# UK DEANS OF SCIENCE

# Response to the Royal Society project:

# Vision for science and mathematics education 5 - 19

## Background

1. UK Deans of Science (UKDS, www.deansofscience.ac.uk) is a national body that seeks to represent the individuals, usually formally designated as Deans, who are responsible for science in HEIs across the UK and who generally hold the budgets for science including any research budgets. Its primary aim is to ensure the health of the science base through the promotion of science and scientists and of scientific research and science teaching in the UK. This response has been agreed by the UKDS Executive Committee.

2. We believe that those with the most knowledge of many of the matters raised are teachers and others who are most directly involved in 5 – 19 education. However, their views and any solutions they propose will need to be robustly tested against the opinions of others and evaluated against all available evidence. We have tried to limit this response to questions where our members' knowledge is relevant as receivers of the 5-19 education system or through their contact with science and mathematics education in schools and the FE sector.

## General questions

**1) Science and mathematics education in the UK**

*a) What is good about UK science and mathematics education?*

UK science and mathematics education:

- has had the vocal, and sometimes active, support of successive Governments for a number of years
- is compulsory in Key Stages 1 to 4 of the National Curriculum
- is based on key concepts, processes and understanding evidence
- attempts to relate the science learned to real life issues
- is delivered by many committed and inspiring teachers.

*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. Political dogma must eventually be removed from education planning, development and delivery. Please note that this is not intended to be a negative political point about the current or other recent Ministers of Education. There has been too much political involvement over many years. The Royal Society's ultimate aim should be to ensure that science and mathematics education is removed completely from the political arena and given to independent experts in schools, universities and appropriate professional, statutory and regulatory bodies.

ii. Action is needed on the curriculum and its delivery that ensures an emphasis on acquisition and retention of an appropriate knowledge base.

iii. Assessment needs to be robust and rigorous.

iv. All pupils who can benefit, and wish to do so, should have the right to study the three separate sciences at GCSE.

v. Science education must have within it more opportunity to engage in challenging and interesting practical work.

vi. Assessment should be more rigorous. We strongly support the move to decrease the contribution of coursework to the assessment of qualifications.

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

i. The effects of league tables on the various Awarding Bodies and the behaviour of many schools and on classroom teaching are sufficiently well known that we will not repeat them here. It is almost impossible to find any possible justification for having several Awarding Bodies (whether they are for profit or not-for-profit companies) competing for 'business'.

ii. Changes in the curriculum are far too frequent. A significant period of stability is needed during which some small evolutionary changes might be made in the present system. This period of relative calm should be used to develop a proper landscape for education that is: thoroughly thought out; based on as much evidence as possible and on the knowledge and understanding of experts from the UK and elsewhere; and leads to the development in every subject of an agreed way forward that is devoid of political bias and produces thoughtful, useful citizens by giving each and every pupil appropriate opportunities to develop their full potential. Although this may well be what every change in education and education policy is intended to deliver, the continual curriculum churn never appears to take account of the whole picture or recognise the individual needs of each pupil.

iii. Discipline is an issue for all school activities, particularly in science subjects.

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

i. The science and mathematics education needs of employers and higher education are frequently different. Because science and mathematics are linear, hierarchical subjects, for those who study them in higher education there is a need to possess a certain quantity of subject specific knowledge and skill.

ii. UKDS are not best placed to comment on the needs of employers, except to note that we hope that the Royal Society will be able to engage in such a way with employers during this exercise that it finds employers who will go beyond the usual generalities and be willing to engage in understanding the content, teaching, learning and assessment in 5 to 19 education and the context within which they are

delivered in both the state and private systems, so that they can make constructive suggestions as to how 5-19 education can deliver what they need.

**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?*

We suggest Korea and two related administrations that have developed under very different circumstances: China and its Special Administrative Region, Hong Kong. We are less familiar with China but believe that the success of all three countries is built less on 'high quality' education (though there is evidence of extremely high levels of teacher commitment) than other social factors. These include total commitment and belief in the importance of education and academic success across the whole population, a 'can do' attitude in business, the encouragement of competitiveness (to be the best) in schools, the high level of parental involvement in children's educational development and the willingness of families of even limited resources to pay for coaching outside school.

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

It is not obvious *per se* that the curriculum, teachers, teaching and assessment methods make the education systems in China, Hong Kong and Korea so successful, but the aspects noted in (a) above.

## Teachers (and the wider workforce)

**1) Teaching as a career**

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

A way must be found to give such individuals the kind of freedom, within sensible constraints, that allows them to have the same level of self management of their work and career as they would have in almost any other profession that they might choose to follow.

**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?*

The minimum entry requirement should be the same as is required for entry to an honours degree (including the equivalent of at least a grade C GCSE in English and mathematics) together with evidence of a real interest in, and commitment to, a career in teaching. To guard against the problem of the 'shelf-life' of previous qualifications or experience a diagnostic test should be used to ensure that at the point of embarking on the

course, the candidate still has the abilities that would be expected of a holder of GCSE English and mathematics and her/his other higher qualifications.

*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?*

While there may be some benefit in having a form of inducement to enter teacher training, the main emphasis should be the creation of inducements that encourage good science and mathematics teachers to remain in teaching.

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

No comment

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

No comment

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

No comment

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

Full-time, part-time, mixed mode and distance learning programmes should all be available to ensure the widest possible participation by all who might wish to become teachers.

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

No comment

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

No comment

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

No comment

**3) Continuing Professional Development (CPD) for teachers**

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

Its most important benefit is to ensure that teachers are able to keep up to date with the latest discoveries and applications so that they maintain the relevance of their teaching.

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

It should not be assumed that they will only keep updated through completion of formal CPD. They should be expected to maintain their personal development by a mixture of formal CPD, attendance at conferences and other relevant events and by personal study.

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

CPD should be practised in some form within each year of a teacher's career.

d) *Should CPD be voluntary or mandatory? Why?*

CPD should be mandatory for teachers as it should in every profession in the UK.

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

There is frequently too little resource available for CPD and its use is not necessarily directed to outcomes that will support the teaching of science and mathematics. Significant funding allocations must be guaranteed and ring-fenced for all science and mathematics teachers.

*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?*

It is better to separate subject related CPD from other professional development.

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

CPD should be accredited and its satisfactory completion - properly monitored and robustly assessed - should be a requirement for maintaining Qualified (Science) Teacher status.

**4) The wider workforce**

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

Laboratory technicians deserve to receive appropriate training – they should all complete 'initial technician training' which is as well developed and delivered as initial teacher training. Such an approach could create a workforce that is able to act in a similar, but probably more effective way, as standard classroom assistants. Some of the training should take place in a higher education environment and should include work experience in schools.

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

They have a need for updating of a similar nature to that of teachers and we would expect it to be acquired in similar ways.

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?*

Apart from the possible use of teaching assistants in support of early learning of mathematics we do not think that it would be possible to recruit sufficient numbers of people with the right skills to support higher level mathematics education. For science classes, please see the response in question 4(a) above.

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?)*

Proper advice on careers in STEM is a continuing problem despite the efforts of professional and other bodies to create excellent informative websites. The suggestion of a national network of careers advisers with specialist knowledge and understanding of careers in STEM is an excellent one. Such a group would need to include in their advice the importance of knowledge of science and mathematics to careers that do not fall directly in the STEM part of the economy.

## Leadership and ethos

We have no comments on this section

## Skills, Curriculum and Assessment

We have no comments to make directly on the questions in this section but offer some general points under 'Other comments'.

**Other comments:**

UKDS is not an expert on the design of curriculum, assessment and skills development in schools. However, in respect of these issues we would make the following general points.

i. It is essential that 5-19 education delivers a *knowledge and understanding* of the basic aspects of the sciences including: the basic building blocks such as the cell, atom, molecule; multicellular organisms and compounds; how to carry out scientific observations and make conclusions based upon them; how to solve problems in science; knowing, appreciating and understanding how science can explain aspects of nature, man and man's interaction with, and effect on, the environment; how science can be applied to develop solutions to challenges including human health and sustainability (including

food, water, energy); a comprehension of aspects of modern technology; aspects of manufacturing industry.

ii. For mathematics, it is essential that 5-19 education develops as a minimum an understanding of numbers and sufficient mathematical skills to comprehend the meaning of risk.

iii. The aim must be to ensure that, within the ability of each individual, all pupils achieve some ability in the above elements of the curriculum so that the vast majority understand the scientific method and recognise the opportunities and limitations of science and mathematics and are able to make some judgments about the sciences and their application. Beyond this, and for those with an aptitude and interest, the curriculum needs to stretch their ability to know in detail and understand in some depth one or more scientific disciplines and be able to make a smooth transition to their study in higher education.

## Infrastructure

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

Science classes, in particular, should normally take place in modern and well equipped laboratories/workshops. As pupils progress, there should be increasing use of external visits where pupils can relate the science to issues of health, manufacturing industry and the world about them.

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?*

No comment

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

No comment

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 comment

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

Please see the comment on external visits in (a) above.

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

No comment

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)?*

No comment

## Accountability

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?*

We do not believe that science and mathematics education should be differently accountable from any other subject.

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

They should each be regulated by a single body with representation from professional, statutory and regulatory bodies, and employers (including employers whose main business is not directly focussed on science or mathematics). Please also see the comment on Awarding Bodies above (General Question (c)).

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

No comment

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

We take this question to relate to performance targets for schools. We are deeply concerned that the nature of measurement of 'success' of schools and teachers (including the publication of league tables) that relate almost solely to the numbers/proportions of candidates obtaining passes, high grades or GCSE *equivalents* have led to several well publicised unintended consequences.

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

No comment

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