27 years in science based industry, I would say that science must be taught in the teachers specialism. When I teach physics, I do so as a physicist with 30 years learning; when I teach biology I do so as someone who got an 'O' level in biology 30 years ago. Pay is another issue. While it is unreasonable to expect teachers' pay to rival industry, the pay structure says don't teach; you will start on the bottom of the pay scale - In my case moving from industry to teaching results in a pay cut of more than half.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
In primary, teaching skills are more important than subject skills - so we should be relaxed about subject knowledge. In secondary subject knowledge is more important.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
If we want career changers than the PGCE must be funded to aid the transistion.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
A total overhall is needed. Too much of the PGCE content is really for the university. In the course I did, there was a small half hearted subject knowledege apect to the course; it was insulting to those with strong subject knowledge and utterly useless to anyone with weak subject knowledge. The rest of the time spent in the university part of the course was looking at academic aspects of the pedagogy of teaching. In fact little of this has proved to be useful. The teaching practice is the key part of a PGCE; here the level of tutoring is very variable and total dependant on the school in which one is placed. By and large, one is dumped into a classroom, observed for a few lessons and left to get on with it. The one thing that does not happen is being taught to teach. This is the key thing that needs to be improved. We must stop universities pretenting that a PGCE is an academic study and focus on the PGCE as training to teach. The start must be to have the tutors in schools trained to teach how to teach.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?

Ultimately the tutors in schools who guide PGCE students should have to be qualified to teach how to teach. It should a major part of their job for which they have time. As it is they have to fit this into a normal teacher's day.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
School based...
8. h) How much of this training should be spent gaining experience in the classroom?
Vast Majority
9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
One Year assuming subject knowledge is fine.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
In science, CPD can look at practical work.
2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
All teachers should have a half-term refresher course every five years.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
See above

4. d) Should CPD be voluntary or mandatory? Why?
Some of each.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
They are too busy and cost.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
No - It will just become another academic rather than practical course.

1. a) How and where should we be training laboratory technicians?
In schools funded to do this.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
Heath and safety etc.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?

Yes - Supporting SEN, EAL and possibly on supporting the teaching in practical lessons. Training again would be in schools and funded.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
We should not get too hung up about careers here. It would be great if we could get more of the population to understand science and mathematics even if they don't have a career in science or engineering. If other sectors of industry had staff that understood science and engineering then that would help science and engineering indirectly.

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Leadership in may schools is mutually exlusive from innovation. Schools' leaderships are too often focused on narrow criteria (Ofsted) and expect other leaders in the school to do the "safe" thing. Innovation can only occur in an environment where failure is tolerated.

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
The head teacher's vision, visibility and commitment.

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
Too little in many schools. Effective governing bodies really to hold the school management to account while being understanding on risk taking.

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Ability to listen. Ability to follow instructions Confidence to have a go. All of these need to be encouraged from KS1. We must stop spoonfeeding children and get then to think. Too many children are conditioned to expect every problem to have a "right answer". By the time they are 11 or 12 years old, it is virtually impossible to move them to an investigative, evaluative approach. I have seen many pupils do an experiment and write down the results they expected rather than the results they observed. Asked why - they will say that thay wrote down the right answer - the obseravtion was the wrong answer!

2. b) How may the acquisition of such skills best be assessed?
True evaluation of practical work and by examination with long form answers so they are not just following a structure.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Not very. In science the step is so big that they are almost starting again

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

The national curriculum must be slimmed down. It must be differentated so that different curricula are applied to different groups. I had the difficult task of teaching atomic structure to a group of students that were unable to subtract three from seven. The curriculum was not relevent to them. At GCSE/A level practical exams must be that - a test of the students' practical skills. The current controlled assessments are excersises in jumping through hoops and neither assess the students' practical skills nor their evaluative skills in a meaningful way.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
AfL is useful even vital in day to day teaching.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
Not easily.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
In maths probably every year through KS2. After that at the age where science ceases to be compulsary. For those that take science further at 18.

8. h) What evidence of learning is needed for assessment to operate effectively?
More than in a BTEC! We need to have evidence of Recall Understanding Evaluation Deduction

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
For secondary science, the ideal classroom would have separate theory and practial areas. There would be ample access to ICT too.

5. e) What other resources and systems should be used to support science and mathematics?
ICT

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
i) By progress ii) By report/grade/exam iii) By skills iv) By skills v) via parliment vi) ?

2. b) How should qualifications in science and mathematics be regulated?
All pupils exams should be regulated by two bodies. One should regulate directly, the other should ensure that the first is doing its job correctly. All procedings and interaction with governements, exam boards etc. must be done openly and in public.

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
Subject only to entrance criteria any student should have a right to take any science/maths course up to age 18.

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Targets are almost aways bad - simply because behaviour changes to ensure that the target is met at any cost. The result is always that the target is met, but the overall result is worse.

Steve Price

1. a) What is good about UK science and mathematics education?
caters well for higher achieving students

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
lower ability students need a simpler or more practical based qualification - not a btec coureswork copying out exercise but an actual active science course that gives them opportunities to become plumbers, electricians etc.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
the scope is too much on higher tier pupils, our lower ability cohort is significantly challenged in terms of their maths and english, they need simpler, job related science and maths

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
stop expecting every child to become a brain surgeon! cater for the employment sector by asking them what skills they need, not dictating specific grades for unneccesary topics.

5. Other comments
a lot of kids switch off due to the maths they need to achieve highly in science, especially in physics - possibly maths needs to catch up with the relevence of their subject to the real world.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?

china, nigeria (private schools) and belgium - all have high pass rates with international students in our country from these examples achieving higly over here.

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
the time allowed for staff to cater for the pupils they have, the support from parents and the accountability of management to train teachers effectively.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
pay increases would be a start, £20,000 for a starting salary for a graduate is insulting. more suppor and less stress would be welcome, if students see teachers stressing then they wil be put off the subjects.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
set them an a-level exam - if they can achieve a B or better let them take the training, also set them some gcse english tests, see if they can score highly on the oral and written tests, some of our recent pgce students can really struggle in marking, assessing etc.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
yes, although these should be tempered and bonuses awarded if pupils achieve above target in each year - this should be externally assessed.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
allows a taster to see if they truly want to dedicate their lives to this vocation

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
schools should interview candidates before they are accepted, this would save a slot of hassle and problems for us if they are unsuitable.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
schools should be allowed to rate the quality of the trainees they recieve

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
they need time in lessons with tough and bright kids, less onorous coursework assignments and more on the job practice

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
in schools.

8. h) How much of this training should be spent gaining experience in the classroom?
almost 100%

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
at least a full year with regular assessment

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
huge, although opportunities for such training are restricted by cost and location

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
regular updates from exam boards and university/college instiutions would help a lot - we get so behind its unreal.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
every year, without fail.

4. d) Should CPD be voluntary or mandatory? Why?
mandatory, or else people fall behind and coast with their teaching

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
costs - impact awards help

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
yes, although it should always be centred around the classroom

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
yes

1. a) How and where should we be training laboratory technicians?
in university labs

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
these need to be highly qualified and valued personnel, they simply are not seen as core members of the teams they work in and yet have the hardest job od the department

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
they should be trained on site with the pupils.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
a national network would be good, our own career advisors are not very good and often sell the wrong and misleading advice to students that is out of date

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
they are hugely decisive on the ability of a science team to work through a unit of work and assess accurately. leadership is a neccessary requirement for any HOD or leader within a school

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
they neef to know their subject inside out, have the confidence of the senior management team, be enthusiastic and an outstanding teacher

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
reward successful grades and target beating results

4. d) How can leadership pathways for experienced teachers be introduced into careers?
not sure what the question means

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
the local area has a massive influence, the job situation and their general stress levels

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
good leadership breeds good teams, poor leadership breeds inability to change and encourages coasting staff

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
the role is misguided and it appears to me form working in three schools a sheer mess at times. governors rarely enter the school grounds and have little influence on the day to day running of the school

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
the maths needs to be strong, students should start early with gcse level work and frankly maths should provide details to every department how they teach thei subject so there are no conlficting approaches

2. b) How may the acquisition of such skills best be assessed?
exams, practical situations
3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
at the moment there is no trust between the two levels, secondaries see the primaries as pandering to their target grades and the reslts we see form staff assessments are over inflated regularly, primaries see us as having over inflated egos and poor achievers,

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
units should be based around specific industries, i.e. medicine, manufacturing, transportation etc

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
exams do help, but there should be a more practical approach

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
science and maths should be in built across the school curriculum

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students’ school careers?
year 9 and year 11.

8. h) What evidence of learning is needed for assessment to operate effectively?
regular assessment, on a classroom scale sees ot work if the assessment is carried out by a separate member of staff

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
it needs to be a balance between the two, some outside and relevent industrial visits or work experience and some in school training

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
not sure

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
technical colleges worked.
4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
we regularly use our ict and metal work facilities for teaching chemistry and other subjects

5. e) What other resources and systems should be used to support science and mathematics?
employer expectations and networking would be useful - possibly some university and college links that students control - could they network with students at these other institutions?

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
better on site technical support and practical experience of expeirments would help new staff

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
girls work at a higher level, this is common sense, our top sets are mostly girls by results, sinlge sex classes are better

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
students need regular wake up calls to make them realise how to work and study and why it is important, parents need to be responsbile for students being prepared to learn, employers need to let us know what they need in terms of skills

2. b) How should qualifications in science and mathematics be regulated?
gcse exams are fine for higher tier, bnut lower tier need more practical examinations

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
see above

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
useful but they have become too unrealistic - the result of an overly competitive system. over competition leads to lower ability becoming, if you will, extinct.

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
schools with lower ability should be assessed but in a different group compared to the grammars

Phil Ramsden

General questions

1) Science and mathematics education in the UK

a) What is good about UK science and mathematics education?

i) Many more school age pupils study science now than ever before and they study all the sciences.

ii)All pupils now study some science up to 16 yrs of age right from when they enter primary school.

iii) About half million pupils (the vast majority of the cohort) take 2 or 3 GCSEs in Science subjects and over half obtain C grade and many A and B. This a much bigger proportion of the cohort than in the even the 1980s and very much more than the 1960s and 70s.

b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?

i) Drastic change at the classroom level is neither necessary nor desirable, evolution towards agreed goals is best and this has been going on within the national curriculum, for many years and it needs to continue. The big issue in science education is still related to allowing pupils to do more science themselves and to be independent learners.

c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)

i) In Primary schools **less time** is devoted to science now it is not tested with SATs , this is predictable due to other pressures but it is worrying and could set back the gains of the 1990s and 2000s . I have heard of primary schools who 'do all their science in Science Week' and others who demonstrate any practical work because of health and safety rules.

ii) In Secondary teaching is dominated by GCSE results and although getting good results are important the intrinsic interest of the subject is sometimes subverted.

iii) However the **most serious threat to the continuing improvement in education** at the moment arises as an indirect consequence of the increase in the number of academies and the corresponding decrease in the size and influence of LEAs. My own experience as a governor shows me how schools tend to try to solve every problem from within the school and not just to save money. They have no clear picture of what support and help are available and they are disinclined to ask for it. In the past LEA inspectors would spot when support was needed but there is no one to do this now. OFSTED would only pick up on a problem by the time it was seriously affecting outcomes which could be years too late.

d) How can a science and mathematics education system best meet the needs of employers and higher education?

One major way would be for employers and HE to become involved in the GCSE examination system again. The universities pioneered School Certificate and Higher School Certificate in the first half of the 19 Century, However by the time the GCE came long in the 1950s one exam board at least , (JMB,) was "finding it a matter of urgency to draw attention to the scarcity of university teachers who were willing to serve as examiners SC and HSC in any subject except maths" and there is every reason to suppose that the likely reason identified by JMB was not confined to the Northern universities ie that "fewer heads of university departments would now agree that all those of their colleagues who take part in the Boards examining work are rendering a service to their departments and to their university" (pg 128 in Fifty Years of Examining by J. Petch, publ by Harrap 1953). This state of affairs has gone from bad to worse and HE have very little input into GCSE specification design and exam marking.

2) Science and mathematics education internationally

a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?

I share the misgivings of Dr Tim Oates of Cambridge Assessment, of the dangers of a " naive descent into policy borrowing" (T.Oates 'Could do better ' Nov 2010 Pg 12.) and of simplistic comparisons with the education system of other countries and would emphasise the importance of rigorous research before any useful lessons can be drawn. The case of the PISA comparisons illustrates my worries well. As someone who has worked as an inspector on the PISA testing in England I have seen the complete indifference with which English schools treat the PISA test, which they regard as an intrusion into the curriculum. Compare this with the situation in Germany where nationalistic parents are encouraged on every bookstall to buy PISA test primers to work on with their children so that the honour of their country will be maintained, just in case their school were chosen. On top of this the raw differences in score on which the all important rankings are based are often only just statistically significant e.g. 7 marks in 200.

Teachers (and the wider workforce)

An education system can only be as good as the teachers within it. But for many years now shortages of science and mathematics teachers have been recorded in England and Wales and the situation elsewhere in the UK is not entirely clear. Problems have been reported both in recruiting sufficient trainees and retaining qualified teachers.

Please answer these questions without feeling in any way constrained by current or proposed mechanisms in place for recruiting, training and/or professionally developing science and mathematics teachers.

1) Teaching as a career

a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?

i) Good teachers must remain **good learners** and so the opportunity and encouragement for teachers to continue to learn/study throughout their careers is paramount. Many PGCE students begin an MA as soon as they leave their PGCE course and this is fine but it shouldn't be at their expense and it should qualify them for say half day week off teaching too. When I was young teacher I joined a scheme based at , what is now, the university of Derby whereby I studied for a London University external MSc in science by research. This involved me doing actual science research at the university on one afternoon and two evenings a week and it really kept me up to date with chemistry at the frontier and I feel sure that the effect rubbed off on my pupils. Such schemes seem no longer to be available sadly.

2) Initial Teacher Training

a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

Primary. All students entering primary teacher training will have GCSEs in double award or triple science now and this is enough to build on in their HE courses in general, so long as they are encouraged not to feel inadequate about factual information they don't have, so long as they have a good model of what science is and how it works. It is however desirable in larger schools for science coordinators to have degrees in science of whatever class. But over the last 20 years TDA figures suggest that due to a shortage in primary PGCE places applicants with the highest degree class have been selected irrespective of the subject and these have tended to be arts graduates. Hence we have been selecting against graduate science teachers going into primary schools for 20 years and this must change.

Secondary. As someone involved for the last ten years in secondary ITT I would agree that whilst graduates with a good degree often make energetic well organised and enthusiastic science teachers the opposite is by no means true. I have seen many graduates with third class degrees make excellent teachers and find satisfying jobs in schools. I would thus leave it to the trainer to be the best judge of who to train and have no restriction in funding linked to the class of degree.

b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?

i) Yes as we are competing with industry for graduates. This could be where good honours graduates are given higher inducements.

c) What is good about initial teacher training programmes in science and mathematics in the UK?

i) I must of course declare and interest here, but I think that courses have evolved over many years as have partnerships with the schools where teaching practice is done. Whilst on the taught part of their PGCE students are in university setting with access to the complex and comprehensive library and ICT facilities of the university and are in an atmosphere where adult study is the norm. This is a big advantage over students studying in schools. A university based programme also gives students access to more than one school for teaching practice and they often do much better in one than the other. On a school-based course they might be 'stuck' with a school which isn't really for them.

d) What changes to these programmes (e.g. philosophy, content, or emphases) are needed?

i) Many ITT providers are striving to involve practicing teachers more and more in provision and this trend need to continue.

e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?

i) the current inspection regime certainly 'focuses the minds' of providers, However, as with schools the emphasis on overall judgements with simplistic criteria can lead to undesirable effects. For example the OFSTED criterion that no university dept can be outstanding unless 50% of its students are themselves outstanding, could lead to changes in grading policy not warranted by student standards. It can also lead to unnecessary rejection of applicants who would have been perfectly acceptable before.

f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
ii) One year PGCEs are barely long enough but there will never be funding for two year courses however funding should always be available for some continued study (see comments to 1a.) above.

g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why? i) University based with links to schools .see answer to 2c.

h) How much of this training should be spent gaining experience in the classroom? At least half.

i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
i) As I said above a longer time than one year for PGCE would be beneficial but costly the important thing is to be funded to continue study after qualifying.

3) Continuing Professional Development (CPD) for teachers

a) What are the benefits of subject-specific CPD for science and mathematics teachers?
i) They are potentially 'game-changing'. The National and Regional Science Learning Centres have been successful in the first five years of their life, and have delivered very high quality courses on teaching and learning and on subject updating which must have made great difference to the teaching back in schools BUT there are still many teachers and ,many schools who don't use them and worse still haven't seriously considered using them, they don't even appreciate that funding is available such that schools pay nothing. This is

because schools increasingly operate as autonomous units making their own decisions and trying to improve teaching and learning by generic courses from within the expertise of the staff. This cannot be enough for science teachers.

b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
i) To go on external courses regularly such as those run by the National and regional Science Learning Centres.

ii) By becoming part of some professional network such as the ASE or RSC and contributing via the internet or at face to face meetings to the development of teaching and learning in the subject.

c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
i) It is important that they undertake it regularly at least once year and more if specific issues exist such as a new exam specification or special problems to overcome in the school. In addition to one and two day courses throughout the year teachers also should earn by length of service an entitlement to more extended CPD every five or so years (like the old sabbatical)

d) Should CPD be voluntary or mandatory? Why?
i) Anyone who has been a CPD provider with teachers, as I have, can bear witness to the great benefits that this can have and especially if the recipients are willing participants. However where a school identifies a problem with a teacher where CPD can help it has to insist that the teachers participates and in such situations in the past most teachers will come round to see what they have been missing and will benefit. Such situations are of course best avoided and this can be done by having philosophy of CPD entitlement as normal part of school life. Problems usually arise where schools are reluctant to send teachers out on courses and where such things are so rare that only the really insistent teachers get a chance.

e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
i) The central key obstacle to schools having well informed systems of CPD is the attitude of head teachers and senior staff to such things. Many schools have problems getting cover staff to use when teachers are out and this is itself real stumbling block. Some have even adopted policies of 'staff in front of pupils' at all times to minimise disruption and maximise learning.

If the culture of a head and senior management team is not favourable to CPD involving subject specific CPD it is very difficult to change their minds for the simple reason that **there is no one** who can communicate and discuss this with them. Such a role would have been played in the past by an LEA subject adviser or senior adviser but they are now largely gone. The school SIP (School Improvement Partner) would never get into such territory unless outcomes i.e. results were being seriously affected and even then the link is unlikely to be made between lack of CPD lack of success.   When did anyone see an OFSTED report commenting on the percentage of subject teaching staff who had been on CPD in the last twelve months?   Under the current system they wouldn't even ask but in 1990s inspections it was routinely done and it was sometimes a very revealing indicator.

f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
i) Yes certainly.

g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
i) Not always but the principle is a good one and longer CPD should be accredited through Masters credits .

4) The wider workforce

a) How and where should we be training laboratory technicians?
The answers to all these questions are covered in the recent ASE Technician Survey Report available via the ASE website www.ase.org.uk . In summary it shows a deteriorating position with regard to technician support and training.

i) Courses are currently available through the Science learning Centres, and CLEAPSS but travel even to regional centres is a problem as many technicians do not have cars and cannot set out very early to use public transport because of child minding commitments. Locally based LEA courses where CLEAPSS or the Learning Centres are the providers are best to overcome this but with the demise of LEAs and the lack of advisory staff there is no one to organise these.   Hopefully as Academies and other schools get established they will work in groups to fill this gap but it is not easy to know who will make the first moves.

b) What CPD needs will laboratory technicians have and how will these best be accommodated?
i) There is a need for basic training for many new technicians but also for more advanced training for those who are now in line to replace senior colleagues who are retiring.

A key issue with regard to technicians highlighted by the ASE survey is that as schools become independent form LEAs e.g as academies there is no one from outside the school to intercede on behalf of technicians when senior mangers decide to cut their numbers or to employ unqualified replacements.   It is often very difficult for heads of science to demonstrate to senior colleagues just how essentials well trained technicians are to a good science department.   Many technicians feel very low status and I have had them say to me "They wouldn't pay for *a technician* to go all that way for a course".

c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
i) There has already been some excellent training for TA s and higher level TAs based around supporting science and this was done by CCDU based at Leeds Metropolitan University, www.ccdu.co.uk/ . It was I pilot and the funding dried up in March 2009.

However the training showed just how much TAs and HLTAs can contribute to science education . They have completely different outlook to a science teacher and complement their work well.

d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)

i) Such advice is very necessary and needs to be integrated into the school whole curriculum and especially the science curriculum. A network of advisers would be a good idea.

Leadership and ethos

Leadership and ethos are complex concepts within education, but are considered to be significant in affecting the overall performance of individual schools and colleges, and the education system as a whole.

Much less is known about the leadership characteristics of those science and mathematics teachers who successfully introduce innovative teaching and learning practices. This implies a culture of initiative and collegiality for developing, as well as delivering, the curriculum. However, systematic evidence is also lacking in respect of the effect of such leadership on student performance and progression in science and mathematics.

a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
i) Good leaders both at school and department level are obviously necessary. There will be plenty of evidence from OFSTED inspections where leadership is always major target for inspection.

My experience is really at departmental level and there a good leader who can lead by example and help the department to work as a team is essential. They have to know their staff well and they have to be given the time to manage them and the running of the dept.

g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
i) Governors should bring their experience form their lives outside school to bear on school issues and thereby see different perspective to that seen by the Head and staff. They should ask questions when ever they can't understand what is being proposed and they should not be afraid to keep on asking questions until a satisfactory answer is received. It is good if at least one governor is form science based industry and one form science HE because they can bring their professional experience to bear on commenting o what the school does.

Skills, Curriculum and Assessment

Acquiring the right scientific and mathematical skills and knowledge is a key component of an 'ideal' 5-19 education process. Teachers teach to a relevant curriculum and enable learners to acquire useful knowledge and understanding, which is then assessed at a critical point in time to certify what a young person knows and can do in these areas.

a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?

i) The 'learning to learn skills' are clearly important an included in these would be the skills of independent enquiry. Also learning how science and scientist work is very important. Manipulative skills become increasingly important as pupils get older and especially post 16.

b) How may the acquisition of such skills best be assessed?

i) Teacher assessment has always been the best method for assessing manipulative skills and but it is all too easy, as has been shown over the last 20 years to panic teachers into not doing it by making the amount of assessment look unmanageable. Class sizes and teachers workloads all play part in making this possible but it remains the only sensible way. Other skills such as knowing how science works can be assessed in variety of written and on line ways.

c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?

i) It is and always has been very important and in the late 80s early 90s many LEA-wide schemes were tried to structure and support transition with regard to science. Many individual secondary schools now have staff whose job it is to support such transition but it needs to be long term over years not just the weeks before transfer.

d) How should a curriculum be structured so that:

i.) Science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science;

Science to 16 years has to be a core subject which all pupils must do. The amounts of total curriculum time currently recommended in DFES models are fine. But there is an issue of schools starting KS4 work in Y9 which is becoming ever more common and exams and exam specifications have not really caught up with this. The recent Expert Group advising the National Curriculum Review proclaimed itself to be agnostic on this issue but felt it needed further investigation before widespread uptake could be recommended.

ii.) teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning?

The issue here is that timetabling should be free enough to allow classes to be in labs whenever they need to do practical, effectively all the time. They also need to have access to good ICT such as interactive whiteboards and internet. 3D projection facilities can make big difference to pupils ability to visualise complex systems e.g. the human digestive system, but these can't be in every lab.

iii.) diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives:

There is no simple answer but current attempts at allowing such provision particularly at KS4 e.g BTEC as an alternative to GCSE should be thoroughly evaluated.

iv.) there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

The way of specifying the content of the curriculum need to be flexible enough to allow teachers to choose new discoveries as examples of what is specified. The current Secretary of State for education has talked of using concepts as way of achieving this and indeed a whole GCSE course used to use this method with great success. This was the Schools Council Integrated Science Project SCISP which ran in the 1970s and 80s. It did not become widely popular because of its emphasis on integrating the three sciences plus geology into topics . However speaking as someone who used to teach it I found the method of specifying content as simple list of concepts to be very liberating. So, for example, if the concept is 'photosynthesis' then a teacher can use any context to exemplify it to pupils and this might include some of the most up to date discoveries. In the early 1980s I and my colleagues used the emerging research data on AIDS to teach the concept of genetic mutation, even though AIDS was unheard of when the specification had been written. Such methods of teaching positively encouraged our pupils to apply the concepts we were teaching in new situations and the exam itself also did this.

This very positive feature was however seen by some as a threat to results and it wasn't possible to prepare pupils for particular questions and this was another factor in SCIPSs demise.

e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

The latter part of my answer to the previous section is also pertinent to this question. There is a sense in which assessment should involve a firm and unbreakable contract between the pupils/ teacher and the examiner as to what will be tested and how. This is essential for teachers to have confidence to use wide variety of teaching and learning and to contexts. It is also essential for pupils to know what of their lessons is useful background and what is essential knowledge and understanding. I firmly believe that a specification in terms of basic concepts such as photosynthesis (sometimes called the big unifying ideas of science) are good way to build an exam specification, together with what are often called the ideas about science ie how it works. This approach stated in SCISP and developed in some GCSEs is now best exemplified in the Twentieth Century Science GCSEs developed at York by Prof. Robin Millar and colleagues and examined by OCR.

As I intimated earlier the tremendous pressure on schools to get the highest GCSE results they can understandably makes teachers very wary of exams where pupils are expected to apply their knowledge in unfamiliar situations but this is really the only sure way to test real understanding.

f) To what extent can/should science and mathematics be effectively assessed through other subjects?

This is a completely novel idea in secondary education and I have no view on it.

g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
This is a difficult subject because any changes would have such far reaching consequences that we tend not to even contemplate it. It has been suggested that the effective raising of the school leaving age to 18 will make GCSE irrelevant and it is even suggested that this is the case now with so many staying on. However I think that there is still room for a formal summative assessment at this time. There are two reasons for this firstly it provides useful information in standardised form to the future destinations of the pupils and secondly that examinations such as GCSE effectively determine what is taught and so the GCSE actually form the most direct method of specifying what is taught in schools. The old adage ' if it's not examined it's not taught' is more true today than it ever was and there is absolutely no sign of this situation changing. I think we should just recognise it and use it to our advantage.

h) What evidence of learning is needed for assessment to operate effectively?
Some written evidence is always going to be needed. And this will need to have been obtained in ways which allow teachers to guarantee that it all the pupils' work. However we should experiment with using in conjunction with it other less secure evidence which give broader picture of the pupil such as. projects practical investigation write ups, extended essays and also video clips.

Infrastructure
Infrastructure refers to the nature of the learning environment in which formal teaching and learning take place. For the purposes of this exercise, picture an 'ideal' learning environment of the future (in one or two generations' time, for example) which has all the resources and support systems in place to enable the best possible teaching and learning in science and mathematics.

a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Secondary science will still need to make extensive us of laboratory facilities but ICT and general study/project areas can now play in increasing part in it. Primary can be done in a well equipped primary classroom ie with a sink. Both primary and secondary should also make use of outdoors and off-site work.

b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (e.g. primary, secondary, middle, all-through schools)? Why?

c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Secondary science will still need to make extensive use of laboratory facilities but ICT and general study/project areas can now play in increasing part in it. Primary can be done in a

well equipped primary classroom ie with a sink. Both primary and secondary should also make use of outdoors and off-site work.

d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?

e) What other resources and systems should be used to support science and mathematics?
A well equipped library/resources /ICT centre is essential. This will be more modest in primary bit it is still needed.

f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Greater flexibility in the school day ie a move away from fixed timetable in secondary would help science but this is radical suggestion which needs carful research.

g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (e.g. should there be single sex classes or schools)?
i) Small scale trails have been done in science usually in one school and although they all claim success I don’t think any have given convincing proof. By far the largest on-going 'experiment' is in comparing single sex schools with mixed ones and here again I don’t think the stats are clear.

One other experiment which could be tried would be allowing girls to be taught alongside boys of different age ie older ones, as it is often claimed that they are more mature socially than boys on their class.

Accountability
b) How should qualifications in science and mathematics be regulated?
i) Although criticised for being too cumbersome and being simply a forum for vested interests to be expressed the 'old' Standing committees Such as the Secondary Examinations and Assessment Council SEAC with its subject committees which included teacher, HE, union, and various other reps did do some valuable work and were steadying influence on Government.

c) How can we ensure that all students can access the science and mathematics courses they wish to?
Possibly by allowing pupils of different ages to be in the same class determined by ability and maturity.
d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Targets are said to focus minds and encourage effort and competition. But if they are all we have to rely on education has failed . A big part of education should be geared to inculcating

in pupils a desire to study and to develop to the best of their ability so that the only person they are really interested in competing against is themselves.

e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
We should avoid orders of merit since such lists often tale no account of the inherent error in the measurement and the significance of the mark differences. Banding of grading sets of scores can alleviate this to an extent.

Other comments:
I am an ex LEA science adviser and OFSTED team inspector for science. I was national Chair of the Association for Science Education, ASE in the 1990s and served for many years on the Royal Society Education Committee during the late 1990 and early 2000s.

Dr S Tunnicliffe, CASTME, Institute of Education

1. a) What is good about UK science and mathematics education?
that it is there!

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
more relevant to real world, recognition of importance of first hand observations and experiences of pre school children and then of primary children with real investigations, science talk, establish sound basis for theory later on, need teachers sharing this philosophy not worksheet and prescriptive science bring back advisory teams

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
emphasis now on good degrees, teaching for the test that i have often seen

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
by matching business needs-real world to children's school experiences making work relevant

5. Other comments
have decision makers with since knowledge rather than pr and law!

6. a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?
can think of any all invalid in force-feeding for test results

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
depends what ae group and ability looking at

8. Other comments:
pre school investment vital
1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
sell teaching as exiting, have fantastic managers, recruit teachers who understand about learning not brilliant academics who can not understand why some 'do not get it'

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
passion for helping children learn, interest in everyday science technology and numeracy in early yars

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
yes, recognition

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
dedicated tutors, in touch with teaching reality

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
historical aspects, why we are where we are and review of developments in all science provision

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
monitoring but realistic benchmarks fit for purpose not ideologically based and recognition of different abilities and poetical of learners, not all narrow academic

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
full, part time, evenings

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
universities, partnership with some schools

8. h) How much of this training should be spent gaining experience in the classroom?

1/3 then reflection before next experience

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
1 year after degree, 3 yrs integrated education and science

10. Other comments:
recognise difference in primary and secondary needs, analyse foundation concepts for pre school and primary and construct understanding rather than deconstruct advanced concepts

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
passion for some

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
joining ASE, maths associations, inset etc, advisory teams

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
when vconveninent careers take different paths

4. d) Should CPD be voluntary or mandatory? Why?
half half, competency required- imaginatively

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
time, costs, school management

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
yes

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
yes

8. Other comments:
one size not fit all

1. a) How and where should we be training laboratory technicians?
colleges, university ed depts

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
don't know ask them
3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?

train aty universities by people who know! also teachers need to learn management of such teams could do often careers people from industry were a joke

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
subject associations in collaboration with colleges/universities

5. Other comments:
engage parents immunities not just chattering classes and politicians
1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
fantastic,also people skills in it
2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
management, people, logistics all project and resource management
3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
by understanding needs!
4. d) How can leadership pathways for experienced teachers be introduced into careers?
?
5. e) What factors are most responsible for creating the ethos of different schools and colleges?
management ethos of leader

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
depends particularly on qualities and beliefs of SMt

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
not much usually , called nodding donkeys by many heads

8. Other comments:
down to people
1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
being able to identify science and maths in their lives knowing vocabulary

2. b) How may the acquisition of such skills best be assessed?
start with parents and careers pre school

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
probably depends on schools , research I've done indicates attitudes of secondary staff a big problem,

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
too complex to answer here but one size not fit all and break down of arts/science divide recognition of skill common- e.g real history is evidentially based

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
formative with action

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
has potential, people's comfort zones and empires an issue

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
depends what rationale is

8. h) What evidence of learning is needed for assessment to operate effectively?
talking with students

9. Other comments:
No Response
1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
most that is meaningful is pout of school, lessons to be learnt, build on firm pre 5 experiences
2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
more, suit different needs, interests, aptitudes
3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
out of class roomexperiences,
4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
depends on subjects, e,g field work for biology

5. e) What other resources and systems should be used to support science and mathematics?
museums, media, fairs etc

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
advisors, allow science specialists at older ages to teach their subject again

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
it varies not conclusive

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
very complex, depends on who is funding it, who is experiencing it and delivering it and working with outcome product-

2. b) How should qualifications in science and mathematics be regulated?
pedagogical knowledge, minimums

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
would it could happen- ennlghtened politicians, advocats for students and resources

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
too narrow and get in comparison game like Pisa

5. e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?
with understanding!

6. Other comments:
this is too long a survey

Linda Sinclair, Hills Road Sixth Form College

1) Science and mathematics education in the UK

- What is good about UK science and mathematics education?
- The specifications are effective in terms of content and range of topics

- What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
- The gap between the skills required for success at GCSE and A Level is widening and there needs to be more effective coordination to enable a smoother transition between levels.
- There needs to be greater development of literacy and numeracy in science specifications at KS4 and KS5.

- What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
- Assessment criteria have become so formulaic that they indirectly discourage independent and creative thinking. There is little (assessed) opportunity for students to develop their reasoning skills, to solve problems more holistically or to apply their skills within a range of different contexts.
- By being overly prescriptive, there is a risk that assessment criteria will trivialise the subject content and encourage 'teaching to the test'. The tendency then is to train rather than educate.
- League tables have too great an influence on teaching and learning decisions – encouraging an emphasis on compliance rather than on quality of outcomes.
- Text books written by examiners discourage wider reading and exploration in that they are seen as the only source of 'correct answers'.
- The tendency for some schools to encourage their pupils to take large numbers of GCSEs (sometimes up to 14 or 15) further reduces the time available for developing deep understanding of subjects and core skills.
- A single awarding body, independently regulated, could be beneficial in terms of:
  - Ensuring a sufficient supply of highly qualified and experienced examiners (currently, in some subjects, the expertise is spread too thinly across awarding bodies)
  - Reducing costs
  - Avoiding the practice in some centres of choosing specifications on the basis of perceived relative difficulty
  - Avoiding the practice in some awarding bodies of 'coaching' teachers

d) How can a science and mathematics education system best meet the needs of employers and higher education?

1) Teaching as a career

a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?

- Offer rewards (monetary and non monetary) that are competitive when compared with other comparable occupations

- Ensure the profession is given appropriate status (this is boosted where professionals are trusted to use discretion and make judgements and undermined where there is excessive governmental interference)

2) Initial Teacher Training

a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

- Any diagnostic test should focus as much on the candidate's disposition, attitude to teaching and learning and passion for their subject as on their scientific/mathematical knowledge and skills. Formal qualifications alone do not determine suitability.

b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?

Make use of bursaries to attract scientists and mathematicians into teaching.

c) What is good about initial teacher training programmes in science and mathematics in the UK?

d) What changes to these programmes (e.g. philosophy, content, or emphases) are needed?

e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?

f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?

g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?

Training should take place in as wide a range as possible of schools and colleges, where there is a commitment to development and improvement, availability of good mentors and a culture of sharing good practice.

h) How much of this training should be spent gaining experience in the classroom?

Around 80%

- How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?

- The current length of teacher training programmes seems to be sufficient but it could be beneficial to extend the professional induction period of a newly qualified teacher such that a longer period (up to 3 years) of on the job development would be required before QTS were granted.

3) Continuing Professional Development (CPD) for teachers

a) What are the benefits of subject-specific CPD for science and mathematics teachers?

b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?

c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?

d) Should CPD be voluntary or mandatory? Why?
Both. Every school/college should ensure regular CPD for all teachers. In addition, teachers should be encouraged to seek further development opportunities to suit individual needs.

e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
School and college leaders must make a clear commitment to CPD which involves making it a budget priority and providing supply cover as required.

f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes, where appropriate.

g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
This may provide an added incentive where teachers are otherwise reluctant to engage in high level CPD. It is also useful to strengthen the CVs of those seeking promotion.

4) The wider workforce

a) How and where should we be training laboratory technicians? Combination of college-based training at suitable vocational centres combined with on the job training.

c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?

Teaching assistants are perhaps less appropriate at post 16 except as study support role.

a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?

- The quality of teachers and departmental leadership plays a crucial role in improving students' learning experience and outcomes. Each school/college will certainly have its own views on how this impact is demonstrated though it is not always easy to measure in an objective way.

b) How can school and college leaders encourage leadership among science and mathematics teachers?

- Provide opportunities for high quality CPD both within and outside the organisation (these should include leadership training and opportunities to visit and observe their peers in their own and other organisations).

c) What factors are most responsible for creating the ethos of different schools and colleges?

- The extent to which there is ownership of a clearly and consistently communicated set of core values and expectations.

g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics? Governing bodies help determine strategic direction and vision – this will include some influence over organisational values and decisions about the overall curriculum balance.

Skills, Curriculum and Assessment

a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?

b) How may the acquisition of such skills best be assessed?

c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?

d) How should a curriculum be structured so that:
i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science;
ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning?
iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives:
iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

f) To what extent can/should science and mathematics be effectively assessed through other subjects?

g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?

h) What evidence of learning is needed for assessment to operate effectively?

Infrastructure

1. Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?

- These subjects require purpose-built, well-resourced facilities and regular opportunities to experience the application of relevant subject skills within the workplace and outside environment (field trips).

b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (e.g. primary, secondary, middle, all-through schools)? Why? The type of institution needs to be determined by local and regional needs and together the providers should seek to ensure the educational needs of young people in the region are fully met. The most important thing thereafter is to ensure strong links and communications between the institutions so that, where appropriate, there is effective transition from one to another.

d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?

e) What other resources and systems should be used to support science and mathematics?
Subject-based networks comprising teachers, technicians and employers play an important role in the development of teaching approaches, updating subject knowledge and sharing resources.

d) How should qualifications in science and mathematics be regulated?
An Ofqual-type body with members drawn from a group of subject experts and relevant professional bodies.

c) How can we ensure that all students can access the science and mathematics courses they wish to? Discourage the creation of additional small institutions in areas where existing provision is effective. Ensure institutions are large enough to enable sufficient flexibility of resourcing which in turn will maximise range and choice of subjects.

e) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?

f) A sensible and measured approach to performance targets can support and improve quality; however, if used to excess, these can distort behaviour and produce unintended consequences.

g) How should measures of performance best be reported to different audiences? What other measures of performance may be required?

Other comments:
The comments in red represent the collective views of the College's heads of Biology, Chemistry, Mathematics and Physics. In addition, a full response will be sent by our Head of Biology. The College would be happy to be contacted in relation to any further follow-up or research that might be required.

Janet Ritchie

1. a) What is good about UK science and mathematics education?
Science teaching has moved away from the recall of facts to encouraging students to problem solve and open ended investigations. There is more emphasis on current issues and relavence to every day life.
2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Some of the curriculum requires specialist knowledge and there is little support for this (e.g. nanotechnology has entered the KS4 curricum.) Too many resources need to much time to find and process. Time constraints for the triple science (especiallY mean rushing through topics.
3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Behaviour of students can be an issue, which can significantly impact the type and regularity of practicals. Teacher time and access to good quaility and appropriate resources.
4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
I think teachers would benefit from having time with employers (e.g. work exchange?). Work closer with local schools/science employers. Use of mentors from industry is helpful. Careers guidance is not up dated with teachers. The new GCSE's have a much greater emphasis on literacy which is good.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
I think the reality TV programs probably helped! Greater openness of what (reallY) happens in schools would be good. Fewer critical comments from media and politicians. Teaching must be seen as a valid and worthwhile option in its own right, not just an option for those who couldn't think of anything better to do. It is a vocation but it is also a job and needs to be

rewarded. Closer working relationships with local companies might also encourage scientists to teach.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
I think academic ability is important however personality and an ability to communicate ideas, enthusiam and life experience can often be equally or more important. The problem with tests is they don't take these skills into account. I think that 2:2 and above degree or equivalent is appropriate but interviews should play an important role, especially for older candidates.
2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
If we are aiming to attract experienced scientists perhaps we should be offering more professional support e.g. a one to one mentors who are actually given time extra a school to support the ITT, two year PGCSE's? Child care allowance? And more help with transport. I've known trainer teachers who have been expercted to more for a term to a more distant school to teach. More checks and advice if you don't get on with your mentor. Training for mentors (regular) and maybe an incentive for mentors...they use up a lot of time.
3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
The PGCE course seems quite good although there seems to be far too much admin. The option to get a masters quailification is a good idea but I feel it over shadows the important issue of actually learning how to teach children and practicing different skills in the classroom.
4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
See above
5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
I think at the moment it is too hit and miss as to who your mentor is and who the teachers are who's classes you have taken over.
6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
No Response
7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
No Response
8. h) How much of this training should be spent gaining experience in the classroom?
At least 1/2. I'd suggest 1/4 on methods of teaching which should be practiced in the class.
9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?

Teachers need to be aware of the latest research and the methods of teaching. They shold be regularly challenged and given ideas. New science break throughs also need to be covered as does what is needed by employers. A lot more time should be allowed for training.
2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Observing other teachers is useful but with the best will in the world these can fall through as other things/pessures arise.. External inset is the best because it forces you to take the time. Conferences like the ASE are particularly good as they are fast paced and you can dip in and out of topics quickly.
3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Every year, ideally this would mean updating each subject once every three years. I,like many teachers, have gone from teaching one subject (Biology) to three in the last few years and keeping up is very difficult.
4. d) Should CPD be voluntary or mandatory? Why?
Some of it should be mandatory e.g. career guidance for teachers/what employers want from science education.
5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Time (especially curriculum time when the teacher is out) Money
6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
No Response
7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
I like the idea of this but I want to be able to choose the areas I feel I need developing and not "hoop jump" in order to fulful a set of criteria

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
I'd like to see science techs encouraged to lern how to demo the more difficult/exciting experiments.
3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Be great if teaching assistants were confident in their science knowledge
4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
STEM is an excellent idea but generally the resources are not immediately useable i the classroom and are is too mch to read.

Keith Ross

1. a) What is good about UK science and mathematics education?

Currently we have a good balance across the science curriculum - we must at all costs keep the science curriculum broad and balanced at least to age 16+. Few of those studying science at school wioll become 'scientists' but they all need to understand how their world works and how science knowledge is created - espcially important if we are to (a) tackle climate change with understanding and (b) prevent people from being hoodwinked by pseudo-science.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Many organisations (IoP? Tory Party) are pushing for specialist teachers of science at KS4 (ages 14-16). This must be set against the need for our pupils to have a broad and balanced understanding of how the world works. For example to understand the role of photosynthesis we need to bring in concepts of energy (starting with solar energy), of chemistry (of fuels and burning, of food and respiration) along with the biology of plants and ecology of life. A physics specialist, or indeed a biology specialist, who has not got this broader view is going to present a very limited understanding to her pupils.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Too many teachers use 'hands up' limiting the opportinuty for pupils to talk and explain things to each other. This reformulation phase of teaching - what is also becoming known as argumentation - needs to be built into lesson time. Maths teachers provide this 'practice time' though usually they ask pupils to work individually, but science teachers provide it more rarely. For example pupils doing practical work need to 'tell each other' why they are doing a particular activity, maybe after a teacher explanation, so that the practical work is purposeful. Similarly after practical experiences pupils need to talk through what they have learnet and understood from the experience. I have attended so many 'lectures' at conferences where the speaker goves no time for thought during his (usually his) presentation, and we have the same problem - people 'hear' what has been said, but have not time for internalising the ideas, so when it comes to explaining to colleagues later what it was about they find it difficult.

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
This is the wrong question. A school education is not there solely to provide for the needs of higher education and employment. The most important reason for including science on the curriculum FOR ALL is not for their employment nor for higher education, since only a minority will need their science for those purposes. An education in science provides (or should provide) scientific literacy - an understanding of how the world works, so they, as future citizens with the vote, can insure that their government (and themselves, by their actions) can take care of the planet and make long term decisions (for example, to protect our environment against climate change). On a less global scale this 'literacy' would include helping them understand what keeps us healthy. It also must include an understanding of the nature of scientific knowledge, to prevent them being taken in by pseudo-science. With this broad balanced scientific literacy the focus of a science education to 16+ pupils might then specialise a bit so that they begin to apply their ideas towards employment or higher

education. The 21st Century Science project, based at the University of York is a good example of such a curriculum. On a less substantial level I have written (jointly) a CDrom entitled "Science Issues" which sets an understanding of scientific ideas into everyday and environmental contexts (available freely from: www.scienceissues.org.uk)

5. Other comments
The move towards 'specialist' science teachers in teacher training (it should be Teacher Education) is unfortunate. The notion of a physics/maths specialist may be valid at 6th form/FE level, but in the 11-16 curriculum (KS 3 and 4) we need science teachers who have a broad grasp of scientific ideas. If Bill Bryson can gain a sufficient understanding of science in 4 years to enable him to write "A short history of nearly everything" it should not be beyond the capabilities of those 'training' to become teachers of science too, especially since they also have the advantage of studying (some) science to 18+ and at degree level. There are not enough 'spare' physics specialists to provide all schools with a 'physics' teacher at KS4 let alone KS3. The main thing is that in our teacher education courses we impress upon the intending teachers that they need a broad grasp of scientific ideas. Many Subject knowledge enhancement (SKE) courses suffer from being amalgamated with university undergraduate specialist courses. I ran an extremely well reviewed SKE course based on my CDrom "Science Issues" (see above) but it was discontinued by central government simply because it was broad-based. By having all sorts of specialists in the group we learnt together and the outcome was a group of 'trainees' who began to have a understanding of scientific ideas that could be applied both locally (to ther home, transport, agriculture ...) and globally.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
My experience of Nigeria was in the late 70's. There were always 2 curriculum 'slots' for science in their secondary phase. For the strongest candidates they tool 3 separate science exams, for the next 'group' they took biology + physical sciences (incl Phys and chem) and for the weakest they tool 'general science'. Unfortunately the teaching was rather didactic, as it was in many schools in the UK too. Those countries where the science curriculum is broadly structured would get my vote.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Physics graduates are extremely hard to recruit, let along good ones (this from my experience as the science tutor on a school-based secondary PGCE teacher education programme, and from my experiences working in ATSE - the Association for Tutors in Science Education). The opportunities for good physics graduates in research and inductry are great and it will be very hard to attract them away from such opportunities. In my opinion it is better to have a good well-motivated biology graduate teaching science than a poorly motivated physicist who cannot find a post in research or industry. Any graduate can broaden her understanding of scientific ideas relatively quickly (after all the physics graduate only has three years extra study in physics compared with other science graduates, and in any case, to teach to GCSE level too complex an understanding of a subject can sometimes

make it hard to interact with pupils at a more elementary level of understanding). We need to focus on those who have demonstrated their ability to teach - to interact with the younger generation, inspire them, give them the time and confidence to understand new ideas. I gave the example of Bill Bryson above of someone who was a committed 'non-scientist' but with a few years' study was able to write an remarkably error-free account of the history of science and of scientific ideas - a book I would recommend to all science teachers in training (and in service if they have not yet read it). So less emphasis on the nature of the first degree, but more emphasis on the ability to teach. Our scheme in Gloucestershire (GITEP) is ideal for getting the balance right between a school-based and a university based PGCE. Student teachers had 4 days in school, where a group of 4 or 5 trainees with different subject worked with a deputy head "Training Manager" on general teaching abilities - discipline, assessment, lesson planning, evaluation etc, and they came to me (and other subject specialists) for one day a week. During the following week they could try things out, and come together with other science trainees the next week with questions, reflections, successes and failures. Clearly financial considerations are important. Their student loan could be waived gradually the longer they stay in teaching. Their PGCE year could attract a 'salary' rather than fees. During their NQT year they need to be given 'easy' classes, and a light, perhaps half, timetable so they can develop their methodology for helping pupils understand the nature of science and its ideas. Once their confidence in place and their reputation begins to be established, they can be given a fuller teaching load with more demanding classes.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
For PGCE secondary science the degree course should contain more than 50% science, but the nature of the science is less important that its breadth - thus oceanography, where the physcal science ideas have been applied to 'real' situations may be a more relevant qualifcation for teaching A Level physics than a degree in theoretical physics. I think that a candiate's GCSE results are more important than whether they get a first or not. However a third class or pass degree is difficult to obtain and does show a remarkable lack of application, so to ask, NORMALLY for a second or first for entry is OK - but not to say others MUST be excluded. For primary 3 yr BEd courses, GCSE grade C in double science would seem to be a minimum standard for 18/19 year old entrants, and for mature students some form of SKE course should be demanded. For PGCE primary, the same. I am strongly against a diagnostic test. On our GITEP course in Gloucestershire, as in many other PGCE courses, we assessed student teachers' subject knowledge by their ability to prepare to teach. Thus any errors in Subject Knowledge (SK) shown during the teaching of a topic were taken very seriously. Over the first 5 years teaching as most topics get covered at every level, a teacher becomes 'expert'. What we want to ensure is that they have the capacity to continue to develop their SK, not that they can pass a test. Who will set these tests? Will they test comprehension and the ability to make sense of ideas which are new to them? If there is one thing the Royal Society campaigns for it shoud be to reject diagnostic tests. However I used a diagnostic test in my interviews for places on our PGCE course. But I expected candidates to get the questions wrong. They were elicitation questions inspired by the work of Ros Driver in the Chrildren's learning in science project from the 80's. A group of

us devised a set of about 100 such multiple choice questions and they are available on the ESCalate website (www.http://escalate.ac.uk/1141). One such question: Does a fertilised hen's egg lose weight, gain weight or remain the same from the time of laying to just before hatching? The three or four candidates who would be present at the interview would argue through their ideas. I looked for those who were able to give sensible arguments using scientific ideas, and for those willing to change their ideas when they heard an alternative better than theirs. This question has elements of physics (mass and weight) of chemistry (the role of oxygen during respiration and the conservation of mass) and of biology (reproduction and development). These sort of questions are embedded into the 'sci-tutors' resource now available on the ASE website, which I helped develop. [see http://www.ase.org.uk/resources/scitutors/professional-issues/p41-misconceptions-and-naive-ideas-of-children/]. It is by examining why students make mistakes, get things wrong, that most learning takes place, and teachers need to pay close attention to these 'alternative' ideas. Diagnostic tests as formative evidence at interview, yes, but not as a pass/fail entry requirement.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
As I said above: Clearly financial considerations are important. Their student loan could be waived gradually the longer they stay in teaching. Their PGCE year could attract a 'salary' rather than fees.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Currently the balance between college and school is good. In a simplified picture the teachers/mentors in school provide the craft - the survival skills, and the tutors in college provide insight into the nature of teaching and learning, of the research findings. Both are needed. Our Association of Tutors in Science Education (ATSE) has few mentor members from school. They don't have time to come to meetings to discuss developments in education. NQTs come into school with many new ideas, (for example giving pupils time to reformulate ideas rather than telling and hoping they'll understand) but they are the junior-most teachers in the department and it is difficult for them to continue to develop new techniques without the safety net of their PGCE year. If teacher education is to become 'training' in teaching schools, it is essential that those teacher-mentors who will tutor the trainees have time to interact with the science education community. That means that those tutors should have time to attend conferences and meetings, to undertake their own research, and become science teacher educators, like their colleagues in university departments of education.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
See (c) There is a real danger that courses wholely based in school will not provide the understanding of 'education'. I started my career in teaching straight from Industrial research and learnt on-the-job, with help form the more established members of the department. It wasn't until 10 years later, returning from 3 years teaching in Nigeria that I had the

opportunity to study 'ediucation' (an M.Ed Studies at Leicestershire University). Everything began to make sense, and I could see many 'holes' in my practice that I was previously unaware of. As a result I became a far better teacher. The question is, could I have been helped in this way at the start of my career? In the James Report in 1972 [http://www.educationengland.org.uk/documents/james/] the idea was broached that teachers should have their second year of training after 2 years teaching. It would have been expensive, but worth it. A cheaper option would be to enable all teachers to keep in contact with their training institution during their NQT year and to return to complete an MEd by a one term, or a one day a week release to enable them to reflect on practice and ensure that 'bad habbits' don;t get engrained. I ran a short workshop in Pakistan in 2007 for secondary science teachers in one of the charity schools I was attached to. One teacher, who had been teaching science for 10 or 15 years, said afterwards, I wish I had had this workshop at the start of my career, I will find it difficult to change now, but I'm going to try.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
The GITEP model described above works very well (small groups of students of diffferent subjects attached to each school with a deputy head "Training Manager" with one day a week where all the scientists (and other subject specialists) can meet with a "Subject Co-ordinator" - either from the University or from the partnership schools). Having said this it is important that all staff, school or college, must have the opportunity to meet up professionally, at conferences, for reserarch, or for mutual INSET.

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
See (e) and my comments about the James Report in (d) above.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
See my comments above, especially about the balance achieved by the GITEP scheme.

8. h) How much of this training should be spent gaining experience in the classroom?
4 days in school, with one day of these for preparation and meetings with mentors, one day a week in college for subject support.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
Secondary: One year PGCE, followed by 8 weeks (eg a day a week for a year) during their first year as a fully qualified teacher (following NQT). Primary: 3 year BEd - again followed by 8 weeks (eg a day a week for a year) during their first year as a fully qualified teacher (following NQT).

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
See my comments in 2d. [I started my career in teaching straight from Industrial research and learnt on-the-job, with help form the more established members of the department. It wasn't until 10 years later, returning from 3 years teaching in Nigeria that I had the

opportunity to study 'ediucation' (an M.Ed Studies at Leicestershire University). Everything began to make sense, and I could see many 'holes' in my practice that I was previously unaware of. As a result I became a far better teacher. The question is, could I have been helped in this way at the start of my career?] CPD is essential - it keeps teachers in touch with developments in their subject specialism and in education generally. It also allows teachers to participate in this development

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
ASE (Association for Science Education) membership has been so useful to me and I have attended our annual meeting/conference almost every year since I joined the profession in 1970. I 'insisted' that my trainees joined (at greatly reduced student rates) and I hope they maintained their membership. The journals, the website, publications and regional meetings all help to provide a world-renouned resource for science teachers. Membership of their subject organisation (IoP, RSC or Inst Biol) with receipt of their respective educational journal. Doing their own small-scale research, or being involved with bigger university or ASE based research programmes. Possibility of this leading to MEd or certainly to publishing material in School Science Review or their professional ed journal. Clearly, also, teachers need to keep abreast of changes which come from the ministry of education. The nationmal Stragies meetings were very useful in keeping teacher in contact with each other and with new ideas, now no longer available.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
It should be on-going. Reading the ASE and their professional journals, attending conferences, doing small-scale research, constantly evaluating practice, working together in departmental meetings. We used to have 'experts' come to run sessions at college. They would speak for an hour, answer a few questions and go away. INSET days can benefit from outside help, but only if they themselves become aware of the school and work with the department over weeks and months. It is a pity that OfSTED plays such a summative role. In the past there were county advisors who worked with schools for their improvement. OfSTED need to work WITH a school over a year - OK come to a judgement, but also see that they have influenced the school for the better - as a result of their help the school has become excellent!

4. d) Should CPD be voluntary or mandatory? Why?
Yes. But informal. There are so many ways that teachers can keep up to date and in contact with educational developments, most of them informal (see (c) above) - so HOW a teacher does their CPD should be a matter between a teacher and their head of department or deputy head.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Time, expence. Time to read and reflect. Expense of taking a day off school (supply cover) or of conference attendance. Each school (department) ideally should have a surplus member of staff who can cover (with some continuity) classes of other members who go for

a day's workshop, whilst having their own classes - ie a lighter timetable with more 'free periods'

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
There are many issues that need to be addressed cross-curricular. There is huge value in teachers observing each others' practice in other disciplines. So yes - there are whole school issues that need to be shared and taken on board by all staff. The danger with whole-school CPD days is that teachers can end up being 'talked at'. It is importasnt that each depaertment has time to internalise and make sense of what is being proposed, and have the opportunity to challenge it or, more positively, show how they hope ot take it on board.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes, but only in part. CPD is or should be an on-going duty of every teacher, and most of this as I say above needs to be informal

1. a) How and where should we be training laboratory technicians?
Lab technicians have a valuable role in class, as classroom assistants during practical activities, so alongside their technical training they need support-training of the same type as teaching assistants.

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
The ASE provides excellent support for technicians - the schools should pay their subscription fees, and pay for them to attend conferences.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
See (a). One big problem with teaching assistants is that they seldom seem to have time to talk to the teacher before the lesson. They are there to support one or two pupils, but their ideas and input are not available to the teacher. The problem is time - when can this colaboration take place - when can they plan together? Ideally there would be more fully qualified teachers at hand - maybe to divide the class, but teaching assistants, trained especially in how we learn, but also in behaviour management, are a very good second best.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Is that something the Royal Societ might co-ordinate?
I have not completed this survey, but don't know how to save it till I have a chance to do so. So I will sent it on incomplete and complete it later on. I will organise an ATSE response over the next month. I wonder if you need personal details in this survey so you have some idea of who is completing the form?

Dean Rowley

1. a) What is good about UK science and mathematics education?
We have a lot of dediacted associations looking at the best possible pedagogy within each subject and how we can provide the best curriculum for our students

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
A greater involvement of the teaching community in production of a forward thinking syllabus (modelled on the version of the open ICT curriculum being discussed) in whcih more options are given to stduents within examiantion syllabi

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
The real lack of discussion with the teaching profession before another round of changes are introduced

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Through discussion and debate with all interested stakeholders to ensure that all phases within education see the benefit and challenge of any changes

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Singapore Australia To some respect Scotland The hallmarks of this education are the ongoing debates within the profession and industry to update the curriculum as the ethos of learning changes within society

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
Greater discussion with the teacher profession and greater professional responsibility for teachers

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Proper defined and funded CPD throughout the career of the teacher looking at goalpost and stages of their development as teachers.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
GCSE Mathematics at grade B and above alongside eveidence of continuing study of maths or science beyond 16 Diagnostic tests looking at ability to apply knowledge to problems should be administered to check the application of skills

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
If the current situation continues then the use of inducements will have to be offered but not neccesarily on the idea of money with the funded CPD an option also

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Some of the training programs enable the students to get involved with pedagogy early

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
More relevance given to pedagogy and application of mathematics and science to problems within the 21st century

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Keeping entrance and exit policies high

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Full and part-time to ensure a wide variety of students

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
HEI Teaching Schools

8. h) How much of this training should be spent gaining experience in the classroom?
50% to 66%

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
For primary there should be dedicated time to Maths,Science & English within a 1 yr course
Secondary: 18 months

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Enables greater discussion amonst peers

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Greater influence of subject associations and online and face-to-face sessions

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Every 2 years an online update with every 5 years funded attachement to a conference

4. d) Should CPD be voluntary or mandatory? Why?
Updates should be mandatory but with extension voluntary CPD

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Funding but this could be got through paying into a joint subejct association

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes but at a vareity of levels and linked to NCSL programmes

1. a) How and where should we be training laboratory technicians?
within schools and jointly through teaching schools

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
No Response

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes and training done through within school models and through collaboration via teaching schools

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
A national network linked to STEMNET would enable professional contacts to be made

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Department leadership has an enormous impact on the standards of quality and engagement within instiutions

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
Pedagogical leadership and a wider understanding of the links

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
internships and collaboration through school to school networks

4. d) How can leadership pathways for experienced teachers be introduced into careers?
Reinvigorting the teacher standards to produce maths and science specialist pathways

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
HIgh capacity leadership Engaging networks

6. f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?
Leadership which is forward thinking leads to greater creativity within the school curriculum and more enagaging courses run

7. g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?
Governing bodies need to dedicate a person to look at STEM education and its impact on the career and learning of all learners

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Understanding of the fundamental links between different topics which needs to be built up through an engaging curriculum from 5 to 19

2. b) How may the acquisition of such skills best be assessed?
Through teacher and peer-to-peer assessment

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Primary and secondary curriculum must overlap and provide engaging problems and puzzles that can be looked at from a variety of angles

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
An open wiki based curriculum that enables a mandatory core to be put in place with extension modules that school incorporate into their curriculum and can be updated as knowledge progreses [based on canadian model]

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
teacher led assessment through work based learning alongside examination of facts and applications

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
Some aspects could be assesed within each other's subject

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
End of Key Stage 2 End of Key Stage 4 18

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Online, within classrooms and within hubs based at teaching schools

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
Yes

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
Maths and science specialism and teaching school specialism based on STEM

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
Use of technology and ICT lessons

5. e) What other resources and systems should be used to support science and mathematics?
Integration of open learning resources into the curiculum (i.e. openlearn from OU)

2. b) How should qualifications in science and mathematics be regulated?
Through OFQUAL with conenctions to STEM

3. c) How can we ensure that all students can access the science and mathematics courses they wish to?
Be offering a wide enough variety

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Performance targets are needed to ensure that standards being aimed for are realistically high

Mike Tuke

1. a) What is good about UK science and mathematics education?

We have some very enthusiastic teachers.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
In science less knowledge required but much more thinking and guessing, and puzzling out and surmissing without being afraid of getting it wrong. More practical work is needed.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Unfortunately a few badly behaved kids make teaching science very difficult and as a result science is dumbed down for health and safety reasons We are a very creative country in terms of the Arts. We need to be creative in the Sciences too

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
It is more important that pupils and students understand how a flush toilet works that the structure of an atom

5. Other comments
Earth sciene is something that often thrills kids. we need to build on this and have more earthscience in the curriculum and much better earth science training for teachers. There is nothing like the thrill of spitting a rock open and being the first person to ever see that fossil which has been hidden in the rock for 100 million years

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
Enthusuasm and hard work of the pupils and students of the

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
They should be teaching, not crowd controlling. It is difficult to get ones enthusuasm for a subject over if discipline is poor.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
GCSE c in sciences and maths for primary Degree for secondary

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes financial because industry can offer so much higher wages

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Teaching practice.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
More earth science. If there is 10% earth science in the national curriculum then all teacher training colleges should have to spend at least that amount of time on training students to teach earth science. preferably more because when the trainee starts teaching in a school he will probably be the only one with any earthscience training

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
No Response

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
Essentially practical. How to deal with class room situations and how to teach the subject. Not too much learning theory.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Preferably universities

8. h) How much of this training should be spent gaining experience in the classroom?
At least 50%

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
Both 1 year

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Very important if you are the only teacher in that subject. Always reinvigorating. I always came back with new ideas to try out

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
These should be provided by ASE or subject sppecific organisations such as the Earth Science Teachers' Association

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Once per year

4. d) Should CPD be voluntary or mandatory? Why?
Voluntary but if someone is not keen to go sometimes then probably he/she is deadwood anyway

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
Money, and cover

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
No Response

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
no It would be impossible to judge the value each CPD and would make for much more paper work.

1. a) How and where should we be training laboratory technicians?
In schools

2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
training in the use of new equipment. Either from a teacher in aschool with that equipment or at venue run by the manufacturer

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes. In maths personal one to one work with pupils is essential.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
A careers master

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
a good leader inspires and organises his staff fairly and well

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
thinking laterally, imagining, working in groups, pairs and individually

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

all of these

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
16 and 18

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Field work is very important in teaching earth science and gives kids an enthusiasm that might have been lacking in the class room. sometimes kids who have not done well in the class room blossom on field work. All science students should spend sometime in museums or better manufacturers workshops

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
the more variety the better

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
No Response

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
Earth science and geography already support each other

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
Separation should be by ability

Laura Turner

1. a) What is good about UK science and mathematics education?
(Maths Ed) The drive to put the learning in the hands of the learner. The move back to a problem solving approach. The importance of Key Processes.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
The obsession with results (for league tables). The lack of suitably qualified mathematicians and the fact that anyone can and does teach such a specialised subject. The non-specialists don't see the connections or the bigger picture and teach everything as a discrete topic. The lack of specialists in primaries. The way a new wave of consultants (often with very little maths specialism of their own) are becoming hugely powerful in large swathes of academies. The ever changing goalposts (how many different GCSE specs have we been

forced to teach in the last 10 years? Approx 6. Make something stick! The way the world and his wife feel they know about maths ed and what's good for us, yet the professional associations/ respected members of the maths community are being ignored! (Maybe not now, though, eh?)

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
Obsession with results and ever changing goalposts. Academies with a one-size-fits-all models. How good ideas like AfL and APP got lost in translation and became tick box exercises by over zealout SLT and consultants. In fact, private consultants in general, making money for themselves off the back of a school's NEED for higher rankings in league tables. How we don't celebrate success at all levels (eg a G grade student getting an F at GCSE).

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
Our pupils must DO mathematics, not just complete pages of exercises. The teachers must be given support in this - how do WE actually know what goes on in 21st Century labs day in, day out. What maths is most important? Useful? TELL US what you need, not just tell us we aren't doing it right! Provide models of high value for money CPD.

5. Other comments
The govt must trust the experts, not pay lip-service to their (your) findings. Don't keep changing the goalposts. Don't keep over-inflating the role of OFSTED to god-like status. Take the fear out of teaching (both from above and below). Don't offer up initiatives / solutions then not tell us how to implement them, so every school interprets differently, then we're judged on it! Don't allow schools to 'play the system' as many do now.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
No idea. I'm sure I'm supposed to cite far eastern countries but can these children solve problems? Can they work with statistics and probability? Or is it all just speed calculation? And have you seen the suicide rates in these countries? Also scandinavian countries are held up as models for success. Then why are they looking elsewhere for inspiration of their own!!

7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
None. We need a model for OUR kids, and OUR society. Our children have different morals and values to kids in many of these 'high performing' countries. We will never get back to a place where adults are feared and authority is respected so we mustn't pretend we can copy these models!

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
It has to be on pay. These are two fields where one can get paid far more in industry (unlike most other fields) and jobs for qualified graduates are getting more plentiful in these fields because of the world we now live in, so pay and condistions must be competitive. Also TIME. Give people enough non-contact time to actuall plan and deliver top quality lessons. As it stands now, most maths teachers are running on empty for most of the week - how can we be inspiring like that!

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
Secondary maths MUST be qualified to degree level IN MATHS. In my last school the head of ks4 maths barely had her own GCSE in the subject (ex-TA, trained on the job), yet got to this position purely because there was no-one else. Diagnostic tests would not be necessary if the qualifications were there. Primary - tough call. If one insisted on A level, there'd be no primary teachers! Yet with only a GCSE in maths how can the teachers build solid foundations for learners.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes. Bursaries, tuition fees paid if stay in schools five years, a premium on top of salary to reflect the shortage. (If other subjects don't like it, they could find something else, we have enough of them!)

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
PGCE should be the ONLY route. Keep training in the hands of the universities NOT other routes like GTP and RTP. These produce maths teachers who are barely qualified in the subject, just 'felt like' teaching maths! The PGCE programmes have lecture based studies as well as school experience.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
I would scrap GTP for mathematics. I would only allow uni's to run PGCE courses, and I would insist on maths graduates only.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
Keep it in the universities. Have an agreed PGCE course content that all unis must work towards. Don't allow schools to become training institutions because many of the people leading these courses are barely qualified in maths themselves!

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?

PGCE only as professional qualification, and constant availability of high quality CPD. Insist on a certain number of hours MATHS SPECIFIC CPD per year.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
PGCE in Universities only. Definitely NOT in schools Definitely NOT GTP.

8. h) How much of this training should be spent gaining experience in the classroom?
Two Thirds

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
A full year (Sept to July). If you made it longer you would lose even more potential specialists!

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Knowing your own subject. Keeping up to date with the latest developments in both content and pedagogies.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
Local clusters (not private consultants!), NCETM, professional associations, social networking sites.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
ALL THE TIME! At the very least once a term.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory. Those of us who value CPD and undertake it voluntarily would do it anyway.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
NO! It doesn't even have to cost! There are experts out there who are teachers (not highly paid consultants) who one could learn from without spending thousands.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Yes. It would make sense to develop individuals and have specialists at all levels of an institution

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes, so the reluctant people might see value, but not at Masters level. Even just a recognition would be enough.

1. a) How and where should we be training laboratory technicians?

In industry.

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
I think maths TA's should be trained in universities.

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
Yes, we need people to tell us about the changing workforce, what new skills are valued. The pupils need to be informed, but so do the teachers!

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
In the classroom significant impact, but why is it that so few members of SLT are mathematicians or scientists???

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Key processes. From year 1.

2. b) How may the acquisition of such skills best be assessed?
By giving a problem solving task to be completed in the classroom and assessed by the teacher. This could be yearly and from a national bank of tasks that can be selected from.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
Very important. Children are boosted so much in primaries to get their results that the levels are not a true indication of a child's ability.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
Ends of key stages.

1. a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?
Anywhere, in any place, (desks, ICT suites, outside the classroom) at any time!

2. b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (eg primary, secondary, middle, all-through schools)? Why?
No difference. Maths is maths wherever you go to school.

3. c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?
ICT for dynamic learning of maths is essential.

4. d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?
Maths could be incorporated into ANY other subject.

5. e) What other resources and systems should be used to support science and mathematics?
ICT, instantly available.

6. f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?
Stop the SLT focus on English. Maths is always the poorer cousin.

1. a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?
Not via league tables!

2. b) How should qualifications in science and mathematics be regulated?
One non-political non-profit making body. Stop huge organisations like Pearson making huge sums from schools.

4. d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?
Dis - constantly teaching to the test. Pupils don't see connections and don't have the skills to take to industry.

Sally Waugh, Hurstpierpoint College

Basis for contribution:
I am a teacher of mathematics (and occasionally science) at Hurstpierpoint College in Sussex (>10 years) and I also assist with interfacing science undergraduates with mathematics at Newnham College, Cambridge (>4 years). I hold a first degree and a PHD in Natural Sciences from Cambridge, both degrees with a maths content. I have worked in industry creating scientific software before concentrating on teaching. I specialise in creating learning programmes in mathematics for individuals and institutions and my work at Newnham involves running a course of vacation work and a study day to prepare Natural Scientists, engineers and computer scientists for their first year of undergraduate maths. When I joined Cambridge as an undergraduate I suffered from inadequate experience of mathematics and I do not wish this difficulty to be repeated in successive generations. I am also currently preparing an interface course for the GCSE/AS boundary to be run at Hurstpierpoint College in June 2012. One aim of the latter course is to help students

appreciate what will be required of them at A level and, if necessary, to deselect themselves from maths as an A level choice if they feel they would be unreasonably challenged by the A level material. I have a serious concern about those students who may deselect maths because there is currently little provision for them to achieve well in the maths elements of their other A levels or university courses.

Limits for publication in the public domain:
I am happy to be acknowledged if necessary as a contributor to the call for views, but, by its very nature, much of my work relies on trust and confidentiality and I cannot grant that my name be publicly associated with any specific comments or evidence which could be linked to any individual or institution, except with prior agreement. I am happy to discuss matters face-to-face with representatives of the Royal Society if required, but I cannot transmit by email any details which could be associated with individuals, schools or colleges with whom I have connections.

A General questions

1) Science and mathematics education in the UK

a) Good qualities:

1. encouraging students to evaluate and criticise data and commentary instead of simply believing everything that they read or that they are told
2. expectation to design and invent new ways of solving problems and designing artefacts (DT product design in particular)

b) Aspects requiring change (some of which are already being addressed):

1. Incremental development of mathematics is too slow and repetitive for the most able students.
2. Conversely, for the less able, too many methods can be presented e.g. methods of multiplication, and the students become confused.
3. Grade inflation for GCSE maths means in practice that grade B students struggle when transferring to AS maths, although they expect to cope well.
4. While numeracy is vital (and must be pursued for the majority – see the Vorderman report), so much emphasis is placed on numeracy that some students who could work in STEM see little of the conceptual side of maths and its applications (see for example Baroness Greenfield writing in the Daily Telegraph 3rd March 2012 pW13, various ACME reports). The topics in “everyday maths”, such as calculating building society interest, are perceived as the limits its of use, and failure to be able to calculate such things convinces a child that they “cannot do maths” when they have not met other aspects of maths at all, or only fleetingly, although these aspects may involve their hidden strengths. This is very common in the GCSE years and such students have no expectation of possessing and using skills in other branches of maths, such as space and shape. If this perception can be

reversed, many STEM-oriented students begin to solve problems by planning the use of concepts and relegating their issues with number to the last line of their answer (e.g. DT GCSE). Usually facility with number then occurs naturally because anxiety is reduced and confidence increased. Considerable research time has been dedicated to the topic of “math anxiety” (see e.g. “Math Anxiety” Explored in Studies, Education Week, Vol. 30, Issue 31, Pages 1,16) and its effects which often persist throughout life if the anxiety is not addressed. In my experience many potential STEM students flourish when they reach the stage of taking apart a STEM problem to choose maths techniques as the appropriate tool rather than an end in itself. This means that they need to appreciate the principles, power and limits of maths techniques, and at that point they can reach for a calculator or MATLAB. Further comments relevant to these students should be addressed by the current ACME consultation Bridging the Mathematics Gap.

5. GSCE science is insufficiently rigorous for the most able students: mathematical content has been progressively reduced until it is not possible to explain some phenomena without taking a detour well beyond the syllabus

6. Many students begin A level sciences from a base of double award rather then single subjects at GCSE. Schools say that the difference does not matter, but I find that it has lowered confidence and therefore places doubt about the subjects in the minds of the students. Many of the double award students change from schools where there is no possibility of studying physics, chemistry and biology separately, so their catching up occurs at a time when they also have the trauma of joining a new institution. This does not help them.

7. Many schools and even Sixth Form colleges dictate which mathematics modules are taken by their students at A level simply because of time table constraints. This is not putting the needs of the students first. Thus some apply to read engineering at university having taken only statistics with pure maths, but no mechanics. This is a very poor start to a degree. (see 1d)

8. Retaking of modules wastes teaching time and can give a false picture of what a student will retain by the time they reach an employer.

9. the huge variations in syllabus content and style of A level/IB/other qualifications lead to difficulties bridging to university material, particularly in mathematics for STEM. Creation of a much more secure common base of knowledge at A level, particularly in mathematics, would ease the transition to university material. Catching up work can be very difficult and most unnerving if other students appear to know more. In 2007 Newnham College asked me to generate an internal assessment of the reasons for first year Natural Science students experiencing a loss of confidence in their first term. Most of the difficulties related to insufficient or unequal experience with mathematics and it was on the basis of this report that the Newnham vacation work and study day were created (see preamble for details). It is sad that at so many HE institutions we all end up with the same “fix” instead of resolving the problem at source.

10. There exists a problem of lack, or perceived lack, of integrity about original work. School course-work and essays on subjects set year after year are bound to attract internet surfing to locate a good answer: that in itself is a skill in research. How to encourage students to learn from what they find and then produce their original document is more the question in hand. Sadly, I have seen some classrooms where it is very hard for students to know how to do this because the example from their teacher is questionable: the teacher will

essentially tell them exactly what to write, but not allow them to write it at the time, because apparently that will not constitute cheating. The students then go to break time and write down everything they were told. Whose work is that?

Matters then become a memory test, on similar lines to the new controlled assessments for English, where those with a good memory compile an essay (from some source or other) and then regurgitate it under exam conditions.

All of this disadvantages high-potential students because they have no genuine opportunity to show that they can address a question originally, and it discriminates against those who have difficulties with memory tasks, such as dyslexic students. I would like to see the return of real STEM projects (see section on Skills and Curriculum), marked with integrity by teacher panels. If the teaching profession really cannot be trusted in this respect, it would be no surprise that good scientists and mathematicians do not wish to join. On the whole, I trust that this is not the scenario, but I would suggest this ought to be considered in a general review and emphasised in teacher training (see Teachers: section 2).

c) Broader issues:

1. unreasonable range of ability in one classroom
2. unconstructive challenges and persistent disruption by students
3. lack of expectation by the students
4. poor parental support especially in under-privileged neighbourhoods: parents are often very supportive of attendance and early years studies, but actually cannot help in secondary education because they have not worked at a sufficiently high level themselves. This leads to lack of parental expectation that their children can survive in Higher Education particularly at Russell Group institutions. The students anticipate that they will be alienated from their home environment if they proceed to these courses: I interview students at Woodard Schools maths master classes (held annually at Trinity College, Oxford) and students often tell me they would not apply to Oxbridge because "I would not fit when I went home".

d) Meeting the needs of HE

- The mathematics element would be much more transparent if a Mathematics for Science A level was mandatory for any student intending to read for a STEM degree. This could be a cut-down version of C1 and C2 plus a few topics from C3, C4, S1 and M1, to which are added scientific study skills such as interpretation of graphs and applications in scientific contexts eg the use of rate equations in chemistry or radioactive decay). (see 1b and 1c) In the long term this should be addressed by the Pathways approach in the current ACME consultation.

Meeting the needs of employers

- I sometimes meet a complaint from employers that students have GCSEs at respectable grades yet still do not possess the anticipated skills by the time they arrive at a work place. It would be good if all students could emerge from schooling, whether at 16 or at 18, possessing a portfolio of examples of everyday maths, science topics and good practices, such as calculating percentages, sources of error and error handling, setting on-line diaries to remind themselves to back-up IT files etc. Students do study a lot of relevant things, yet GCSEs and A levels are not often regarded as a library of experiences to be consulted later, so 16-year-olds do not expect to trawl through their school notes to make a note-book suitable for starting work and many do not look at their notes even if they continue with studies in that subject. Employers will always need induction days for staff, but they have my sympathy when they feel they must re-educate needlessly. The existence of a signed-off portfolio should form part of all basic qualifications and should be completed correctly, if necessary being copied diligently. It does not matter if the required reference sheets have been copied from a text book: what matters is that the sheets exist and that the students expect to use them (it might even motivate their studies is there is tangible output). We seem to have lost sight of such practical outcomes of education, perhaps because we have been so disillusioned about the integrity of coursework (see Teachers: section 3b).

2) Science and mathematics education internationally

b) useful practices

- a culture that excellence is to be pursued and rewarded (Far East – China, Japan, Singapore, Hong Kong – and certain European countries). In the UK the apparent removal of the word "failure" from our education system has resulted in a culture of inclusiveness to the point of removing competitiveness in some instances, because if there is no "worst" outcome, then how can there be a "best" outcome? Surely we should attend to the moral and ethical situation which prevents winners behaving arrogantly and unpleasantly, and generate a society in which every single child is celebrated for some genuine and important contribution which is not treated as the "booby prize" by the other students.
- an acceptance that creating a good basis involves a lot of repetitive examples in maths and STEM e.g. Kumon maths from Japan. I interview many international students who apply for Russell Group and are proud that they repeat difficult examples until they can work them fully every time. I do not think that this is the only correct way to learn, but it provides an excellent grounding in early years and engenders a willingness to persevere until a method is ingrained. The primary years maths system in the UK seems to spend a very long time looking at various ways of effecting multiplication, for example, yet students regularly emerge without knowing their tables or understanding the scaling effect of applying multiplication because "rote learning" is "unacceptable" to the student mind.

B Teachers (and the wider workforce)

1) Teaching as a career

a) Improve student attitude and school discipline: many of those joining the teaching profession as trained scientists and mathematicians have experienced working in technical employment, answering clear questions, usually planning and effecting solutions to deadlines, and in an adult environment. They enjoy discussing their science and wish to help in education, but I have repeatedly been told by such employees that they "don't want their time wasted" by what they perceive as the circumstances of education: endless form filling, reports and parents evenings, the irritation of having class after class wasting working time on misbehaviour, and the constant threat of litigation if a teacher tries to enforce discipline. While these circumstances may be given incorrect relative weightings compared with reality, many experimental scientists just wish to “get on and do a good job” and anticipate that that they will be merely frustrated if they attempt to teach below the HE sector.

There is also a frustration about coursework and original work (see General questions item b10, d and Teachers: section 3). STEM and maths teachers would dearly love to be able to encourage students to examine their own practical questions, particularly in A2 years, designing experiments and working independently. One problem is time within the syllabus (which will be eased by fewer module exams) and the other is the issue of integrity and the apparent lack of trust in teachers to guide, advise and answer questions without dictating the content of the project. A tie-up with CPD is considered below in section 3).

2) Initial teacher training

a) entry requirements: minimum entry requirements: at least one level in education above the level at which the subject will be taught, with the exception of teaching primary mathematics when an A2 grade of at least a B would be preferable. If less is demanded for mathematics then it is entirely possible that a teacher of primary students will enter the profession with very little understanding or experience of the abstract nature of mathematics, thereby freezing their students into the numeracy=mathematics scenario.

c)good aspects: 1) generally very dynamic
2) NQT and mentor system results in a bank of well-prepared lessons ready for future use.

d) changes: greater emphasis on constructive marking: far too many reports and numerical exercises are marked as incorrect but the correct answer is not given, so students cannot fill in the gaps in their work and are left with only the incorrect answer in their memory. To quote Mattarella-Micke and Beilock (Situating math word problems: The story matters, Psychonomic Bulletin & Review 2010, 17(1), 106)
“.... if an incorrect answer becomes more accessible, it should interfere with correct answer retrieval.”

e – g) Under Infrastructure Section a), the use of county/university learning centres is mentioned. These would be an excellent initial training ground for teachers and a country-wide inspection system would provide a useful means of standardising training.

3) Continuing CPD for teachers

General comment: top quality graduates in STEM are probably permanently interested in new developments in their subjects, rather than just teaching material specified by examination boards. A lot of available CPD time in schools is spent keeping up with methods of teaching and ways of answering questions to achieve good exam grades, which benefits the students and the school system, and informs the teacher how to do their job. The scientific development of the teacher is rarely addressed in these schemes. It would be good to see far more opportunities for teachers to spend a few days working at hi-tech companies as part of their CPD. This could be coupled with presentations by the company at the teacher's school, visits by the students with or without their teacher, and perhaps work experience for some students. Again, possibly even working side by side with the teacher on a project. Such partnerships could be very beneficial for all parties.

e) One of the biggest hurdles with CPD is arranging cover: work must be sorted out to give to the cover teacher, then when the students do this work they rarely have access to subject-specific assistance, and the whole process is often regarded by all concerned as “more trouble than it is worth”. It is certainly unpopular with students nearing examinations. Is it possible to have a “CPD season” after GCSE and A level exams are finished in the summer, so that STEM teachers go away in a set week and other subjects in other weeks? This should cause least aggravation but would give an extended opportunity for teachers to learn.

There are also hidden difficulties with a mother or father displaced from the home, so financial allowance for such things as child-care is extremely important.

C Leadership and ethos

a) General qualities:

Enthusiasm, clarity of ideas and expression, obvious enjoyment of their subject, providing opportunities to learn and explore, encouraging initiative, involvement with learning not dictating from above

e) and g) Good general performance of any business or structure requires clear leadership but its success at a personal level requires a cohesive element which binds and builds up the participating individuals. Far too often reliance is placed only upon application of rules and sanctions to provide a sufficiently cohesive element. Most teachers would agree that one of the greatest stresses in education arises from individual pupils whose ability to disrupt the classroom repeatedly wastes time, energy and enthusiasm on behaviour control, yet the teacher feels at the end of the process that he/she has not modified the attitude of the individuals towards a better long-term behaviour or contribution to society. It is ultimately frustrating that the time and resources of the teacher are repeatedly drained at the same time as the other pupils lose, little by little, effective learning time and positive feedback.

Effectively meeting the public challenge of “You can't make me do anything” draws heavily upon the cohesive element of the school, rather than just the regulations and sanctions. When the teacher at the front is prepared to take a stand on the subject of right and wrong towards all individuals, then there is very often support voiced (with relief) within the classroom where students recognise a common standard. The teacher can only afford to take such a stand when assured that it will be supported by the lead teacher. Thus leadership must take into account not just logical outcome but the drivers of emotion, psychology and spiritual involvement which contribute to the locally acceptable definitions of right and wrong.

Recently there has been much media discussion about the role of faith in society and the cohesive and supportive nature of all faith communities. The Queen has spoken at Lambeth

Palace (www.royal.gov.uk, 15 February 2012) and David Cameron and Baroness Warsi have respectively spoken (variously) and written on the subject (Daily Telegraph Tuesday 14 February 2012 page 2, editorial pages 1 and 29). In my own community there has been a launch of a ROC (Redeeming Our Communities www.redeemingourcommunities.org.uk) initiative (17th February) where official bodies (police etc), care providers (statutory and voluntary), other providers and faith communities deliberately act together to address local problems. In all of these initiatives and locations the element of cohesiveness is recognised as resident in beliefs shared by groups of people, and living out of that belief. The impact of this on education is seen in the strong performance of faith schools and the competition for places at such schools, with parents of potential pupils spending much time, effort and money to fulfil conditions which allow their children to qualify for admission. Not all parents share the faith structure of those schools, yet there is sufficient respect for the codes of conduct at these establishments, that the vast majority of non-faith parents accept the codes for their children. This is certainly the case at the school where I work (a Woodard school with a strong Christian ethos): there are children of many faiths working together and obeying rules based upon Christian principles, and while religious observance days are permitted for other faiths, such as Eid for Muslim students, parents do not question the Christian descriptions of right and wrong as the correct lead qualities for the school (www.hppc.co.uk).

It seems that a head teacher must communicate and exercise clear instructions academically, coupled with a well-defined moral and ethical stance. If this stance is not taken from a recognised faith, then serious consideration should be given to producing a document defining moral and ethical issues and justified definitions of right and wrong in that community, and not just regulations: school students need clear guidelines on how to treat each other and how can they adhere to a code which is neither publicised nor justified?

D Skills, Curriculum and Assessment

a) General skills:

Starting from about Year 3, development progressively of: reading accurately, looking up words which are not fully understood, keeping neat records of their findings (definitions, formulae and facts), reading and understanding graphs and diagrams, deciding what to plot on graphs and why, writing out proper and full interpretations of graphs and calculations, calculating accurately, estimating answers so that an error can be spotted, back-checking for those errors, an appreciation of experimental errors...

Both STEM and mathematics draw upon the abilities of asking pertinent questions, planning how to answer them using achievable steps and then researching and evaluating the outcomes. The UK system tends to be strong in early years at encouraging children to ask scientific questions and learn elements of numeracy in mathematics. The connectedness of the two, with mathematics the language of science is harder to establish. For example, when filling-in for a member of staff for a year 3 class I was amused but saddened to be informed that the class could not say the “5x table” in that classroom because they had learned it in the next door classroom.... Ideally, students would spend time researching small scientific facts from books and the internet and connecting them with simple calculations from year 3 onwards. What starts out as a filling-in-the-boxes exercise can gradually become a planning and researching exercise as the student matures, as long as substantial time can be allowed.

The removal from GCSE science of almost all algebra except substitution in a given equation means that students do not really see maths as a tool for science even at age 16. Certainly in AS and A2 years it will be beneficial when fewer module examinations are taken and teaching time may permit more exploration in maths lessons of the power of techniques, and in STEM give time for discussing which tool to select: more complex and relevant problems should be analysed at this stage but there is rarely teaching time for such a luxury. In early years the best assessment is probably completion of a workbook, but by A level the reintroduction of longer questions in maths and less prescribed questions in both science and maths would raise expectations that initiative will be required. Teaching to the test now raises howls of protest as soon as examination papers depart from a familiar format, and the need for universities and employers to receive good scientists and mathematicians is apparently secondary to the presentation of an examination certificate. This will be addressed by the ACME Pathways consultation.

b) It would be good to see development of real project work in the classroom, with students investigating questions they have raised themselves. The current approach to assessing practical aspects of science does produce certain standards, but the questions are set for the students and the most able often experience little satisfaction in terms of the problems examined. At any level, the students are most likely to produce their own work if they have tackled a new question: everything else is readily copied from the internet because good answers have been around for years. (see also Teachers section 3)

f) Ideally aspects of everyday maths and subject-specific mathematics (e.g.Chi-squared tests in A2 biology, Spearman's Rank in geography) could and should be assessed within the relevant subjects, but overlap with mathematics, science and other subjects (e.g. economics and geography) should be considered by expert panels and guidance issued. For example: In June 2009 a biology paper (OCR A F212) was issued with the following question:

“The population of the white-backed vulture, *Gyps bengalensis*, in India has fallen by 97% to an estimated 4000 vultures...

...Calculate the **original** population of the white-backed vulture. (2 marks)

A student came to me for advice when their photocopy script showed that they had been given no marks for the answer 133,000, with some relevant working. I checked the mark scheme and it required the answer 133,333. I suggested to a senior examiner that mathematically the student's answer was correct, and showed suitable understanding of the word “estimated” when applied to the count of vultures, and should therefore have been awarded 2 marks. I was informed that the decision about the required numerical answer was discussed with some concern but had eventually been made without reference to a mathematician, because no mathematician was available at the time. All scripts were then marked in accordance with the mark scheme. I found that a very unsatisfactory response.

Similarly, in economics and geography slightly different terminology can be used for statistics and the alternatives should be addressed within both subjects to avoid confusions.

g) One set of examinations per year with the exception of November retakes for GCSE mathematics and English to allow candidates to progress.

E Infrastructure
a-c) It would be wonderful if every secondary school had visits from mathematics and science road-shows on the lines of the Millennium Maths Project, plus access to a local centre for STEM and mathematics with state-of-the-art laboratories where demonstrations and practical classes could be given using large scale analysis techniques and genuine laboratory experience. This could be at a wing of the local university or at a county centre. If this could be tied in with teacher training then teachers could experience their first classes in an environment familiar to them, with a well-prepared presentation, and trainees in mathematics, STEM, geography, economics and other subjects could all teach students visiting the centre for a day at a time.

With sponsorship from companies, A2 students could even take part in research projects (Skills section d) to provide data for companies, while preparing for themselves a portfolio of practical work for A2 assessment, the innovative nature of the work guaranteeing that the work was that of the student. Similarly, students more suitable for apprenticeship schemes could work with representatives from companies. Overseeing these projects would give trainee teachers experience with differentiating by task and outcome, and all parties benefit.

b) Some students benefit from moving to a new place of study because they are able to leave their history behind them. This aside, fewer educational moves means that less teaching time is necessary for ensuring that students have a common experience. For the able this could permit investigation of problems in more depth, so preventing boredom, and for the less able there is more time to practice foundational material. For STEM and mathematics in particular it would give valuable time to attend to scientific literacy: far too many students do not perceive, or do not learn, the use of technical vocabulary, either because they do not meet the words or because they are presented hurriedly.

g) Girls often are, or allow themselves to be, pushed into the background in mixed sex science lessons. The intervention of a good teacher should find ways around this (for example boys versus girls investigations) and having been in the position of a female student in a male-dominated learning environment in my Tripos in Cambridge, I would recommend that girls be encouraged to learn to survive in mixed classes while in school, otherwise later they could find themselves struggling to take the lead in their university careers.

Other comments:
- It is important to ensure that text books are more accurate than some of the current offerings. For example, I am told that one biology text for A2 contains 42 errors at the last

count. As a second example, the OUP text book for IB physics refers to “breaking” instead of “braking” radiation, presumably because the spell checker found a word it recognised and the text was not read thereafter by a physicist...

F Accountability

c) i) Raising the standard of teaching of mathematics in Sixth Forms is vital. I have recently taken a private student for A2 mathematics whose class teacher (not a specialist) reads up the text book the night before and then cannot explain the mathematics when quizzed by the students.

ii) Having more staff in Sixth Forms is also vital so that all students can be taught the mathematics modules of their choice. (see section about timetable constraints, General questions 1b).

Iii) Improve general guidance at the time of opting for A levels, especially ensuring that students know which mathematics modules are required for university courses so that they will be able to apply for courses of their choice. They will then also be prepared as well as is possible for the transition from A2.

Anne Watson, Oxford University

1. a) What is good about UK science and mathematics education?

1. That we have a strong historical tradition in ensuring that our best students understand what they do in depth. This has been severely challenged by recent accountability and testing practices but still some teachers maintain this standard. We have a significant number of internationally recognised researchers in the fields of mathematics and science education and have on occasions (not right now) led the world in educational innovation and could do so again. We have until recently striven to ensure that teachers understand what they are teaching, and in addition there was a sea-change in scientific knowledge and teaching at primary level with the introduction of the NC. We were one of the first countries to make science compulsory for all students, especially at primary level. Until recently, all teachers were graduates but their personal subject knowledge is under threat from qualities in their own education and other limiting factors in training and curriculum and professional accountability. Science receives huge boosts of popularity from people like Brian Cox and Maths from Marcus du Sautoy but the popularisation of mathematics often focuses in ideas that are way beyond school capabilities. Our innovative practice in ICT from 1980 onwards was world leading, especially with the wide use of LOGO in schools, but this development has not been maintained.

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?

The mathematics curriculum is, and has become more so in recent years, very focused on things that can be done by machines now and closed procedural questions, which are predictable, dominate at GCSE. Getting a grade C has very little to do with achieving a lasting understanding of mathematical ideas that can be developed and used. So assessment needs to change. the mathematical knowledge of teachers is often not adequate to develop minds beyond these procedural tests. I lead one of the highest rated, most selective, PGCEs in secondary mathematics in the country and I now have to test applicants even those who have mathematics degrees. There is no time on ITT courses to work sugnificantly on personal subject knowledge. I do not think that school-based routes give much time to this at all. If this is a problem now at secondary level, I shudder to think about primary. there is a desperate need to develop subject knowledge of all people teaching mathematics, and for this to be funded and recognised. There also needs to be room in a curriculum and assessment regime for this knowledge to be sued to inspire children. The mathematical knowledge of teacher educators is an unexplored area. So I am saying that mathematical knowledge of those who teach, those who teach teachers, needs strengthening and also of those who write the curriculum. On a more exciting note - we are in danger of continuing with a curriculum that mimics what was thought useful in the 19th century, never mind the 20th. A 21st century mathematics curriculum nneeds to fully exploit the affordances of digital technologies to pose and tackle new questions, to bring more students into realsm of expertise that can be applied in the workplace, that have access to the mathematics that costs money to access, alongside a deep understanding of the rulesn and procedures that are the tools of the trade. It is possible to use these as tools. At present we teach people how to use a screwdriver to screw screws, instead we could be teaching them how to make one, how it works, how to develop a better one, and how to use it to make a cabinet. A better education hs to recognise that many of our students are uprooted and migrated and have many problems; maths can be empowering and enable them to be included in society, but too often it is used to separate out the failures and contribute to disaffection in secondary schools. Too little attention is paid to developing deep understanding over time, so that students feel that they have significant knowledge. I do nnot think we shall improve things by borrowing wholesale ideas from elsewhere - as mathematics education is influx everywhere. I speak as someone who has been consulted by educators in all major achieving countries. We need to develop a UK perspective which works for our population and our diversity and our major employment routes, including the mathematics for innovative and creative manufacture.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
I won't go on about these but my answers are hinted at in the sections above - testing and disenfranchisement

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
See ACME mathematical needs report.

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Alberta: close cooperation between policy makers and knowledgeable people such as teachers and academics. Coherent policy for people with other languages and first nation people. Prestige and support given to teachers to carry out research and innovation. Reluctance to set students; more emphasis on recovery. Teacher educators and teachers with higher level of mathematical knowledge (this is a guess from my experience) and an expectation that they will do subject specific M level study. Some of this is similar to New Zealand which also does an excellent job with a population which is in many ways like ours. I could also name the usual Pacific Rim countries but they don;t seem to be doing a good job of long tails of underachieving students, have high rates of stduent anxiety and private tutoring to pass high stakes procedural tests. However, they do have strong traditions of teachers working together to improve and this is funded and expected.
7. b) What specific aspects of other countries’ high-performing education systems should we be learning from?
Expectations about teachers' continued learning and professional development over time. Respect for teachers' knowledge. Respect for research knowledge about learning mathematics.

8. Other comments:
No one has a robust 21st century curriculum yet. We could lead on this because we tried it in the 80s and 90s but successive attempts have veen squashed due to testing requirements and also to teacher knowledge. the closest we have is the MEI A-level suite but that has flaws.

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Status of teachers needs to be higher at all levels; stop blaming teachers for everything and stop making them right all the country's wrongs. Develop sustained career paths involving study and acrcreditation and hence respect for their learning. Improve working conditions - in some high-achieving countries teachers have more non-contact time than here. Time to plan is ring-fenced; time to work together is ring-fenced. Stop the decline in professionalism in maths teaching whereby people can enter the profession through routes that do not necessrauly engage clever people with big ideas in their chosen profession. It is NOT a job that can be done well by anyone with a bit of maths. At the same time, taster experiences could be part of every students' undergraduate experience - these (UAS and SAS) work well in engaging students in the problems and rewards of teaching. Evaluate the new bursary scheme.

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
We insist on a 2.2 or above in maths or maths-related subject which has at least 50% of its content as a variety of degree-level maths. We ask them to audit their knowledge on the NCETM audit which we find adequate for our purposes once we have accepted them, and to

act on the diagnosis that results. However, we also have an interview maths test which is about mathematics from KS3 and 4 but probes beyond the obvious - it is not just what they can do but HOW they know it and what they notice about interesting results that we wnat to find out. You can helpo anyone to learn what is in a textbook (although some textbooks are wrong about some things) but it is the undelrying curiosity and connections and big ideas we want teachers to have. I cannot comment about primary but I am sure that grade C GCSe is not enough if nothing more is learnt.

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes, money and time. This is a national urgency.
3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
Ah! Here I have a problem. I would like to say that HE courses give students access to the knowledge and critical groundings they need to become autonomous, effective teachers. The usual argument is that HE routes relate to recent research and produce the best teachers. recent reviews have supported this - Ofsted. However, in many universities the teacher education is not dione by active researchers but by others, often part-time and temporary rather than embedded in the research culture. Who trains the trainers and what knowledge do they need? What they do have is a strong focus on teacher development and knowledge of practices beyond the school placement. School-based routes run the risk of sustaining current practice which is often mediocre and based on the limited models put forward by the Strategy, or is geared towards the notion that all children must be labelled and sorted and tested rather than focusing on the development of long term mathematical understanding of big ideas. So what is good is the graduate nature of teaching, the possible access to research and critical comparison between the practices of different schools, and the supported developmentin schools by mentoring departments. What is weaker is the lack of time or focus on subject knowledge, lack of access to active researchers or research as a thing that teachers might do to develop practice. It is also silly that the profession only insists on initial training and not on updating and development.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
Teachers need to have some idea about how children learn their subject, and what approaches work well for different topics. Mathematical knowledge is diverse and one kind of teaching or lesson type does not work for everything. HE courses work best because of the group of students being able to discuss, work together and compare settings and practices.Lab schools would be good for innovation. It is unlikely that innovation can be experimented with in schools that are constantly worried about test reuslts - academics and free schools are as unfree as any others in this respect.

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
I cannot answer this fully, but I do know that they should be inspected by knowledgeable people and this is often not the case. There should be standards for teacher educators, like

an expectation that they too engage in CPD and subject knowledge enhancement. If science and maths trainiing took place in closer cooperation with university subject departments, insteade of education/social science departments, there might be more empohasis on knowledge BUT this does not mean they should be taught by university mathematicians , that would eb inappropriate. Lab schools or lab classes could be used by a range of institutions. There are no books in Uk about how to be a maths teacher educator that make coherent suggestions about practice - just websites that offer examples of 'best practice' - but who decides what is 'best'?

6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
A structured mix of institutional and school-based study works well so long as there are clear developmental milestones and stages.

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Universities with string links with, and respect for , schools and teachers but with active researchers whose work feeds inot the training; paired with schools that understand teacher development and allow development of ideas and variety of ways to teach.

8. h) How much of this training should be spent gaining experience in the classroom?
Something has to move over to make room for subject knowledge, so less than the current 2/3 of a full-time course. However, students do need to experience long enough for things to go wrong and for them to learn how to rescue classes and individuals.

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
Five years, during which tine there should be evidence of and time for further study while employed as a teacher and incentives to continue. Most of this would be school-based of course, working as a teacher. Many jobs have a five year probation period so this is not unreasonable.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
Mathematics is largely an abstrcat subject which has applications and hard concepts that develop over time. It is very easy to fall into the trap of teaching what is necessary for the next test without learning from others what might work better for students over time. Subject-specific CPD enables teachers to learn what research tells them,and other practitioners do, in particular topic areas, and to cricially evaluate particualr approaches. It also enables them to learn from a vast research literature about issues such as gender, social class and how these act to disadvantage students in maths - there are specific things about maths that make, for example, some social groups less able to achieve. CPd also promotes a group way of working so that thinking about your work and trying to improve it becomes a group endeavour rather than an isoltaed activity, and this encourages people to keep going, especially if a course is accredited.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
belonging to subject associations so they can get access to a range of views, not just one view as you get on a 'day out' trainbing model. Then also CPD courses of some kind, maybe towards CMath Teach or M level modules, which structure such shairiung more critically. It should be expected that teachers belong to a professional association.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
Throughout. certainyl durin g the first five years to establish the habit, but whether this should include comleting an Mlevel course should be discussed further. M level in a practice -based subject ought to require more experience.

4. d) Should CPD be voluntary or mandatory? Why?
Mandatory, because this is a profession.

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
It is important that NCETM continues to provide a portal for courses and a kite mark - their kite mark describes best practice according to ersearch about teacher education. Obstacles are: requirement, funding, 'rarely cover', school leadership faulure to recongise its importance.

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
No, these are separate - the first job is to teach maths well and better.

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes, but not too soon and it needs to have breadth and depth. It is not enough to write a couple of essays about gender and say you have 'done' effective CPD.

1. a) What impact do teachers’ leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
I am running out fo steam but there is some ersearch about subject departments which ought be accessed: Witzier and Visscher; Childs Burn and McNicholl, Beswick Watson and DeGeest etc. usually it is finding time to work on mathematics together that nmakes the difference.

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
The skills tomwork with others as developing colleagues.

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?

The AST idea seemed like a good one to me, what happend to it? I am contributin ideas about primary via other routes but there need to be subject experts in primary schools who work alongsisde other teachers to spread skills and knowledge, not just to do their own teaching and run the scheme of work.

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Can we not use the word 'skills' as in maths what matters is generalisation, understanding conceptual overlaps, memory for structure - in fact Krutetskii found all this in his book of 1967. You start getting them from birth, see Nuffield study by Nunes Bryant and Watson

Maulfry Worthington

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Children's understanding of the abstract symbolic language of mathematics.

5. Other comments
I am very concerned that the Royal Society appears to have overlooked mathematics for children under 5 years of age, since this is the most significant phase. During these years children begin to develop their early understandings of what mathematics is, use symbols and graphical representations for mathematics. In the Foundation phase children develop personal views of mathematics and about themselves as young mathematicians that will influence their beliefs, confidence and competences throughout the Primary School.

6. a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?
I am concerned that you feel that answers are to be found only outside this country! However, I believe that there is a problem in translating research into practice in this country, and due to politicians anxieties for the short term, a good deal of mathematics teaching in Primary schools continues to focus on teaching skills at the expense of mathematical processes and mathematical thinking and understanding.

8. Other comments:
For the past 20 years (and in collaboration with a colleague) I have been researching the abstract symbolic language of mathematics. Our work is supported by extensive research (including PhD research) and by independent researchers. It relates to earlier work by Martin Hughes in England, and by Penny Munn (Scotland) and to theories developed in the Netherlands, (including the Free University, Amsterdam) - although our pedagogical approaches differ in practice. Redcliffe Children's Centre and Maintained Nursery in Bristol is a Centre for Excellence in Mathematics and has received 'Outstanding' for mathematics from OfSTED. The work on mathematics at Redcliffe exemplifies the work we do on children's mathematical graphics. See also: www.children-mathematics.net Our work was acknowledged in the Williams Maths Review (2008) - DCSF and following its publication we

were commissioned to write a document for teachers. However, with a change of government we are unsure that the current government will take interest in this important aspect of mathematics. There is considerable interest in our work in the UK and internationally. For

1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Strengthen mathematics in the Foundation Stage and in the Primary school. In 2009 Jo Boaler highlighted many of the problems with mathematics in Primary schools in her publication 'The Elephant in the Classroom'.

3. c) What is good about initial teacher training programmes in science and mathematics in the UK?
In additon to the mathematics, initial teacher education needs to focus on children's understanding and development in mathematics.

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
See my previous comments. In mathematics there is far too much emphasis on children's errors and misconceptions and insufficient recognition of their strengths. A democratic, positive perspective would better support learners.

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
It is unfortunate that the existing Mathematics Specialist programme (MaST) for teachers was aimed largely at Key Stage 2 teachers, since most have no experience or knowledge of children in the Foundation Stage (yet are expected to advise Foundation Stage teachers. The content of MaST training varied from one university to another and included little on early years maths.

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
In the longer term I believe that ALL teachers (not only those teaching science and maths) should have a Masters degree.

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
No Response

4. d) Should CPD be voluntary or mandatory? Why?
An independent study of one aspect of our CPD for mathematics was undertaken by the National Centre for Excellence in the Teaching of Mathematics. The research was entitled 'Researching effective CPD in Mathematics Education' (RECME) and our Network groups were featured as a successful approach in the final report,

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
Yes - but only if it is of sufficiently high quality.

1. a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Considerable - since it is the headteacher / curriculum leader whose philosophy will shape what happens in a setting or school.

1. a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?
Much more than skills are required (please see my earlier response regarding children's attitudes and beliefs).

2. b) How may the acquisition of such skills best be assessed?
From a positive perspective: unfortunately there is a widespread view of mathematics as a 'hard' subject and that many children find it difficult and therefore under achieve. Many of children difficulties originate in the ways in which they experience maths in the Foundation Stage and Key stage 1.

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?
No Response

4. d) How should a curriculum be structured so that: i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science; ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning? iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives: iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?
Children do not learn mathematics in a linear fashion as curricula often suggest - and for this reason the importance of greater flexibility needs to be acknowledged.

5. e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?
In the Foundation stage and Primary schools formative assessment based on a positive assessment of what children show they can do (rather than focusing on any difficulties they have.

6. f) To what extent can/should science and mathematics be effectively assessed through other subjects?
In the Foundation stage it is best assessed through play.

7. g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?
No Response

8. h) What evidence of learning is needed for assessment to operate effectively?
Teachers' and practitioners evidence from classroom observation of their pupils.

7. g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (eg should there be single sex classes or schools)?
I am extremely concerned about separating children by 'achievement' in Primary schools, giving the wrong message to children and teachers (see Boaler, 2009 on this).

K Yeoman, University of East Anglia

1. a) What is good about UK science and mathematics education?
Generally science education is good, we have maintained our position with the OECD countries. We have a substantial amoutn of practical work, but perhaps this needs to be better targeted, with clearer pedagogical aims. Factual content is still very important. We need to still offer both triple and double science. We should not allow students to chose single sciences (I have an undergraduate student doing biology who dropped chemistry at Key Stage 3, in my opinion she was badly advised). Societal impacts are important, but should not take precidence over hard content. Maths is another story, we have slipped badly in terms of our OECD position (not that great anyway).

2. b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?
Maths needs to go back to the traditional O level Syllabus, teach tables, basic arithemetic. Reption, reptition, planty of exmaples and practice. Children are not shown different methods for working, this is very fashion drive.

3. c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)
teacher and technician trianing and then CPD. Teachers lose confidence in practical science, as they havn't really done much of it themselves

4. d) How can a science and mathematics education system best meet the needs of employers and higher education?
One which is driven by understanding of concepts and facts. Practical skills.

5. Other comments
No Response

6. a) Name three countries anywhere in the world where you feel ‘high-quality’ science and mathematics education are to be found? What are the hallmarks of this ‘high quality’ science and mathematics education?
Finland, China,

7. b) What specific aspects of other countries' high-performing education systems should we be learning from?
Finland have less practical work, but I suspect it is more targeted. There are stronger pressures in China to be more socially mobile. Education is a way out of poverty Opportunity for more extracurricular work

8. Other comments:
Get scientists more involved. We want to be, there is not always the incentive though.
1. a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?
Make the profession more attarctive. Remove budensome paper pushing. Stop making them go through hoops. Let them teach and enjoy their subject. provide Lab-sabbaticals to increase confidence

1. a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?
2:1 (hons)

2. b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?
Yes, career progression, and get the golden handshake back

3. c) What is good about initial teacher training programmes in science and matAhematics in the UK?
They learn about the science of teaching and then gain real classroom skills

4. d) What changes to these programmes (eg philosophy, content, or emphases) are needed?
It still needs to be based in academia, on the job may not provde you with the best training

5. e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?
They need to be taught how to teach, how to deal with situations. Their subject should have been covered by their degree. Specialist teachers please for all sciences.
6. f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?
No Response

7. g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?
Universites coupled with schools

8. h) How much of this training should be spent gaining experience in the classroom?
placements, at least 6 months

9. i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?
two years

1. a) What are the benefits of subject-specific CPD for science and mathematics teachers?
confidence

2. b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?
provide Lab-sabbaticals to increase confidence

3. c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?
at least once a year

4. d) Should CPD be voluntary or mandatory? Why?
mandatory, you must keep in touch with science

5. e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?
none

6. f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?
Could be

7. g) Should CPD be accredited (eg through the awarding of Masters-level credits)?
yes

1. a) How and where should we be training laboratory technicians?
back in science labs
2. b) What CPD needs will laboratory technicians have and how will these best be accommodated?
they must learn to be flexible in providing and maintaing new equipment and offer up to date practicals

3. c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?
Yes, they should also be trained properly

4. d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)
School, Universities, Reseach institutes

1. a) What impact do teachers’ leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?
Schools need strong leaders, at the top and within each department. I don't know where the evidence is, this comes from my extensive expereince with schools

2. b) What kinds of leadership skills should science and mathematics teachers be able to acquire?
courgae to try new things, provide better practical opportunites

3. c) How can school and college leaders encourage leadership among science and mathematics teachers?
CPD, mentorship

4. d) How can leadership pathways for experienced teachers be introduced into careers?
mentorship

5. e) What factors are most responsible for creating the ethos of different schools and colleges?
It is possble for this to happen, there may be problems, but there is alwaty a way around

1. a) What skills are particularly important to young people’s progress in (i) science and (ii) mathematics, and when should they begin
to acquire them?
Investigative skills Interest Excitement

2. b) How may the acquisition of such skills best be assessed?
Seeing how things are done and doing them

3. c) How important is the impact of the transition between primary and secondary phases in terms of pupils’ progression in (science and mathematics) education?
Massive

Appendix.

Vision for science and mathematics education 5–19

Call for Views

The Royal Society, the UK's National Academy of Science, is undertaking an ambitious new project to set out an evidence-based vision for a future world-class, high-performing 5–19 education system, particularly with respect to science and mathematics.

Using international comparisons, the 'Vision for science and mathematics education 5-19' project will help ensure the UK has a scientifically and mathematically literate population as well as sufficient numbers of scientists and mathematicians to help solve the many challenges the world will face in the coming decades. It will take a fresh approach to tackling concerns widely held or expressed by governments, employers and the science and mathematics communities about the UK's future economic competitiveness and individuals' future prospects.

Five specific areas for inquiry have been identified, all of which are essential considerations for establishing and sustaining a high-performing and well-respected science and mathematics education system:

- teachers (and the wider workforce);
- leadership and ethos;
- skills, curriculum and assessment;
- infrastructure;
- accountability.

This Call for Views covers each of these areas. We would welcome views and evidence from all organisations and individuals, particularly from those with educational expertise and an especial interest in improving science and mathematics education. We want to know what needs to be done to help ensure that all young people have an inspiring introduction to science and mathematics, and that those who wish to pursue these subjects further are enabled to do so.

Please send us your submissions to this Call for Views by Friday 16 March 2012 at the latest to: vision@royalsociety.org . We would particularly welcome any robust data or other evidence to support your views about improving the science and mathematics aspects of the education system and would be grateful if you would reference this fully so that it can be followed up.

Notes for completing the Call for Views

1. Please do not feel a need to answer every question.
2. Where appropriate, please cross-reference your responses.
3. Personal information will be treated as confidential and will only be used for the purposes of the Call for Views.
4. Submissions, or extracts from them, may be published on our website or in other outputs we publish. Please inform us if you do not want to be identified in anything we publish or

highlight clearly any particular aspects of your submission that you would wish to be anonymised.
5. If you are submitting a response on behalf of an organisation, please make this clear and include details of the relevant person to contact should we wish to discuss issues raised in your submission.

If you have any queries about the content of this document, please email: vision@royalsociety.org

General questions

1) Science and mathematics education in the UK

a) What is good about UK science and mathematics education?

b) What aspects of UK science and mathematics education need changing and how may they be improved to meet the challenges of the 21st century?

c) What, if any, broader educational issues concern you? (These may or may not relate directly to science and mathematics education)

d) How can a science and mathematics education system best meet the needs of employers and higher education?

Other comments:

2) Science and mathematics education internationally

a) Name three countries anywhere in the world where you feel 'high-quality' science and mathematics education are to be found? What are the hallmarks of this 'high quality' science and mathematics education?

b) What specific aspects of other countries' high-performing education systems should we be learning from?

Other comments:

Teachers (and the wider workforce)

An education system can only be as good as the teachers within it. But for many years now shortages of science and mathematics teachers have been recorded in England and Wales and the situation elsewhere in the UK is not entirely clear. Problems have been reported both in recruiting sufficient trainees and retaining qualified teachers.

Please answer these questions without feeling in any way constrained by current or proposed mechanisms in place for recruiting, training and/or professionally developing science and mathematics teachers.

1) Teaching as a career

a) What needs to be done to make teaching a top career choice for trained scientists and mathematicians?

2) Initial Teacher Training

a) What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses? Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

b) Should inducements be offered to attract entrants into science and mathematics teacher training? If not, why not? If they should be offered, then why and what might they be?

c) What is good about initial teacher training programmes in science and mathematics in the UK?

d) What changes to these programmes (e.g. philosophy, content, or emphases) are needed?

e) How can the standard of science and mathematics initial teacher training programmes be of a consistently high quality across the UK?

f) What types of courses (full and/or part-time) should be provided for training new science and mathematics teachers. Why?

g) In what sort(s) of institution(s) should science and mathematics teacher training take place? Why?

h) How much of this training should be spent gaining experience in the classroom?

i) How long should courses be for training (i) primary; and (ii) secondary science or mathematics teachers to become fully qualified?

Other comments:

3) Continuing Professional Development (CPD) for teachers

a) What are the benefits of subject-specific CPD for science and mathematics teachers?

b) How should science and mathematics teachers best keep up with their subject and with new approaches to teaching, assessment and the curriculum?

c) At what times throughout their teaching careers and with what regularity should teachers undertake subject-specific CPD?

d) Should CPD be voluntary or mandatory? Why?

e) Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome them?

f) Should subject-specific CPD be linked to broader CPD development strategies within schools and colleges, for example in areas such as leadership and assessment?

g) Should CPD be accredited (eg through the awarding of Masters' level credits)?

Other comments

4) The wider workforce

a) How and where should we be training laboratory technicians?

b) What CPD needs will laboratory technicians have and how will these best be accommodated?

c) Will there be a role for teaching assistants in science and mathematics classes? If so, what should this be? How and where should they be trained?

d) Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)? (Do we, for instance, need a national network of careers advisers with specialist knowledge and understanding of careers in science, technology, engineering and mathematics?)

Other comments

Leadership and ethos

Leadership and ethos are complex concepts within education, but are considered to be significant in affecting the overall performance of individual schools and colleges, and the education system as a whole.

Much less is known about the leadership characteristics of those science and mathematics teachers who successfully introduce innovative teaching and learning practices. This implies a culture of initiative and collegiality for developing, as well as delivering, the curriculum. However, systematic evidence is also lacking in respect of the effect of such leadership on student performance and progression in science and mathematics.

a) What impact do teachers' leadership qualities have on the quality of science and mathematics education, and on the performance of science and mathematics departments within schools and colleges? What evidence exists for this impact?

b) What kinds of leadership skills should science and mathematics teachers be able to acquire?

c) How can school and college leaders encourage leadership among science and mathematics teachers?

d) How can leadership pathways for experienced teachers be introduced into careers?

e) What factors are most responsible for creating the ethos of different schools and colleges?

f) What impact do leadership and ethos have on the quality and range of science and mathematics education offered within schools and colleges? What evidence exists for this impact?

g) What is the role of governing bodies in shaping the ethos of schools and colleges and how, if at all, does this impact on their provision of science and mathematics?

Other comments:

Skills, Curriculum and Assessment

Acquiring the right scientific and mathematical skills and knowledge is a key component of an 'ideal' 5-19 education process. Teachers teach to a relevant curriculum and enable learners to acquire useful knowledge and understanding, which is then assessed at a critical point in time to certify what a young person knows and can do in these areas.

a) What skills are particularly important to young people's progress in (i) science and (ii) mathematics, and when should they begin to acquire them?

b) How may the acquisition of such skills best be assessed?

c) How important is the impact of the transition between primary and secondary phases in terms of pupils' progression in (science and mathematics) education?

d) How should a curriculum be structured so that:

i. science and mathematics are adequately incorporated as subjects which have both conceptual and applied contexts e.g. practical work in science;

ii. teachers are able to use what they judge to be the most effective pedagogical methods and approaches to learning?

iii. diverse types of student acquire the specific knowledge, understanding and skills they will need for their adult lives:

iv. there is flexibility to include new topics or react to new discoveries or advances in science that can enthuse and excite?

e) What characteristics of assessment best serve learning in its various forms in school science and in mathematics?

f) To what extent can/should science and mathematics be effectively assessed through other subjects?

g) At what age(s)/stage(s) should public examinations and testing be conducted during students' school careers?

h) What evidence of learning is needed for assessment to operate effectively?

Other comments:

Infrastructure

Infrastructure refers to the nature of the learning environment in which formal teaching and learning take place. For the purposes of this exercise, picture an 'ideal' learning environment of the future (in one or two generations' time, for example) which has all the resources and support systems in place to enable the best possible teaching and learning in science and mathematics.

a) Where will/should science/mathematics primary and secondary school learning take place, both within and outside school?

b) Will science and mathematics education benefit from having more, or less, diverse types of 5–19 educational institutions (e.g. primary, secondary, middle, all-through schools)? Why?

c) What kinds of specialised facilities, linked to key areas of learning in science and mathematics, should be available in the future?

d) How might teaching and learning in science and mathematics be supported by and support learning in other subjects, for example through using other facilities?

e) What other resources and systems should be used to support science and mathematics?

f) What other more general changes to school infrastructure would support excellent science and mathematics teaching and learning? How can we measure this?

g) What evidence is there of the effect on their learning of science and mathematics of separating cohorts by (i) age and (ii) gender (e.g. should there be single sex classes or schools)?

Other comments:

Accountability

Those who are responsible for science and mathematics education within schools and colleges should be accountable for their performance.

a) How should science and mathematics in a 5–19 education system best be made accountable to (i) students; (ii) parents/guardians/carers; (iii) higher education; (iv) employers; (v) taxpayers; and (vi) ministers?

b) How should qualifications in science and mathematics be regulated?

c) How can we ensure that all students can access the science and mathematics courses they wish to?

d) What are (i) the advantages and (ii) the disadvantages of performance targets and do any apply particularly to science or mathematics education?

e) How should measures of performance best be reported to different audiences? What other measures of performance may be required?

Other comments:

Permissions

a) Are you content for us to publish extracts of or the whole of your submission? Yes ☐ No ☐

b) Would you like to be kept in touch with the project? If 'yes' please provide a contact email address. Yes ☐ No ☐ email address: ____________________________________