

Vision for science and mathematics education 5–19

A response from the Society of Biology to the Royal Society Call
for Evidence

16th March 2012

Introduction

The Society of Biology is a single unified voice for Biology: advising Government and influencing policy; advancing education and professional development; supporting our members, and engaging and encouraging public interest in the life sciences. The Society represents a diverse membership of over 80,000 - including practising scientists, students and interested non-professionals - as individuals, or through the learned societies and other organisations listed at the end of the response.

The Society of Biology welcomes the opportunity to input to the Royal Society's Vision project and acknowledges its ambitious scope. Our individual members and member organisations consistently identify education as one of their key areas of interest, with many members undertaking their own work to support 5-19 education.

Over time we have produced a number of statements and consultation responses which, taken together, describe the Society of Biology's views on science and mathematics education. Given the wide-ranging call for views in this large and complex area of policy, we recognize that it would be possible to write at some length under each heading. However, given the response time, we have provided brief responses to your questions with links to any previous evidence, reports and policy responses that express our views in more detail. We would be happy to discuss any areas of our response in more detail if that would be helpful.

General questions

Science and mathematics education in the UK

What is good about UK science and mathematics education?

- In schools, biology is primarily taught by suitably qualified and high quality subject specialists.
- There are good Continuing Professional Development opportunities available for teachers
- World-leading science within the Higher Education sector plays a major part in developing initiatives.
- There is a tradition of successful innovation in science education.

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 should be a mandatory requirement for all teachers to undertake subject specific CPD throughout their career.
- Better development of literacy and numeracy skills in students undertaking science qualifications should be supported. In particular our members raised concerns with the lack of confidence in student's knowledge of mathematics and the applications of it within the sciences.
- Better coherence between the mathematics curriculum and the science curriculum at both GCSE and A-level must be achieved. However it is important to note that whilst we are supportive of some continuation of mathematics qualifications post-16, we are not advocating a broad brush approach where all students studying A-Level Biology would be required to study A-level Mathematics as well. Thought should be given to appropriate combinations of qualifications for progression to a range of

end points which include further study at HE or beyond, direct entry into industry roles, and non-STEM careers.

- We need clear and useful pathways for all learners. This is particularly true up to the age of 16, but also applies beyond that. It is also particularly true for those wanting to follow a vocational pathway but, again, it also applies to academic routes¹.

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

- The narrow and very ‘tutor’-led focus that has resulted in a ‘tick box’ ethos, as a result students enter higher education less able to work as independent learners. The reduction in content has increased the gap between Further Education and Higher Education. The focus on ‘fact’ has led students away from wanting to develop a deep approach to learning and recognition of the importance of understanding. The GCSE and A-level exams frequently reward a superficial (regurgitating of facts) approach to learning which again is not matched to HE.
- The combination of competition between Awarding Organisations, arbitrary performance measures and high stakes examinations, has led to a reduction in the quality of assessment items, in teaching and learning and in standards².
- We are concerned about the pace of the review of The National Curriculum, the structure of the review bodies, and the review process³.
- Texts tied to specifications have become “bibles” and encourage students and teachers to use just the single source. It also imposes huge costs when preparing the delivery of a new specification because texts tied to previous specifications are seen as redundant. Members cited examples where in larger biology departments the cost of replacing all text books after a change in specification can cost up to £15,000, increasing the reluctance to change from one Awarding Organisation Specification to one more suitable one for their cohorts. This undermines the value of having competition in the system.
- There is some concern about flexibility of the curriculum requirements for free schools and academies, specifically from a science perspective, but not limited to it.

Teachers (and the wider workforce)

Teaching as a career

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

- In summary the key characteristics that make any career highly regarded are:
 - entry requirements for the degrees are high (as with Medicine and Dentistry)
 - pay once in employment is suitably high; there is vigilance about the employment costs of these professions, but due regard to the importance of expressing value for and retaining expertise

¹ A SCORE response to the Department for Education consultation 4 January 2012, Study Programmes for 16-19 year olds

² SCORE (response to Select Committee Inquiry) 7 November 2011, How Should Examinations for 15-19 Year olds in England be Run?

³ SCORE, April 2011, National Curriculum Review, response to call for evidence

- continual interest and challenge; the need for continuous professional development is key to retaining excellent individuals in the profession
- conditions of employment are excellent
- support from a network of ancillary staff (for example technical staff in the laboratory)
- Additionally, a clear career pathway which rewards excellent teachers and stresses the link to their subject without taking them out of the classroom into management.
- There should be better recognition for teachers who go above and beyond their everyday duties through the running of STEM Clubs, links with research institutions, and innovative practical and field activities. These activities should be recognised through the Ofsted Framework and career progression opportunities.
- Finally, better support for those who wish to link their teaching with research opportunities within FE and HE, to support their interest with the subject matter whilst they teach. This could inform their classroom practice and support any school aims of providing research informed teaching, retaining subject specialist staff and also keeping students engaged.

Initial Teacher Training

What should the minimum entry requirements be for entry to primary and secondary science and mathematics teacher training courses?

- Primary: At present the real problem is the shortage of science graduates applying, and so appropriate support to encourage more science specialists to enter the primary science profession is what is needed.
- Secondary: Due to the large number and variety of bioscience undergraduate courses it is hard to specify minimum entry criteria for teacher training courses. ITT institutions currently recruit from the top tier of biology graduates (2.2 and above) and we support the ambition to attract the very best graduates into the profession.

Should diagnostic tests be applied to test the suitability of candidates? If so, what types?

- Due to the range of undergraduate degrees in the biosciences, diagnostic tests might be a useful identify areas of weakness in incoming graduates' likely subject knowledge. However, we would not advocate using these sorts of tests as an interview tool, instead they could be used to tailor the subject-specific support given to PGCE and NQTs during their training.

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?

- It would be more productive (especially on retention) to offer better career progression – possibly through links to professional bodies; and to offer teachers of sciences the opportunities to explore other interests (either educational or scientific) whilst remaining a teacher.
- As there is a shortage of specialists in these subjects, there is definitely a need to offer inducements. However current Government policy⁴ has reduced the number of PGCE places

⁴ Training our next generation of outstanding teachers - Implementation plan, Department for Education, November 2011.

available for Biology Specialist Trainees, and this risks sending the message to excellent biology graduates that teaching is not a viable career pathway under the current administration.

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

- There are different entry routes available to those wishing to undertake a teaching career through the Graduate Training Programme, PGCE, Teach First and Bachelors of Education (BEd).

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

- Practical training courses are needed, as science graduates will have specialised in one area of science e.g. biology, and may need to be retrained in techniques used in other areas e.g. physics.
- Refresher courses are needed for areas of science not studied by trainees during their degree i.e. chemistry courses for biology graduates.
- Courses teaching trainees how to assess students in practicals and their written work are needed, as these are important skills to have (and are not learned during a degree), these assessments can be difficult to get right, and are also important for evaluation of teaching
- There should be a good range of courses to cater for a diverse range of students, with plenty of opportunity to observe good teaching and to practice teaching.

Continuing Professional Development (CPD) for teachers

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

- To improve subject knowledge (and therefore the satisfaction of their learners) and keep up to date with contemporary subject developments.
- It improves the quality of lessons by increasing teacher's confidence and enabling them to become more comfortable with the curriculum they are teaching.
- Developing pedagogical approaches to practical work and updating knowledge of new practical techniques has benefits.
- It may help to improve retention of subject experts by maintaining their enthusiasm for their subject and offering a clear progression route or reward system.

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

- Build in mandatory, ring-fenced time to engage with subject specific CPD ensuring a broad definition of that term. This should cover not just attending CPD courses but engagement with employers, research institutes, other educational establishments and the appropriate Professional Body.

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

- Every year. A ring-fenced allocation of time for every teacher every year which is properly resourced and supported by senior management.

Should CPD be voluntary or mandatory? Why?

- Mandatory but with maximum flexibility to allow the individual teacher to design their own programme to meet their own requirements and interests

Are there key obstacles preventing science and mathematics teachers from accessing subject-specific CPD? If so, how can these be overcome? Links back to subjects- regional training with input from HE departments.

- Teachers find it increasingly difficult to be allowed out given the costs involved, especially cover. Given financial constraints in schools and no ring-fenced funding for CPD, subject specific CPD is often a low priority for college managers.
- CPD often focuses on whole college, generic issues and not subject specific.

Other comments

- As stated by D Wiliam (2010)⁵, “Teacher quality can be improved by replacing teachers with better ones, but this is slow, and of limited impact. This suggests that our future economic prosperity requires improving the quality of the teachers already working in our schools. We can help teachers develop their practice in a number of ways; some of these will benefit students, and some will not. Those with the biggest impact appear to be those that involve changes in practice, which will require new kinds of teacher learning, new models of professional development, and new models of leadership.”

The wider workforce

How and where should we be training laboratory technicians?

- In the appropriate institution which focuses on vocational training. Courses should involve partnership with local employers and where possible with a large on the job component.
- School laboratory technicians are a vital part of the workforce. The Society of Biology is piloting a Register for Science Technicians⁶⁷ (under licence from the Science Council) which aims to provide and recognise basic and continued training and development for those in technical roles.

⁵ Teacher quality: why it matters and how to get more of it, Spectator ‘Schools Revolution’ conference, March 2010

⁶ <http://www.sciencecouncil.org/content/new-registers-science>

⁷ <http://www.societyofbiology.org/newsandevents/news/archive/newtechnitionsregisterscheme>

Who should be responsible for providing advice on careers in or related to science, technology, engineering and mathematics (STEM)?

- Better careers advice is necessary, providing information on a wide-range of science based careers (not merely academia). There are number of groups e.g. STEMNet, Professional Bodies, AGCAS and ICG who do this, but the coverage can be spread unevenly across geographic regions or too focused on specific areas giving students false expectations or inappropriate advice.

Leadership and ethos

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

- There needs to be routes for excellent classroom teachers to be promoted but to remain in the classroom. It is likely that this would have to be through a national scheme and could relate, for example, to Chartered Status (CBiol) as offered by the Society of Biology. One possibility would be to allow promoted teachers time to take on national roles (CPD, curriculum development, research, working on assessments). All of these are currently possible but they do not form part of a leadership structure.

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?

- Ethos evolves over time and relates to the wider context in which an institution operates.
- Leaders at all levels should share the common ethos.
- Part of this ethos should be the freedom to challenge accepted wisdom and be listened to.
- This requires careful handling by managers.
- Everyone should be heard and if possible, consensus in decision making is best but leaders have to lead and are paid to do so.

Skills, Curriculum and Assessment

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

- We are very clear on the importance of practical skills, which are central to biology⁸, and also provide an opportunity to develop knowledge and understanding of key concepts. SCORE's numerous responses and work in this area provides further detail on this topic in relation to 5-19 education⁹.
- We would also like to emphasise the importance of mathematical skills in biology. As stated earlier science and mathematics are intrinsically inter-linked and throughout 5-19 education it is essential

⁸ <http://www.societyofbiology.org/policy/policy-statements/practical-biology>

⁹ <http://www.score-education.org/policy/wider-learning-experience/practical-work-in-science>

that the two strands of science and mathematics work effectively alongside each other achieving coherence in the sequencing of topics.

- More details on this area can be found in the SCORE response to the National Curriculum Review¹⁰ and the Society of Biology response to House of Lords Science and Technology committee enquiry on higher education in STEM subjects¹¹.

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

- Assessment of pupils should be disentangled from school accountability and performance measures. Only then will students' study programmes and learning be driven primarily by their needs.
- Assessment also plays a major role in influencing what is taught and learnt and assessment schemes are important for setting the ethos of a subject. So it is important to retain some form of practical assessment.

Infrastructure

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

- In purpose build and fully resourced facilities, allowing for creative use of teaching methodologies and a degree of freedom and flexibility for teachers.
- In partnerships with the wider science communities, especially local STEM employers who have a vested interest in encouraging good scientists and mathematicians for their future workforce.
- Fieldwork and outdoor learning is particularly important to support the teaching of Biology and therefore appropriate consideration should be given to ensuring learners gain authentic and personal experience of biological thinking and application of knowledge both within the laboratory and the field.¹²
- Clearly, the sciences need laboratories and technicians to enable practical work – which is an essential part of the sciences¹³. These can be costly to run. Therefore, we have grave concerns about the changes to the funding formula for post-16 education and the loss of the 12% weighting given to the teaching of the sciences – through the funding of complete study programmes rather than individual qualifications¹⁴.

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

- Well-maintained, well-equipped, well-designed, dedicated laboratory spaces and access to local functioning ecosystems.
- Equipment, software, training and technical support including the appropriate use of ICT.

¹⁰ <http://www.societyofbiology.org/policy/consultations/view/45>

¹¹ <http://www.societyofbiology.org/policy/consultations/view/58>

¹² SCORE, April 2011, National Curriculum Review, response to call for evidence

¹³ A SCORE response to the Science and Technology Committee, 2011, Laboratory and field work

¹⁴ A SCORE response to the Department for Education consultation document, 2011, 16 -19 Funding Formula Review

- Staffing and equipment appropriate for class size.¹⁵

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)?

- Whilst related to HE, there is evidence that suggests that gender does make a difference in terms of learning with females statistically more likely to adopt a strategic approach to learning and males a deep approach.^{16 17} Research has also shown that fear of failure is higher in female students which may account for the adoption of a strategic approach.^{18 19}

Accountability

How should qualifications in science and mathematics be regulated?

- The professional bodies have a role in setting the criteria for A-levels and accrediting specifications.
- The professional bodies are well placed to act as a guardian for their disciplines by bringing together a single committee for their subject that includes academics from higher education, professionals and teachers
- We think that proposals from Awarding Organisation through which each AO would have its own committee are unworkable and repetitive²⁰.
- Exams should be regulated by Ofqual²¹; but they need to be given greater powers. In particular, Ofqual should be able to look at exam papers before they have been taken²².

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The Society of Biology is pleased for this response to be publically available. For any queries, please contact Society of Biology, Charles Darwin House, 12 Roger Street, London, WC1N 2JU. Email: education@societyofbiology.org

¹⁵ <http://www.societyofbiology.org/policy/policy-statements/practical-biology>

¹⁶ C. Smith and H.Mathias, An Investigation Into medical Students' Approaches to Anatomy learning in a Systems- Based Prosection Course, Journal of Clinical Anatomy, Volume 20, 2007, Page 843-848. 'T'

¹⁷ C.Smith and H.Mathias, Medical students' approaches to learning anatomy: students' experiences and relations to the learning environment, Journal of Clinical Anatomy, Volume 23 Issue 1, 2010 Page 106-114 'T'

¹⁸ P. Ward, First Year Medical Students' Approaches to Study and Their Outcomes in a Gross Anatomy Course, Clinical Anatomy, Volume 24, 2011, Page 120-127

¹⁹ Cortright R et al (2011) Does sex (female versus male) influence the impact of class attendance on examination performance? Adv Physiol Educ 35, 416-420.

²⁰ Society of Biology response to Cambridge Assessment, 2011, Consultation on higher education/awarding body engagement

²¹ SCORE response to OFqual consultation, 2011, From Transition to Transformation – Strategic Regulation of Awarding Organisations and Qualifications

²² SCORE response to the Education Select Committee inquiry 7 November 2011, How Should Examinations for 15-19 Year olds in England be Run?

Member Organisations represented by the Society of Biology

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Agriculture and Horticulture Development Board
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Nutrition Society
The Rosaceae Network
Royal Entomological Society

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Science and Plants for Schools
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Society for the Study of Human Biology
SCI Horticulture Group
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