

Draft National Curriculum for science

A SCORE response to the Department for Education's consultation on the revised draft science curriculum for Key Stages 1–2, proposed draft Key Stage 3 science programme of study and request for comment on the published Key Stage 4 programme of study for science

16 April 2013

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Introduction

1. SCORE is a partnership of organisations, which aims to improve science education in schools and colleges in England by supporting the development and implementation of effective education policy. The partnership is chaired by Professor Julia Buckingham and comprises the Association for Science Education, the Institute of Physics, the Royal Society, the Royal Society of Chemistry and the Society of Biology.

Summary

2. SCORE supports the aims of the National Curriculum Review, but is concerned that the focus on increasing rigour primarily through the addition of content has led to a curriculum that will not achieve these aims. Rigour can be achieved through the in-depth understanding of a smaller amount of content, rather than a superficial understanding of a larger amount.
3. The National Curriculum should take as its starting point the learning outcomes that students should achieve by the end of each Key Stage, with content included if it facilitates these outcomes.
4. The way in which the Review has been carried out, with insufficient time for the drafters to properly consult stakeholders on the content and, in some cases, stakeholders only being able to comment once content had already been defined, has resulted in a curriculum that lacks the coherence within and across subjects that SCORE would like to see. It is particularly difficult to see the progression of ideas that is crucial to an understanding of the sciences.
5. SCORE is pleased to see the prominence of Working Scientifically throughout the curriculum, though further work is needed to ensure these sections are as valuable as they could be.
6. SCORE has concerns about the implementation of the new curriculum, particularly alongside the other reforms to GCSEs and A-levels being introduced at the same time.

Structure and aims

7. The National Curriculum Review was launched: to increase rigour, raise standards and improve coherence in the school curriculum; to ensure children acquire a core of essential knowledge in key subject disciplines; and to allow teachers greater freedom to use their professionalism and expertise. SCORE has always supported these aims.
8. During the process, it has become apparent that the first aim (increased rigour and raised standards) was seen as the more important and it was to be achieved by building the curriculum around statements of content, incorporating more of them and moving some content previously introduced at higher Key Stages down to lower Key Stages. Throughout the development, SCORE has expressed concerns about this approach. Increased rigour does not necessarily follow from increased content (see

para 18) and raising educational standards cannot be equated with increasing the level of the content (para 19).

9. It is not clear how the proposed curriculum provides more freedom for teachers to use their professionalism in science. There remain inconsistencies (in language and approach) across the curriculum and topics are not coherently developed between the science disciplines or with other subjects. These issues are more obvious in the secondary curriculum, which seems to be at an earlier stage of development.
10. The majority of the statements of content are correct and appear at the appropriate place in the curriculum. In primary, in particular, most of the content will look familiar to teachers (with some exceptions, which are noted below).
11. Additionally, we support the view of the Expert Panel that the National Curriculum in the sciences should develop a deep understanding of some big ideas in biology, chemistry and physics and we support recent statements that students should develop mastery of a core of knowledge and the ability to reason scientifically.
12. Although subject-based ideas are developed in the topic structure, there is less evidence of the development of thematic big ideas through the key stages; and this is a missed opportunity.
13. The draft of the curriculum published in February 2013 represents a useful working document and basis for discussion but requires further review. The secondary curriculum in particular needs further revision work to improve consistency, coherence and coverage.
14. The notes and guidance column in Key Stages 1 and 2 is useful, and should be extended to Key Stage 3, to help ensure consistency between the primary and secondary curricula, and to support teachers, particularly those who are non-specialists. Notes and guidance need a consistent and recognisable structure to improve usability, and as non-statutory content should not contain advice on how to teach. However, the statutory content also needs to be self-explanatory without the notes and guidance.
15. It would be useful to include a glossary of technical terms appropriate to each Key Stage to ensure consistency; the book on 'The Language of Measurement' produced by the Association for Science Education would be a good starting point.

Content

16. It is not clear that there is any rationale behind the inclusion or omission of content. There are examples of content that appear for their own sake rather than being part of a development of ideas – big or otherwise.
17. SCORE continues to argue that there should be clear principles for choosing the content that is included in the National Curriculum. For example:
 - Content should only be included if it is rich, earns its place and encourages a deep understanding of core ideas from the sciences. This is in line with the views of the Expert Panel.
 - The intended learning outcomes – what it is that students should know and be able to do by the end of the period of study – should be made clear and content should only be included if it builds towards those learning outcomes.

- Content should not be introduced for its own sake: it should be demonstrably important at the point that it is introduced. If it could be covered later – when it is more likely to be understood and it can be taught more efficiently – then that is better than covering it earlier in a superficial way.
18. We acknowledge that if content should only be introduced when it is appropriate for the developmental stage of the students, the outcome may be a curriculum that is not evenly balanced between the three sciences at every Key Stage. However, this is preferable to attempting to achieve an impression of balance at the expense of the inclusion of content at the educationally appropriate point, and content that is included can give students the opportunity to develop attitudes, practices and knowledge that will be useful across all science subjects.
 19. Particular attention should be given to ensuring that important transitions (particularly from EYFS to Key Stage 1 and from Key Stage 2 to Key Stage 3) are carefully managed with respect to the consistency and order in which content is introduced and developed across the sciences for effective progression.
 20. There is a large degree of variation in the way the content for the three science subjects has been presented, presumably as a result of them having different authors, which compounds the impression of a lack of consistency between the three sciences.
 21. However, these remain drafts. As such they need to be tested against the views of the teaching profession; and they need to be audited for the amount of content and how their content contributes to the development of ideas through the Key Stages.
 22. The curriculum contains a lot of content statements. As far as SCORE is aware, no audit has taken place to determine the teaching time needed to cover all the required content across all subjects (for example, how long are teachers expected to spend on composition of the Earth and atmosphere and circular motion). This would be a valuable activity, since it would help to ensure both the appropriate volume of content, and make it easier to demonstrate balance between the subjects in the higher key stages. However, the intention of such an activity would not be to prescribe how subjects should be taught, and should be carried out with an awareness of the fact that the National Curriculum is not intended to specify the complete school curriculum.
 23. Such an analysis is likely to show that the curriculum has become overloaded. If that is the case, then there are a number of implications:
 - it puts pressure on teaching time: teachers will have to cover more material in the same time, thereby reducing the opportunities for their students to develop a deep and lasting understanding; knowledge will be held superficially and temporarily
 - teachers will be tempted to present students with a set of accepted and arcane facts that have to be learnt without seeing their interconnections or appreciating their origins or implications;
 - time pressures will mean less time for effective practical work to support students' deep and lasting understanding.
 24. We are concerned that some content has been brought down from higher Key Stages. This is intended, presumably, to contribute to a raising of standards. However, it is not

the content but the quality of teaching and the nature of the assessment that will ensure standards are raised and maintained. It is risky and probably counter-productive to introduce content at too high a level too soon. It will

- widen the gap between what is taught and what is learnt; content will be 'delivered' and treated trivially;
- students will be drilled to deal with more complicated ideas without understanding their meaning or how to use them;
- mean that many of the large proportion of non-specialist teachers will struggle to teach more challenging content.

For example, Year 5 students are asked to "understand how some materials will dissolve in liquid to form a solution", but will not by that stage have been introduced to the idea of particles, which will prevent a proper understanding of the topic.

25. SCORE has a significant concern that instead of discovering the intellectual beauty of the sciences as ways of understanding the world, students will be given an inauthentic experience of them as being collections of unconnected facts. This is likely to have a negative impact on the uptake of the sciences post-16 and will inevitably make it unlikely for the Government 'to create a culture where people feel science, engineering and technology are relevant to them'.¹
26. Like the Expert Panel, we would prefer to see a curriculum that encourages a deep understanding of a core of big ideas – both thematic and subject-based - rather than one that leads to a trivial grasp of a multitude of, occasionally advanced, ideas. Rigour could then come through the teaching and assessment of these big ideas.
27. There should be an additional audit of the way that ideas are developed through the Key Stages and across the disciplines. It is important that the sequencing of material in all subjects should be designed with coherence and progression in mind, so that students encounter related topics in the most appropriate order, in a consistent manner and in a way that builds on ideas from across the subjects. For instance, although catalysts are introduced within the biology Key Stage 3 curriculum, they are not covered within the chemistry curriculum until Key Stage 4.
28. Links between the sciences and with other subjects is of particular concern. There are many areas of science which are not exclusive to one discipline (such as the atomic theory of matter) and it is important that these are taught in a coordinated way. Understanding of many phenomena draws on a broad range of disciplines, and teachers need to be aware of this in their lessons. The notes and guidance could incorporate such cross-disciplinary advice.
29. It is therefore also important that the content of the science curriculum is structured with proper consideration being given to areas of overlapping content, in particular with respect to the mathematics, computing, design and technology, history and geography programmes of study. The sequencing of material in all subjects should be

¹ See <https://www.gov.uk/government/policies/engaging-the-public-in-science-and-engineering--3/supporting-pages/raising-public-awareness-of-science-engineering-and-technology>, accessed 9 April 2013.

designed with this coherence in mind, so that students encounter related topics in the most appropriate order.

30. The introduction of a new curriculum should be an opportunity to ensure that content, particularly for the science subjects, is kept up to date (through regular review) and reflects not only the current wide-ranging contexts and often interdisciplinary nature of scientific endeavour, but also the needs of pupils in the twenty-first century. This should be addressed in a variety of ways:
 - The biographies included in the notes and guidance should reflect a wider variety and span of scientific achievement than is currently the case.
 - The notes and guidance should include more contemporary contexts to reflect the impact that science has on everyday lives.
 - Both the notes and guidance and the curriculum itself should acknowledge current challenges that will be addressed using science; this could include (but not exclusively) health, climate change and energy supply.
31. The curriculum contains only a limited amount of Earth science. The statements that do appear seem random and haphazard - they do not form a coherent body of knowledge, and do not represent core Earth science, as would be recognised by most Earth scientists. Aspects of the Earth science curriculum appear to have been cherry picked without proper consideration for whether they fit with the topic area they have been introduced with. For example, rocks are introduced in Key Stage 2 science, but in Key Stage 3 geography, and metamorphic rocks are not explicitly mentioned, even though they are some of the most common rocks that students might be familiar with, for example slate and marble. SCORE has previously mapped the Earth science curriculum across overlapping subjects, and is happy to provide this mapping to the Department for Education.
32. There is also no consideration of Space as a topic in Key Stage 3, nor personal hygiene and adolescence; these omissions should be rectified. For humans puberty must be included in Year 5. This is a crucial developmental phase in the human life cycle. If it is not included at that point then there will continue to be schools in which this topic is not properly taught and students who are not prepared at an age-appropriate time for the changes happening to their own bodies. Year 6 is too late.
33. It would be preferable if the content of the curriculum were presented over a whole Key Stage or in phases rather than year by year. This would make it more adaptable for schools that work with mixed age classes.
34. Each science requires a paragraph at the beginning of its programme of study that sets out the nature of that subject, what it is that we want students to appreciate about that subject, and why that subject is of value to them and to society. This will provide teachers with an overview that will help direct their teaching when addressing the detailed content knowledge.

Working scientifically

35. SCORE is pleased to see the working scientifically sections of the programme of study in a prominent place, with different types of enquiry made explicit.
36. Through working scientifically, students should reach an understanding of what distinguishes scientific endeavour from other forms of knowledge. This should include

an understanding of what makes scientific evidence robust, whilst also subject to challenge and change as new technologies and ideas emerge, as well as the ethical considerations needed when undertaking scientific research. In addition, students should gain the technical and investigative skills needed in order to engage in scientific enquiries.

37. The 'using and applying mathematics' section needs to be given greater prominence within each Key Stage, contextualised in terms of each science discipline and appropriately sequenced with, for instance, the content of the mathematics and computing curricula, for instance with respect to the use of semi-real or real data, and the introduction of algebraic curves, which should occur in Key Stage 4.
38. The 'nature, processes and methods of science' section for Key Stages 1 and 2 is not very clear; we are particularly unclear what is meant by 'statistical cycle'. This is not a phrase that will be known to science teachers.
39. The language used in the working scientifically section needs to be accurate and consistent. Words such as 'reliability' are used incorrectly, and could usefully be included in the glossary of terms (see para 10), as could terms such as 'risk' and 'hazard'.
40. Further guidance and exemplification of context is needed within 'Working scientifically', for example what is meant by 'taught to evaluate risks'? (Key Stage 3). Clarification should be provided to determine if there is risk during practical experiments (stools under tables etc.) or risk more widely, which might be more appropriate for Key Stage 4.
41. The section headed Measurement is misnamed as it contains no statements about making measurements. This is a lost opportunity to specify the range and accuracy of measurements expected of pupils at this Key Stage (Key Stage 3).
42. The lack of specificity and exemplification in the Measurement section makes it very difficult for teachers to plan progression across Key Stages, and will lead to a lack of consistency between schools and between science disciplines.
43. The section headed 'Scientific attitudes' is misnamed. It does not describe accurately the content included within it (Key Stage 3).

Progression

44. More explicit consideration is required with respect to:
 - a. progression from EYFS to Key Stage 1 (the expectations of the former are actually greater than those of the latter);
 - b. progression within specific topics (eg in Year 1, students are expected to be taught to 'identify and describe the basic structure of a variety of common flowering plants' but not to describe their functions until Year 3; it would be better to introduce aspects of function earlier and develop these later);
 - c. progression across the Key Stages (in particular, the transition from Key Stage 2 to Key Stage 3 being affected by the overly detailed and prescriptive nature of Key Stage 2 and the lack of clarity regarding the detail in which material in Key Stage 3 should be covered).

45. SCORE agrees that it is essential that the curriculum is designed to allow students to progress through the Key Stages, building on knowledge and understanding. However, it is difficult to determine how progression will work, particularly for the Key Stage 4 curriculum, given the ongoing uncertainties surrounding A-level design. This reflects the different processes being used to decide content at different stages of the education system.

Notes and guidance

46. In our response to the draft primary curriculum published in August 2012, SCORE advised the inclusion of 'boundary statements' to make clear when learning would be addressed later in the programme of study. Although these have been partially added, we would like to see them included more consistently throughout the document.
47. In the primary curriculum, each section has a useful introduction that sets out the way that children will approach their learning of science. Broadly, in key stage 1, they will experience phenomena, in lower key stage 2 they will start to look for and recognise patterns and in upper key stage 2 they will start to seek and give explanations. However, we feel that this progression could be made even clearer by stating these principles in the introduction to the science section. Additionally, the guidance notes could be used to highlight the opportunities for progression through the key stages.

Learning outcomes and assessment

48. SCORE would like to see clear learning outcomes that outline what students should know, understand and be able to do by the end of each Key Stage. These should be framed to define the learning required, but sufficiently flexible to allow teachers the space to teach.
49. In this response, we have acknowledged the aims of achieving more rigour and raising standards. Throughout, we have challenged the assumption that these aims are best addressed by increasing the amount and raising the level of content. Throughout the process, we have maintained that the way to improve rigour and maintain standards is to improve the quality of assessments and the assessment system. It is possible to pose deep and challenging questions about the most basic principles, for example Newton's laws. It is also possible to set trivial and superficial questions about, for example, circular motion. As has been stated, SCORE would prefer to see the amount and level of the content statements being reduced and the quality of assessments being improved to ensure that students are challenged by the depth of their understanding rather than the surface area of their knowledge.
50. If designed appropriately, assessment can work as a lever to ensure that students have an authentic experience of the sciences in school; SCORE is encouraged that the sample testing regime for Key Stage 2 may include measures to assess practical work in the classroom, and it is hoped that this will encourage schools to undertake more, and more effective, practical work.

Implementation

51. The introduction of additional content will have a significant impact on teachers, particularly teachers who are not subject specialists. For example, the energy section of the physics curriculum will present a challenge, as will the inclusion of evolution in

the primary curriculum. It is important that sufficient support mechanisms are put in place to ensure that teachers are ready to teach the curriculum in September 2014.

52. SCORE would like to see central coordination of the support and advice for teachers; we are aware that the National College for Teaching and Leadership is doing some work in coordinating changes to ITE, but we would advise that their remit is widened to include providing advice and support to the profession more widely.
53. SCORE's research on the resourcing of practical work² suggests that there are large numbers of schools that will struggle if specific items of equipment are required in the curriculum. As we have said in previous consultation responses, if specific equipment is referred to in the programmes of study, provision needs to be made to ensure schools are able to access this equipment. For example, 65% of primary schools report shortage of data loggers (which appear in the lower Key Stage 2 statutory content), around 25% of primary schools reported shortages of working buzzers and motors (which are required for the year 6 programme of study), and around 35% of primary schools reported shortages of magnets.
54. The proposed phased introduction of the new curriculum is immensely complicated, and will put enormous pressure on schools, particularly given the proposed changes to GCSEs and A-levels taking place at the same time. For example,
 - There will be students who go through the new Key Stage 4 in 2014 and 2015 but take GCSE exams based on the previous criteria.
 - There will be cohorts of students who could start new GCSE courses in 2015 and 2016 who have followed (at least in part) the old Key Stage 3. Their grounding will be different from those who start GCSE courses in 2017 (who will have had three full years of the new Key Stage 3).
 - New A-levels will be introduced in 2015. These specifications will have to accommodate (over their lifetime) four different types of student: those who have been through existing GCSEs and the existing National Curriculum; those who have been through existing GCSEs and the new National Curriculum; and those who come through the revised GCSEs, as well as those in schools which do not follow the National Curriculum. The fact that new A-levels are being developed in parallel with new GCSEs will also add to the burdens for schools.

Process for moving forward

55. SCORE continues to have grave concerns about the process by which the curriculum has been drafted, and these concerns have been expressed a number of times.
56. We would like to see audits of the curricular statements to:
 - Identify the amount of time available for each area of content
 - Ensure that ideas are introduced with all the necessary scaffolding, and that ideas are not introduced if they do not lead anywhere

² This research will be published on SCORE's website on 2 May 2013 at www.score-education.org

- Demonstrate how thematic ideas are developed through the content statements.
- To revisit and develop the aim of achieving a deep understanding of a core of essential knowledge, built on the 'big ideas' in each of the sciences
- Ensure there are clear learning outcomes for each statement, that can be assessed effectively

57. We are concerned that this statutory consultation will be the first and only chance for any changes to be made to the draft documents for Key Stage 3 (and 4). It is likely that there will be many comments and some of them will conflict with each other. Therefore, the next drafts cannot be the final ones. Any changes might introduce new problems. Time needs to be set aside for enough iterations to allow for thoughtful and meaningful comment by appropriate experts to be refined, collated and checked.

58. Further work is needed on the making the language consistent across the drafts published in February. It is vital that this is carried out by someone with subject knowledge, to avoid further errors being introduced.

59. SCORE would be pleased to comment on further drafts of the National Curriculum before distribution to schools.

60. We note that the Key Stage 4 programme of study is provided for information. It is not clear when, or indeed whether, this will be the subject of a consultation but SCORE would welcome the opportunity to comment.