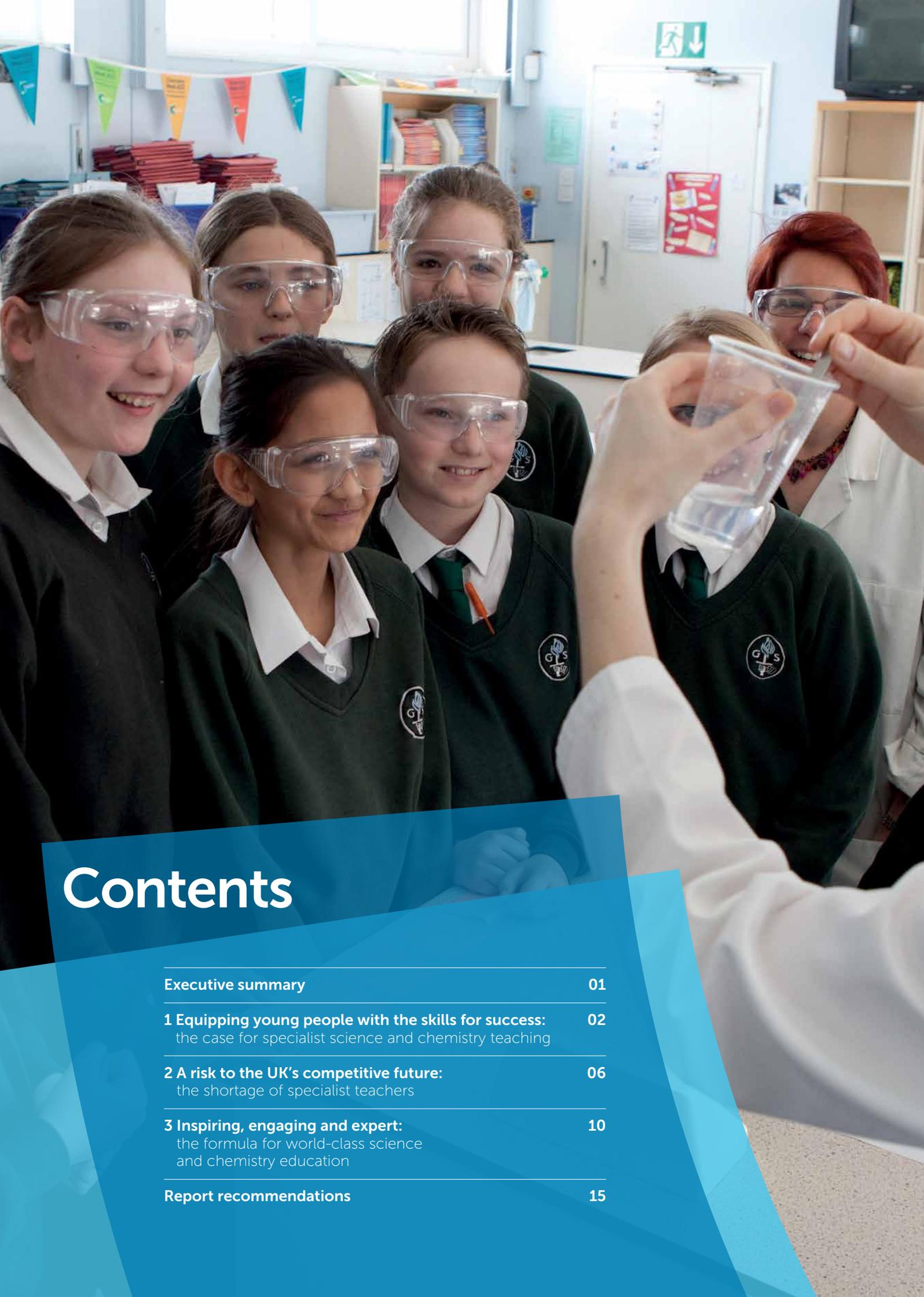


# Inspiring, engaging and expert: the formula for world-class science and chemistry education





# Contents

<b>Executive summary</b>	<b>01</b>
<b>1 Equipping young people with the skills for success:</b> the case for specialist science and chemistry teaching	<b>02</b>
<b>2 A risk to the UK's competitive future:</b> the shortage of specialist teachers	<b>06</b>
<b>3 Inspiring, engaging and expert:</b> the formula for world-class science and chemistry education	<b>10</b>
<b>Report recommendations</b>	<b>15</b>

# Executive summary

Science underpins growth sectors across the country and is a central driver of and contributor to the British economy. Yet too many young people are missing out on job opportunities in these sectors because of a lack of science and chemistry skills. Chemistry-using businesses are currently left searching for employees: by 2020, the shortfalls in apprentices and graduates are estimated to be 12,000 and 19,000 respectively.

At the same time other countries—such as Singapore, Hong Kong, Germany, and Poland—are out-ranking the UK in international league tables. If the UK's science and chemistry education provision cannot keep pace with competitors, new investment in chemistry-using industries may go elsewhere, removing jobs on a permanent basis.

To prevent this risk, the UK must ensure young people receive a science and chemistry education which is engaging, inspiring and expert. We need to sow the seeds of curiosity in and appreciation of science in primary schools and beyond through the subject-specialist teaching of science and chemistry.

It is widely agreed, including by the Department for Education, the National Audit Office, and the Wellcome Trust, that subject-specialist teaching greatly enhances science education. Evidence shows that subject specialists have a deeper understanding, possess increased confidence, and improve pupils' attainment and attitudes towards their subject. Some of the most successful science education systems—such as in Shanghai, Hong Kong, and Poland—prioritise subject-specialist teaching.

There is a shortage of subject experts in schools in England. A third of secondary-school chemistry teachers do not have a chemistry degree. A Wellcome Trust survey of a sample of primary schools found that worryingly 17% of science subject-leaders have no science qualifications higher than GCSE level.

Subject-specific continuing professional development (CPD) is just as important for teachers to be effective specialists, yet many schools do not fund or prioritise CPD, leaving teachers unsupported.

**This report calls on the Government to give students in England a world-class science and chemistry education by ensuring that by 2020:**

- Every post-14 chemistry student, including those studying the subject as part of a combined science qualification, is taught by a chemistry-specialist teacher;
- In every primary school, the science subject-leader is a specialist.

The report contains specific recommendations for the Government to implement, working with a variety of stakeholders, to:

- Ensure chemistry teachers and primary science leaders have the right subject expertise;
- Ensure chemistry teachers and primary science leaders have access to continuing professional development;
- Learn from best practice overseas, and build a better understanding of the situation in England.

Cutting edge science remains a central component of a growing and resilient economy. Our children deserve the best science and chemistry education we can provide to secure their economic futures and to furnish them with the skills, knowledge and vision to meet global challenges head-on.

If we want to send our children into the world equipped to meet those challenges then we should not send our teachers unprepared into the classroom.

# 1. Equipping young people with the skills for success: the case for specialist science and chemistry teaching

## Matching chemistry skills to job opportunities

Numerous industries in the UK rely on chemistry as an essential component of their business, from those directly producing chemicals to “chemical-using” industries such as aerospace, automotive, energy, textiles and health.

These chemistry-using sectors contribute significantly to the economy and employment rate. For example, government figures show that the chemical and pharmaceutical sectors alone made up 1.9 per cent of gross value added to the UK economy in 2011 (reaching £27bn). The flourishing industrial biotechnology industry is predicted to contribute £4-12bn by 2025.<sup>1</sup>

These industries are consistently searching for skilled, qualified employees. But there is a skills gap. Cogent, the Sector Skills Council, has estimated that chemistry-using industries in the UK will need 33,000 apprentices and 37,000 graduates by 2020, yet projected supply is only 21,000 and 18,000 respectively.<sup>2</sup> Employers also report that 21 per cent of employees are not fully proficient at their jobs.<sup>3</sup>

In addition to providing a wide variety of employment opportunities, jobs in chemistry are personally and professionally fulfilling because they contribute to solving some of the most important and intractable challenges facing the UK and the world. Global problems such as climate change, food supply and anti-microbial resistance all rely on chemistry for solutions, while having highly-skilled chemists is fundamental in tackling pressing issues in the UK such as meeting the nation’s long-term energy needs.

## Young people are missing out

With large numbers of young people currently unemployed or in low-pay employment, it is crucial to ensure the workforce of today and tomorrow is equipped with the right skills and knowledge to take advantage of the growing job opportunities in industries which rely on chemistry.

If current skills shortages are not addressed, there will also be an impact on the UK’s competitiveness and ability to create more jobs in the future.

The country’s chemists are internationally renowned, and are frequently cited as a major reason why companies choose to locate in the UK, or retain a UK-based research presence.<sup>4</sup> An international analysis from the Department for Business, Innovation and Skills identified that despite the UK’s good global reputation for science, the country shows “weaknesses in the talent base, especially in terms of basic skills [and] science, technology, engineering and maths (STEM) skills”.<sup>5</sup> The same report also highlights that the UK’s comparator countries “are making significant efforts to train, attract and retain STEM talent”.<sup>6</sup> There is a significant risk that if the UK cannot maintain and improve its skills base, new investment will go elsewhere.

The path to careers in chemistry – and to securing the scientific and industrial competitiveness of the UK – starts at school. We need to ensure that school students not only receive an excellent chemistry education but that Britain’s children are inspired by expert educators at the outset of their learning journey through a thorough grounding in general science at primary level.

<sup>1</sup> *Sustainable Returns: Industrial biotechnology done well* (Forum for the Future, 2013) <http://www.forumforthefuture.org/sites/default/files/images/Forum/Projects/Industrial-Biotech/Final%20report%20IB%20PDF.pdf>

<sup>2</sup> *Britain’s chemical and chemistry-using industries: Strategy for delivering chemistry-fuelled growth of the UK economy* (Chemistry Growth Strategy Group, 2013)

<sup>3</sup> *Cogent Sector Skills Council – Labour Market and Econometric Data* (Cogent, 2010) [http://www.cogent-ssc.com/research/Publications/factsheets/Cogent\\_FactSheet.pdf](http://www.cogent-ssc.com/research/Publications/factsheets/Cogent_FactSheet.pdf)

<sup>4</sup> *The economic benefits of chemistry research to the UK* (Oxford Economics, 2010)

<sup>5</sup> *Insights from international benchmarking of the UK science and innovation system* (BIS Analysis

Paper Number 03, January 2014) <http://www.gov.uk/government/publications/science-and-innovation-system-international-benchmarking>

<sup>6</sup> *Insights from international benchmarking of the UK science and innovation system* (BIS Analysis Paper Number 03, January 2014) <http://www.gov.uk/government/publications/science-and-innovation-system-international-benchmarking>

"I was taught A-level chemistry by chemistry specialists, and they really sold to me the idea of studying chemistry at a higher level. As they had first-hand experience of doing chemistry degrees, they were able to explain what a course would be like, and due to their specialist knowledge they were able to teach the subject confidently and enthusiastically. I felt as if my teachers could really widen my understanding of the subject due to their specialist knowledge".

Chemistry undergraduate

However, the UK's overall rating for science education in the recent OECD PISA assessment, including the specific rating for England, lags far behind those of many international competitors including Singapore, Germany, Poland, Vietnam and the Chinese regions of Shanghai and Hong Kong.<sup>7</sup> This is also the case at primary school level, with a lower percentage of students in England achieving the "Advanced" and "High" benchmark at age 9-10 compared with pupils in Singapore, Korea and Japan.<sup>8</sup>

### Unlocking opportunities and potential requires specialist teachers

Teaching secondary school chemistry and primary school science which is inspiring, engaging and relevant requires specialist subject knowledge and skills. From our extensive work with teachers, we understand that specialists in their subject can have a far greater positive impact due to their deeper understanding of the subject matter, the resultant increased confidence, and the ability to improve attainment levels and attitudes to science.<sup>9</sup>

A number of the more successful jurisdictions under the PISA rankings prioritise specialist science teaching. This is the case in Shanghai where all secondary and primary school teachers have a degree in the subject they teach, in Poland where pupils are taught science by specialists from the age of 10, and in Hong Kong where over 90 per cent of single subject chemistry teachers are subject-trained through a degree route.<sup>10</sup>

### Box 1

**The Royal Society of Chemistry is the largest non-governmental funder of chemistry education in the UK. Our members are active at every level of the education system.**

#### In 2013:

- Our Education Co-ordinators met 4,987 teachers throughout the UK
- 614 teachers attended our CPD courses
- Our Talk Chemistry online community reached over 2,000 teacher members
- Every secondary school in the country received our magazine "Education in Chemistry"
- Thousands of teachers found high-quality teaching and learning resources from our Learn Chemistry website.

<sup>7</sup> PISA results 2012 (OECD, 2013) <http://www.oecd.org/pisa/keyfindings/PISA-2012-results-snapshot-Volume-I-ENG.pdf> Specific results for England: <http://www.oecd.org/unitedkingdom/PISA-2012-results-UK.pdf>

<sup>8</sup> *Trends in International Mathematics and Science Study (TIMSS, 2011)* [http://www.nfer.ac.uk/publications/TMEZ01/TMEZ01\\_home.cfm](http://www.nfer.ac.uk/publications/TMEZ01/TMEZ01_home.cfm)

<sup>9</sup> *Science and Mathematics Education, 5-14. A 'state of the nation' report* (Royal Society, 2010) <http://royalsociety.org/education/policy/state-of-nation/5-14/>

<sup>10</sup> For Shanghai see *Report on research into maths and science teaching in the Shanghai region. Research by National Leaders of Education and Subject Specialists in Shanghai and Ningbo, China 11-18 January 2013* (National College for School

Leadership, 2013), for Poland see *TEDS-M 2008 Encyclopaedia: A Guide to Teacher Education Context, Structure, and Quality Assurance in the Seventeen TEDS-M 2008 Countries (IEA, 2013)* and for Hong Kong see *Statistics on Primary and Secondary School Teachers 2012/13* (Hong Kong Education Bureau, School Education Statistics Section, July 2013).

"I have recruited and worked in departments with specialist and non-specialist chemistry teachers. Specialists are able to provide a better quality of education due to their breadth of knowledge. They're much more flexible in the classroom and are often more likely to come up with creative ways to teach the subject beyond the text book. In my school, those taught by a chemistry specialist at GCSE have been much more likely to continue the subject at A-level – I believe this is because the quality of teaching has been better and the teachers are more likely to make the subject exciting".

Head of Chemistry at an English state secondary school

The importance of subject specialism is recognised by the Department for Education (DfE), which stated in 2010 that "research [in the UK] strongly suggests that subject knowledge as well as overall attainment [of teachers] is a key determinant of success, especially in the sciences and mathematics".<sup>11</sup> The DfE also stressed that specialist science secondary teachers were "essential to high quality teaching of these subjects".<sup>12</sup> The National Audit Office (NAO) confirms that teaching is of better quality where secondary chemistry and primary science teachers hold qualifications in the subjects they teach<sup>13</sup>, while the current Chief Scientific Advisor stated in his former role as CEO of the Wellcome Trust that "specialist teachers and their subjects need to come to the fore in the delivery of STEM education".<sup>14</sup>

Specialists are frequently more able to explain complex concepts effectively, answer detailed questions from pupils and teach beyond the text book. This is confirmed by the Science and Learning Expert Group, which reported on science and mathematics education to the UK Department for Business, Innovation and Skills (BIS) in early 2010:

*"Specialist knowledge and experience enables teachers to explore and illuminate their subject, bringing it alive for students through personal experience and knowledge of current research and debate. Deep and inspiring subject knowledge also allows teachers to respond knowledgably to students' interests and provide stretch and challenge for the most able students".<sup>15</sup>*

The Wellcome Trust highlights that a lack of teacher subject knowledge can be a major obstacle to good-quality science provision in schools and can lead "teachers to display a closed pedagogy where the presentation of unrelated facts take precedence over conceptual understanding".<sup>16</sup>

Our experience indicates that chemistry specialist teachers often have a significant impact on the decisions of students to study the subject at A-level or university. The same effect is seen in physics, where statistics show that fewer students go on to study the subject at A-level if taught by a non-specialist teacher, as highlighted by the Parliamentary Office of Science and Technology in 2013.<sup>17</sup>

<sup>11</sup> *The Case for Change* (DfE, 2010) <https://www.education.gov.uk/publications/standard/publicationDetail/Page1/DFE-00564-2010>. Original references for this point are Smithers and Robinson, 2005; Goldhaber and Brewer, 1997 and 2000; and Wilson et al, 2001. Note that these points relate to physics rather than chemistry.

<sup>12</sup> *Training our next generation of outstanding teachers: Implementation Plan*. (DfE, 2011) [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/181154/DFE-00083-2011.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181154/DFE-00083-2011.pdf)

<sup>13</sup> *Educating the next generation of scientists* (National Audit Office, November 2010) <https://www.nao.org.uk/report/educating-the-next-generation-of-scientists/>

<sup>14</sup> *Training our next generation of outstanding teachers: Implementation Plan*. (DfE, 2011) [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/181154/DFE-00083-2011.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/181154/DFE-00083-2011.pdf)

<sup>15</sup> *Science and Mathematics Secondary Education for the 21st Century. Science & Learning Expert Group Report* (BIS, 2010) <http://scienceandsociety.bis.gov.uk/learning/2010/02/25/new-science-and-learning-expert-group-report/>

<sup>16</sup> *Perspectives on Education: Primary Science* (Wellcome Trust, September 2008) [http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh\\_peda/documents/web\\_document/wtd042076.pdf](http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtd042076.pdf)

<sup>17</sup> *STEM education for 14-19 year olds. POSTNOTE Number 430* (Parliamentary Office of Science & Technology, March 2013) <http://www.parliament.uk/business/publications/research/briefing-papers/POST-PN-430/stem-education-for-14-19-year-olds>



## 2. A risk to the UK's competitive future: the shortage of specialist teachers

Despite the known benefits subject specialist teaching brings, there remains a shortage of specialist chemistry teachers and specialist primary science subject leaders in England.

A significant number of teachers are expected to teach chemistry at secondary level, or lead science teaching in primary schools, without the initial subject-specific training they need. To be effective, all specialists also need subject-specific continuing professional development, but many teachers do not have access to this support.

This report, our first on specialist teaching, focuses on England. There are likely to be similar issues in Wales and Northern Ireland, and in Scotland at the primary school level. We will explore these issues in greater detail in future work.

### Box 2

#### Royal Society of Chemistry definitions of specialists<sup>18</sup>

##### Secondary school chemistry specialist

In order to be a chemistry specialist, a teacher should:

- i have a chemistry degree or closely-related relevant degree<sup>19</sup>, OR have demonstrated sufficient expertise in the subject through previous industry employment, OR have completed a 24-week Subject Knowledge Enhancement (SKE) course;
- ii AND have obtained Qualified Teacher Status;

In addition, we believe that teachers should also engage in sustained chemistry-specific continuing professional development.<sup>20</sup>

There are some existing chemistry teachers who have been teaching the subject for some time but do not meet any of the criteria in (i). These experienced teachers may have acquired a significant amount of the knowledge required to be a specialist, so they may not need to undergo a full 24-week SKE course. In such cases, the teacher should complete training to address any specific gaps in their subject knowledge.

##### Primary school specialist science subject leader

In order to be a specialist science subject leader a primary school teacher should:

- i have at least an A-level qualification (or equivalent) in a science, OR undertake extensive training to address any gaps in their subject knowledge;
- ii AND have obtained Qualified Teacher Status.

In addition, we believe that science subject leaders should also engage in sustained science-specific continuing professional development.

A science subject leader's role should be to lead and support science teaching throughout the school by sharing their skills and knowledge. They should not be expected to teach all science within the school.



### There is a shortage of subject experts

Data from the 2013 annual school workforce census shows that only two thirds of secondary chemistry teachers in England have a degree or higher in chemistry.<sup>21</sup> This picture is not the same across all the sciences – as identified by SCORE<sup>22</sup> - while there is a shortage of degree-qualified biology, chemistry and physics teachers across the English teaching workforce, chemistry and physics are particularly under-represented.<sup>23</sup>

As illustrated in Box 2 (page 8), a chemistry degree is by no means the only route through which teachers can become chemistry specialists, provided they have developed the necessary expert knowledge. However, we find that not enough teachers undertake Subject Knowledge Enhancement (SKE) courses.

Notably, in Scottish secondary schools there are no shortages of the kind experienced in England. Generally speaking, all those teaching National Qualification level 4/5 (equivalent to GCSE) are expected to have studied the subject they teach for at least two years, either as a full degree in the subject, or as part of a related degree. While this is not a legal requirement, this prioritisation has resulted in the overwhelming majority of chemistry teachers beginning their teaching career as subject experts.

At the primary level, the Wellcome Trust surveyed a sample of schools and found that in only 6 per cent did the science subject leader have a science degree.<sup>24</sup> A science degree is highly desirable for a primary science subject leader. However, our definitions (Box 2) reflect our belief that an A-level in a science subject (or equivalent training) can be sufficient. In 20 per cent of schools surveyed by the Wellcome Trust, the subject leader did hold an A-level, but we are extremely concerned that in 17 per cent of schools the subject leader's highest science qualification was only at the GCSE level.

<sup>18</sup> These are simplified working Royal Society of Chemistry definitions for the purposes of this report. More detailed definitions were published by SCORE (of which we are a member) in 2011 <http://www.score-education.co.uk/media/7987/spec-teach.pdf>. Over the coming months we will be working closely with our SCORE colleagues to further develop the definitions of subject specialist teachers and recognition of professional development.

<sup>19</sup> As identified by subject grouping in the Joint Academic Coding System (JACS)

<sup>20</sup> For our definition of continuing professional development, please see Box 3 of this report

<sup>21</sup> School Workforce Census 2013: <https://www.gov.uk/government/publications/school-workforce-in-england-november-2013>. Data covers maintained schools, free schools and academies

<sup>22</sup> SCORE (Science Community Representing Education) is a partnership of organisations, which aims to improve science education in UK schools and colleges by supporting the development and implementation of effective education policy. The

partnership comprises the Association for Science Education, Institute of Physics, Royal Society, Royal Society of Chemistry and Society of Biology. Further details are available here: <http://www.score-education.co.uk/home>

<sup>23</sup> Subject Specialist Teaching in the Sciences: Definitions, Targets and Data (SCORE, July 2011) <http://www.score-education.org/media/7987/spec-teach.pdf>

<sup>24</sup> *The deployment of science and maths leaders in primary schools. A study for the Wellcome Trust (Isos Partnership, October 2013)*

### Failure to support continuing professional development is failing students and teachers

Holding expert subject knowledge through a degree or other routes is essential in becoming an effective subject specialist, but continuing professional development is also important for new and existing teachers.

#### Box 3

### Royal Society of Chemistry definition of Continuing Professional Development (CPD)

Individuals should be responsible for maintaining, improving and broadening their knowledge and skills to ensure continuing competence as a professional throughout their career.

Professional development activities include:

- Attending training courses to develop subject-specific skills and knowledge
- Keeping an up-to-date knowledge of developments in education and related legislation through reading magazines, journals and other media
- Attending conferences and events
- Engaging in networks
- Reflecting on the outputs of professional development activities and taking responsibility for further development

Teachers may apply to become a Chartered Science Teacher (CSciTeach) and/or Chartered Chemist (CChem) which recognises high levels of competence and good practice along with a commitment to continuing professional development<sup>25</sup>.

There is substantial evidence to show that continuing professional development (CPD) has a positive impact on specialist teaching – for both

teachers and students<sup>26</sup>. Ofsted's 2013 report on science teaching in English schools specifically makes the connection between schools which had gained an outstanding inspection grade and those whose teachers had access to science-specific CPD.<sup>27</sup> A review of UK science by HM Treasury in 2002 found that CPD is "vital in improving science teachers' understanding of, and ability to teach, all areas of science".<sup>28</sup> More recently, the National Science Learning Centre has argued that it is crucial that teachers of STEM subjects are "expected and encouraged to engage with subject specific professional development throughout their career in order to remain up-to-date and retain enthusiasm and thirst for their subject."<sup>29</sup>

Given the large numbers of primary science subject leaders without a science degree, CPD is especially important in ensuring these teachers have the support they need to teach and co-ordinate science lessons effectively. A review of Scottish teaching highlighted that weaknesses in the performance of children in primary education can partly arise from low levels of confidence among primary teachers about their own knowledge of some aspects of what they are teaching.<sup>30</sup>

As an additional benefit, research also suggests that increased CPD could contribute to higher retention rates of teachers<sup>31</sup>, meaning that it could play a role in keeping more chemistry specialists and primary science subject leaders in the profession.

We have found that far too few specialists are undertaking CPD, in part because schools are not making it a priority to provide this support. In this respect, the situation appears little changed from 2002, when HM Treasury stated that only "around 15 per cent of science teachers at secondary school take up subject-related CPD a year".<sup>32</sup> The National Science Learning Centre has stressed that many schools and colleges do not prioritise teachers' participation in subject-specific CPD<sup>33</sup>, while evidence from the Wellcome Trust suggests that spending on literacy and numeracy CPD may be prioritised over science CPD in primary school staff development budgets.<sup>34</sup>

## Impact of Continuing Professional Development (CPD) provided by the Royal Society of Chemistry in partnership with Science Learning Centres

A 2008 evaluation of the Royal Society of Chemistry's "Chemistry for Non-Specialists" CPD programme showed that there were early indications the scheme had improved teachers' chemistry knowledge and understanding, their motivation and attitudes towards chemistry, and the amount of practical chemistry that they were teaching. Teachers also reported a positive impact on pupils, improving their understanding of chemical concepts and motivation to study chemistry.<sup>35</sup> A further evaluation of chemistry and physics CPD showed that these impacts could be significant even for short bursts of training. There was substantial evidence of increased teacher knowledge with participants moving from a situation where they held little or no understanding of specific concepts (which they were actually teaching in school) to a position where they were able to demonstrate full understanding directly after the course as well as a significant period of time later.<sup>36</sup> This was confirmed in a report by the National Audit Office, which noted that there was statistical evidence that "participation by teachers in [the programme] is associated with improved teaching and learning, and higher take-up and achievement in science at their schools."<sup>37</sup>

<sup>25</sup> For more information see <http://www.rsc.org/Membership/Qualifications/CharteredStatus/>

<sup>26</sup> See, for example, points 7 and 8 in the University of Cambridge's evidence to the *Education Select Committee inquiry into 'Great Teachers'* in April 2012: <http://www.publications.parliament.uk/pa/cm201012/cmselect/cmeduc/1515/1515we09.htm>

<sup>27</sup> *Maintaining Curiosity in Science* (Ofsted, 2013) <http://www.ofsted.gov.uk/resources/maintaining-curiosity-survey-science-education-schools>

<sup>28</sup> *SET for success. The supply of people with science, technology, engineering and mathematics skills. (The report of Sir Gareth Roberts' Review, 2002).* [http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/d/robertsreview\\_introch1.pdf](http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/d/robertsreview_introch1.pdf)

<sup>29</sup> *The future of STEM education: A National Science Learning Centre White Paper (National Science Learning Centre 2013)* [https://www.sciencelearningcentres.org.uk/media/filer\\_public/7f/d3/7fd32ef0-a746-452b-a681-](https://www.sciencelearningcentres.org.uk/media/filer_public/7f/d3/7fd32ef0-a746-452b-a681-8e5d15f5a1da/the_future_of_stem_education_-_web.pdf)

[8e5d15f5a1da/the\\_future\\_of\\_stem\\_education\\_-\\_web.pdf](https://www.sciencelearningcentres.org.uk/media/filer_public/7f/d3/7fd32ef0-a746-452b-a681-8e5d15f5a1da/the_future_of_stem_education_-_web.pdf)

<sup>30</sup> *Teaching. Scotland's Future: Report of the Donaldson Review* (Scottish Government, 2011): <http://www.scotland.gov.uk/Resource/Doc/337626/0110852.pdf>

<sup>31</sup> *The Impact of Science Learning Centre continuing professional development on teachers' retention and careers* (Sheffield Hallam University, 2013) [https://www.sciencelearningcentres.org.uk/media/filer\\_public/7a/e1/7ae12f3e-030b-4e5f-b27a-41b04cddeb46/shu\\_retention\\_full\\_report.pdf](https://www.sciencelearningcentres.org.uk/media/filer_public/7a/e1/7ae12f3e-030b-4e5f-b27a-41b04cddeb46/shu_retention_full_report.pdf)

<sup>32</sup> *SET for success: The supply of people with science, technology, engineering and mathematics skills. (The report of Sir Gareth Roberts' Review, 2002).* [http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/d/robertsreview\\_introch1.pdf](http://webarchive.nationalarchives.gov.uk/+http://www.hm-treasury.gov.uk/d/robertsreview_introch1.pdf)

<sup>33</sup> *The future of STEM education: A National Science Learning Centre White Paper (National Science Learning Centre 2013)* <https://www.sciencelearningcentres.org.uk/media/>

[filer\\_public/7f/d3/7fd32ef0-a746-452b-a681-8e5d15f5a1da/the\\_future\\_of\\_stem\\_education\\_-\\_web.pdf](https://www.sciencelearningcentres.org.uk/media/filer_public/7f/d3/7fd32ef0-a746-452b-a681-8e5d15f5a1da/the_future_of_stem_education_-_web.pdf)

<sup>34</sup> *The deployment of science and maths leaders in primary schools. A study for the Wellcome Trust (Isos Partnership, October 2013)*

<sup>35</sup> *Evaluation of the Chemistry for Non-Specialists Training Programme: Final Report.* Jones M., Harland J., Mitchell H., Springate I. and Straw S. (NFER, 2008). ([http://www.rsc.org/images/Evaluation\\_tcm18-189144.pdf](http://www.rsc.org/images/Evaluation_tcm18-189144.pdf))

<sup>36</sup> *Impact of focussed CPD on teachers' subject and pedagogical knowledge and students' learning.* Scott P., Ametller J., Edwards A. (University of Leeds, June 2010). [https://www.sciencelearningcentres.org.uk/media/filer\\_public/dc/ab/dcab2366-6829-47dd-a40c-235fc1fda76d/leedsimpactfocussedcpd2010.pdf](https://www.sciencelearningcentres.org.uk/media/filer_public/dc/ab/dcab2366-6829-47dd-a40c-235fc1fda76d/leedsimpactfocussedcpd2010.pdf)

<sup>37</sup> *Educating the next generation of scientists.* (National Audit Office, November 2010) <https://www.nao.org.uk/report/educating-the-next-generation-of-scientists/>

# 3. Inspiring, engaging and expert: the formula for world-class science and chemistry education

Given the evidence that higher levels of specialism can so significantly impact the teacher and student experience of chemistry and primary science education, the shortage of specialists must be addressed. If students in England are to successfully secure careers in science and chemistry-related employment, we must compete more effectively with the highest-achieving countries.

**To give students in England a world-class science and chemistry education, the Government must ensure that by 2020:**

- Every post-14 chemistry student, including those studying the subject as part of a combined science qualification, is taught by a chemistry-specialist teacher;
- In every primary school, the science subject-leader is a specialist.

To achieve this, the Government should work with a variety of stakeholders to:

- Ensure chemistry teachers and primary science leaders have the right subject expertise
- Ensure chemistry teachers and primary science leaders have access to continuing professional development
- Learn from best practice overseas, and build a better understanding of the situation in England

## Ensure chemistry teachers and primary science leaders have the right subject expertise

In England and Wales, financial incentives exist to attract science and chemistry graduates into teaching. Indeed, the current government drive to attract good graduates to secondary chemistry teaching in England and Wales has resulted in its targets for chemistry Initial Teacher Education courses being exceeded last year.

However, these targets are far lower than would be required to contribute significantly to addressing the current shortage of chemistry experts, and the need for such experts is expected to grow over the years ahead.

Ministers and the National College for Teaching and Leadership (NCTL) should set higher targets for recruitment of chemistry graduates into secondary teaching, and plan recruitment numbers and strategies further into the future. As well as increasing targets for chemistry Initial Teacher Education courses in England, incentive programmes such as teacher training scholarships and bursaries should be continued and implemented more widely.

There has been much less focus on recruiting science graduates into primary education. Given the small numbers of science graduates teaching in primary schools, this deserves urgent attention. Policymakers should investigate the full range of options to address this, including rolling out successful secondary-level schemes at the primary level.

<sup>38</sup> As recommended in *Initial Teacher Training in Chemistry: what does its future hold for England? Recommendations for policy action by the Royal Society of Chemistry*. (Behr Outcomes and dataforeducation.info, December 2013).

<sup>39</sup> SCORE response to the National College for Teaching and Leadership consultation: Pre-ITT Subject Knowledge Enhancement - proposal

for 2013/14 and beyond <http://www.score-education.org/media/12571/2013%20-%20ske%20consultation%20final.pdf>

<sup>40</sup> SCORE response to the National College for Teaching and Leadership consultation: Pre-ITT Subject Knowledge Enhancement - proposal for 2013/14 and beyond <http://www.score-education.org/media/12571/2013%20-%20ske%20consultation%20final.pdf>

<sup>41</sup> As outlined in letter by SCORE to Secretary of State for Education, Rt Hon Michael Gove MP, in March 2014 <http://www.score-education.org/media/14426/201403%20jb%20to%20sos%20for%20website.pdf>

"I am a chemistry teacher, but my degree was actually in psychology. After taking a biology PGCE I became a biology teacher, but after a while I wanted to move into teaching chemistry. Instead of making the transition straight away, I decided to take a Subject Knowledge Enhancement course, which provided me with the knowledge I needed to teach the subject effectively. Since becoming a chemistry teacher, I've also undertaken regular continuing professional development in chemistry to ensure I'm the best teacher I can be. Without this extra training, I don't think I'd have been able to teach the subject as effectively as I now can".

Chemistry teacher, London

**Recommendation 1:** *The Government should increase its targets for chemistry Initial Teacher Education courses in England.*

**Recommendation 2:** *The Government, along with its partner organisations, should work with the chemistry community to determine how ongoing and future chemistry teacher supply requirements should be calculated and monitored to ensure sufficient and sustainable Initial Teacher Education provision.<sup>38</sup>*

**Recommendation 3:** *The Government should maintain and increase successful initiatives to encourage more chemistry and science graduates to enter teaching.*

**Recommendation 4:** *The Government should urgently address the severe shortage of science graduates becoming primary teachers. It should consider rolling out some of the more successful secondary science teacher recruitment incentive programmes to primary, and explore new, further ways to increase numbers.*

Without the commitment and willingness of teachers to teach subjects outside of their background expertise, chemistry teaching would be in an extremely difficult situation. It is important that these teachers are given the opportunity to develop the subject expertise they need, by undertaking a Subject Knowledge Enhancement (SKE) course.

As highlighted by SCORE, 24-week SKE courses have had a particularly positive impact on subsequent recruitment of participants to Initial Teacher Education in chemistry, as well as physics.<sup>39</sup> SKE courses are also especially valuable to the sciences as they provide a useful way to up-skill those teachers required to teach two or all three sciences, and also provide a supported route for those making a career change, or for those returning to teaching after a long absence.<sup>40</sup>

However, not enough teachers undertake the relevant SKE training. Recent changes to the allocation methodology for SKE have resulted in a dramatic reduction of SKE places for the 2014/15 training year due to a very short recruitment period.<sup>41</sup> As recommended by SCORE, SKE providers should be allowed to recruit up to 16 months in advance to ensure that all candidates who require SKE have access to it.

Wider coherent data on uptake and provision of SKE courses is not available, so it is difficult to make concrete conclusions relating to its impact. In general, we have found that too few teachers have undertaken the SKE route to chemistry teaching, and we believe that there needs to be greater effort to increase uptake and provision. Collecting data on the number of existing teachers who have undertaken SKE would also be useful.

**Recommendation 5:** *Secondary schools should ensure that all new chemistry teachers not holding a chemistry degree or equivalent professional experience complete a 24-week Subject Knowledge Enhancement course.*

**Recommendation 6:** *The Government should allow Subject Knowledge Enhancement (SKE) course providers to recruit to their courses up to 16 months in advance to ensure all candidates who require SKE have access to it.*



<sup>42</sup> Further details are available here: <http://www.wellcome.ac.uk/Education-resources/Education-and-learning/Our-work/Teacher-training/WTS052326.htm> and here: <http://www.broomfield.n-yorks.sch.uk>

<sup>43</sup> Further details are available here: <http://www.gtcs.org.uk/professional-update/professional-update.aspx>

<sup>44</sup> Report on research into maths and science teaching in the Shanghai region. *Research by*

*National Leaders of Education and Subject Specialists in Shanghai and Ningbo, China 11-18 January 2013 (National College for School Leadership, 2013).* <http://www.nationalnumeracy.org.uk/resources/79/index.html>

### **Ensure chemistry teachers and primary science leaders have access to continuing professional development**

Given the importance of CPD, it is essential to increase levels of uptake. There is clearly also a responsibility for teachers to seek out and undertake CPD, but in many cases they simply do not have the opportunity to do so. The Government, and schools themselves, should show leadership on this issue and increase provision and funding of CPD for science (at primary level) and chemistry (at secondary level).

**Recommendation 7:** *Schools and governing bodies should consider the specialist knowledge of their staff, and ensure that sufficient time and funding is allocated for subject-specific Continuing Professional Development (CPD).*

Some good practice on CPD is already taking place in England, and it is important that the Government and schools learn from this. For example, as part of its ongoing and extensive work around primary education, the Wellcome Trust is currently piloting a Primary Science Specialist CPD course with the National Science Learning Centre, designed specifically for primary science subject leaders who are seeking greater confidence, subject knowledge, teaching expertise and subject leadership skills.<sup>42</sup> The pilot is being evaluated by a team from the University of York who are expected to make a final assessment of the randomised controlled trial later in 2014.

**Recommendation 8:** *The Government, and primary schools, should analyse the results of the Wellcome Trust and the National Science Learning Centre's Primary Science Specialist CPD pilot in order to determine whether funding should be made available for all primary science subject leaders to benefit from the training.*

It is worth noting that the Scottish General Teaching Council is moving to ensure that from August 2014 all Scottish teachers must be enrolled in a "Professional Update" programme. This requires every teacher to demonstrate that they are

actively participating in CPD.<sup>43</sup> If the programme is a success, particularly for science teachers, its extension should be considered across England.

**Recommendation 9:** *The Government should monitor the effect of the "Professional Update" programme in Scotland, particularly on science teaching. If the scheme has a positive impact, it should consider implementing a similar scheme.*

### **Learn from best practice overseas, and build a better understanding of the situation in England**

Although it is clear that levels of subject specialism in England are not sufficient, there are data gaps that should be addressed. Data on subject specialism at primary level is not complete, there is a shortage of data around SKE uptake, and geographical variations in subject specialism are not entirely clear. Better data would allow the Government, schools, and local authorities to identify problems and apply targeted solutions.

**Recommendation 10:** *The Government should collect and assess data on the subject-based qualifications, training and deployment of chemistry and primary science teaching staff. This data should be made available for analysis at local, regional and national levels.*

It is also important to learn from overseas jurisdictions that outperform the UK on science teaching and have large numbers of specialist teachers, such as Shanghai and Poland, to look for ways to replicate good practice. The National College for School Leadership (now the National College for Teaching and Leadership) recommended, for example, learning from Shanghai's focus on subject specialism following a study tour of the region in 2013, stressing that failure to do so could impact on the UK's ability to meet the demands of global competition<sup>44</sup>.

**Recommendation 11:** *The Government should undertake research into the impact of science specialism in other jurisdictions, and identify areas of best practice that could be applied in England.*



# Report recommendations

To give students in England a world-class chemistry education, the Government must ensure that by 2020:

- Every post-14 chemistry student, including those studying the subject as part of a combined science qualification, is taught by a chemistry-specialist teacher;
- In every primary school, the science subject-leader is a specialist.

To achieve this they should:

## **Ensure chemistry teachers and primary science leaders have the right subject expertise**

### **Recommendation 1:**

*The Government should increase its targets for chemistry Initial Teacher Education courses in England.*

### **Recommendation 2:**

*The Government, along with its partner organisations, should work with the chemistry community to determine how ongoing and future chemistry teacher supply requirements should be calculated and monitored to ensure sufficient and sustainable Initial Teacher Education provision.<sup>45</sup>*

### **Recommendation 3:**

*The Government should maintain and increase successful initiatives to encourage more chemistry and science graduates to enter teaching.*

### **Recommendation 4:**

*The Government should urgently address the severe shortage of science graduates becoming primary teachers. It should consider rolling out some of the more successful secondary science teacher recruitment incentive programmes to primary, and explore new, further ways to increase numbers.*

### **Recommendation 5:**

*Secondary schools should ensure that all new chemistry teachers not holding a chemistry degree or equivalent professional experience complete a 24-week Subject Knowledge Enhancement course.*

### **Recommendation 6:**

*The Government should allow Subject Knowledge Enhancement (SKE) course providers to recruit to their courses up to 16 months in advance to ensure all candidates who require SKE have access to it.*

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### Ensure chemistry teachers and primary science leaders have access to continuing professional development

#### **Recommendation 7:**

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#### **Recommendation 9:**

*The Government should monitor the effect of the "Professional Update" programme in Scotland, particularly on science teaching. If the scheme has a positive impact, it should consider implementing a similar scheme.*

### Learn from best practice overseas, and build a better understanding of the situation in England

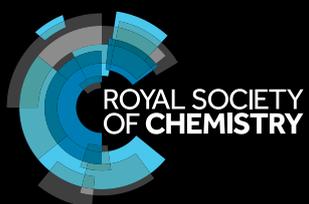
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