

Submission from the Royal Society of Chemistry to the Lords Select Committee concerning education for 11-16 year olds

April 2023

The House of Lords committee on education for 11-16 year olds opened an inquiry into a number of aspects of the current secondary education system in England. The inquiry aimed to consider how well the secondary education system is preparing students for a future digital and green economy. This is a response to their initial call for evidence, focused on some of the topics listed in the call; the relevant topics are listed in bullet form at the start of each section.

Introduction

1. The Royal Society of Chemistry is an international organisation connecting chemical scientists with each other, with other scientists, and with society as a whole. Founded in 1841 and based in London, UK, we have an international membership of around 50,000. We use the surplus from our global publishing and knowledge business to give thousands of chemical scientists the support and resources required to make vital advances in chemical knowledge. We bring people together to spark new ideas and new partnerships and we support teachers to inspire future generations of scientists.
2. We are submitting this evidence as we believe that everyone is entitled to an excellent chemistry education that is engaging, inspiring and relevant. Learners should be equipped with the skills and understanding they need to be scientifically literate citizens and to pursue the study of chemical sciences at higher levels should they so wish. The chemistry education that school-age learners experience is fundamental to achieving this. This response has been informed by our established policy positions, published research and guidance, alongside discussions with the other science learned societies.

A single route through the sciences

- The range and breadth of subjects covered in the 11-16 curriculum
 - The effectiveness of the 11-16 curriculum in equipping young people with the skills they need to progress into post-16 education and employment in a future digital and green economy
 - The impact of the 11-16 system on the motivation and confidence of pupils of all abilities
 - Lessons for improving education for the 11-16 phase from educational policy and practice from overseas, or from the devolved administrations
3. The current GCSE-level science options in England require learners to make a choice about their futures at age 13. This choice is not always their own - some schools decide which qualifications are offered to which learners, creating an 'illusion of choice'. Recent research has highlighted this 'Educational gatekeeping', finding that only 22% of learners from the least advantaged backgrounds studied triple science, compared to 71% of learners from the most advantaged backgrounds.¹ Research has also previously identified methods used to allocate learners to GCSE combined or triple science e.g. a science assessment or exam (46%), the set a learner is in for science (42%), and learner decision (37%).² Therefore although multiple routes exist, not all routes are open to all learners which leads to inequitable access.
 4. Therefore, the Royal Society of Chemistry advocates for a single route through the sciences. We take this position for two main reasons: progression and choice.
 - a. **Progression:** multiple qualification pathways lead to inequitable progression opportunities. Some qualifications may not appropriately prepare learners for chemistry A-

¹ <https://www.ucl.ac.uk/ioe/departments-and-centres/departments/education-practice-and-society/aspires-research>

² *Science timetable models research*, Shift Learning (2019), <https://d25f0oghafsja7.cloudfront.net/sites/default/files/2019-06/shift-learning-science-timetable-models-research.pdf>

level, or other Level 3 qualifications and specific prior knowledge can't be assumed when there are multiple qualification pathways at Level 2. Schools and colleges may need to either adapt their teaching to cover all possibilities or require specific qualifications at Level 2 to study Level 3 qualifications.

- b. **Choice:** as already mentioned, multiple routes at GCSE mean that learners must make decisions that could narrow down future options for work and study at the age of 14. Some schools will decide which qualifications are offered, and to which learners. Perception of qualification 'difficulty' may also limit learner confidence and expectation of what can be achieved, and consequently their options for progression. Additionally, inequitable access also arises because learners studying triple science are more likely to come from socially advantaged backgrounds. A recent survey conducted by Teacher Tapp revealed that 13% of schools in socioeconomically disadvantaged areas did not offer triple science at all, compared with just 1% of schools in the most socioeconomically advantaged areas.³
5. However, we stress the importance of maintaining the separate disciplinary identity of the three sciences within any potential single qualification. Chemistry has a distinct way of understanding the material world; this understanding should be developed in learners through a coherent and deep understanding of chemistry's core fundamental principles. From a strong disciplinary foundation, connections can be made to the other sciences and beyond, enabling learners to appreciate both the interconnectedness of chemistry and the multidisciplinary nature of many issues and advances.
6. A single route should make it easier to ensure coherence between the curricula in the sciences, for example where there are instances of shared substantive and disciplinary knowledge, while providing more opportunities for interdisciplinary links to related subjects such as mathematics and computing. We are not advocating for all learners to follow one of the existing courses, rather it should be a completely new qualification which incorporates the best features of the existing separate and combined science qualifications.
7. Explicitly recognising scientific disciplines at school level is essential for learners to make informed choices about further study and careers – they need to know whether they find the subject interesting, useful and enjoyable. Learners are also more likely to be able to differentiate between the sciences when there is separate timetabling of the disciplines, use of individual exercise books, 3 discipline teachers for each class, and specific job roles i.e. chemistry teacher.⁴ Therefore, with a single science qualification the system would need to ensure that disciplinary identity is reinforced through things such as timetabling, specialist teaching and subject-specific professional development.
8. Any new qualification must be accessible, and support progression to the next stage. Progression can be supported if the content choice is informed by the foundational knowledge and skills of chemistry; due regard should be given to ensuring content is included at a level that is accessible. In the report *The elements of a successful chemistry curriculum*⁵ we have set out our suggestions for 'Big Questions' that define the central areas of interest in studying chemistry. For each Big Question we have identified key ideas that need to be understood to answer each question, these are intended to be explored at different levels of sophistication and can therefore be applied to support the development of a continuous progression of learning (see pg 13-15 of the [report](#) for more detail).

³ *Triple science teaching arrangements in schools*, Teacher Tapp, 6 December 2022 (accessed 12 April 2023), <https://teachertapp.co.uk/articles/triple-science-teaching-arrangements-in-schools/>

⁴ *Science timetable models research*, Shift Learning (2019), page 32, <https://d25f0oghafsj7.cloudfront.net/sites/default/files/2019-06/shift-learning-science-timetable-models-research.pdf>

⁵ *The elements of a successful chemistry curriculum*, Royal Society of Chemistry (2020), <https://www.rsc.org/new-perspectives/talent/chemistry-curriculum-framework/#undefined>

9. Qualifications Wales are currently undertaking reform of their 11-16 curriculum, including adopting the learned societies' position on a single route through the sciences.⁶ A single GCSE qualification for the majority of learners is being developed, called GCSE 'The Sciences'. This could act as an important case study if a single route through the sciences is subsequently adopted in England.

The importance of practical work for the development of relevant skills

- The effectiveness of the 11-16 curriculum in equipping young people with the skills they need to progress into post-16 education and employment in a future digital and green economy
 - The impact of the 11-16 system on the motivation and confidence of pupils of all abilities
10. It is imperative that practical skills remain a core component within the chemistry curriculum. Practical work is important in providing learners with the skills needed to progress in a career in the chemical sciences, including emerging jobs in the green economy (such as biofuel engineering), as well as skills needed to become scientifically literate citizens. Such skills include analysis of hazard and risk, ability to take accurate measurements, and an appreciation of application and innovation in the sciences.⁷ Practical skills are also an important factor in the motivation and confidence of all pupils. Our '*Chemistry for All*' research into reducing inequalities in chemistry aspirations and attitudes revealed through student interviews that practical work helped to foster their personal value of and enjoyment of chemistry.⁸
11. To ensure all learners have the opportunity to develop their practical work skills, opportunities for practical work should be embedded into the chemistry curriculum, and schools should be resourced to provide quality practical chemistry education. A recent survey of science teachers and technicians across the UK and Republic of Ireland revealed that insufficient funding, difficulty accessing equipment and consumables were major barriers to conducting practical lessons. Furthermore, school technicians are a key resource within schools for running successful practical activities. Among the 42% of UK mainstream state schools that were understaffed for science technicians, 57% cited a lack of technician support as a barrier to running practical activities.⁹ *The Science Technician Workforce in Secondary Schools* report details poor pay and conditions for technicians where the majority are employed on a term-time only basis, with an associated lower salary.¹⁰ We therefore recommend that the government should review technician pay and conditions to address the issue of recruitment and retention amongst technicians.

Developing a more relevant curriculum with clear career opportunities

- The range and breadth of subjects covered in the 11-16 curriculum
 - The effectiveness of the 11-16 curriculum in equipping young people with the skills they need to progress into post-16 education and employment in a future digital and green economy
 - The impact of the 11-16 system on the motivation and confidence of pupils of all abilities
12. Our report on '*Chemistry's Contribution: Workforce trends and economic impact*' highlights the important role of the UK's 275,000 chemistry professionals, working in a diverse range of sectors, many of which are related to sustainability.¹¹ In the Royal Society of Chemistry's '*Green Shoots: a*

⁶ *Qualified for the future: GCSE The Sciences (Double Award)*, Qualifications Wales (accessed 19 April 2023), <https://haveyoursay.qualifications.wales/gcse-the-sciences-dbl>

⁷ *The elements of a successful chemistry curriculum*, Royal Society of Chemistry (2020), <https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf>

⁸ *Is chemistry accessible for all?* Royal Society of Chemistry (2020), <https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-is-chemistry-accessible-for-all.pdf>

⁹ *The Science Teaching Survey 2022, Lack of technician support is a barrier to practicals*, Royal Society of Chemistry 2022 (accessed 18 April 2023), <https://www.rsc.org/new-perspectives/talent/the-science-teaching-survey/2022/lack-of-technician-support/>

¹⁰ Worth, J. (2020). *The Science Technician Workforce in English Secondary Schools*. Slough: NFER <https://www.rsc.org/globalassets/22-new-perspectives/talent/nfer-science-technicians-workforce-report-1.pdf>

¹¹ *Chemistry's Contribution: workforce trends and economic impact*, Royal Society of Chemistry (2020), <https://www.rsc.org/contentassets/8122a7694dd14a4f9779ceec4e9dbb0a6/workforce-full-report>

sustainable chemistry curriculum for a sustainable planet report, 68% of practicing chemists in industry and academia reported a gap between the skills and knowledge that chemical scientists currently have and those needed for green jobs now and in the future.¹² This research also found that although 66% of the young people we surveyed would be interested in future careers or study related to sustainability, only 38% felt that studying chemistry can lead to lots of jobs in sustainability and climate change.² Additionally, 70% of 11 to 14 educators and 65% of 14 to 16 educators we spoke to raised concerns that there is ‘too little content in the chemistry curriculum that directly relates to sustainability and climate change’. Therefore, we recommend that any changes to or reform of the chemistry curriculum must emphasise climate change and sustainability; so that young people are equipped with the skills and careers information needed to progress into green jobs in the chemical sciences and contribute to the future green economy.

13. Evidence shows that young people want their science curriculum to be more relevant to jobs within and beyond science. Recent findings from the ASPIRES3 research, in which more than 7000 21–22-year-olds in England took part, 72% of young people said that they would have liked their school science curriculum to have been more relevant – that is, less abstract and more grounded in contemporary life and societal issues, such as personal health and climate change.¹³ *Chemistry for All*, a five-year study conducted by the Royal Society of Chemistry also found that when teachers used chemistry to help students understand the world around them, it positively impacted their interest in and enjoyment of the subject.¹⁴
14. The ASPIRES2 survey showed that students may not understand the careers opportunities chemistry can offer.¹⁵ 31% of chemistry A-level students said they picked chemistry A level because they were interested in the subject, but only 7% of chemistry A-level students reported they intended to pursue chemistry, or directly related courses after school. Our open letter signed by industry leaders called on the government, academy trusts and local authorities to take action to improve careers advice.¹⁶ We recommend that the government continues to work on ensuring that more contemporary societal issues, such as climate change, are embedded within the curriculum to increase motivation and confidence of young people to continue to study Chemistry.
15. The research aim of our [Chemistry for All](#) study was to explore and address the barriers to participation in post-16 UK chemistry education. We found that to increase the number of students who continue with chemistry post-16, and increase the numbers from underrepresented groups, it is essential that:
 - a. The perception that chemistry is a difficult subject only suitable for ‘naturally clever’ students is challenged within schools;
 - b. a diverse range of people (gender, ethnicity, social background, age, etc.) are portrayed as contributing to chemistry and working in it and with it;
 - c. partnerships between schools and organisations that can complement what schools do for students’ learning and engagement with chemistry are facilitated;

¹² *Green Shoots: a sustainable chemistry curriculum for a sustainable planet*, Royal Society of Chemistry (2021), <https://www.rsc.org/globalassets/22-new-perspectives/sustainability/sustainability-curriculum/green-shoots-a-sustainable-chemistry-curriculum-for-a-sustainable-planet.pdf>

¹³ ASPIRES Research (2022), ASPIRES 3 Project Spotlight 2: “*Make it more relevant and practical*”: *Young People’s Vision for School Science in England*. London: IOE, UCL’s Faculty of Education and Society, “[Make it more relevant and practical](#)”: [Young People’s Vision for School Science in England \(ucl.ac.uk\)](#)

¹⁴ *Is chemistry accessible for all?* Royal Society of Chemistry (2020), <https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-cfa-report.pdf>

¹⁵ Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020), *ASPIRES 2: Young people’s science and career aspirations, age 10-19*, https://discovery.ucl.ac.uk/id/eprint/10092041/15/Moote_9538%20UCL%20Aspires%20%20report%20full%20online%20version.pdf

¹⁶ Open letter from industry leaders, Royal Society of Chemistry (2019), <https://www.rsc.org/news-events/articles/2019/sep/open-letter-from-industry-leaders/>

careers advice and information about the range of courses and qualifications available with a post-18 chemistry qualification start in early secondary school; helping more students realise that there are a range of paths that they can take.

Improving the attractiveness of teaching as a profession

- How the 11-16 system could be adapted to improve the attractiveness of the teaching profession, and the recruitment, training and retention of teachers
16. The Department for Education's (DfE) recent research found that more than 70% of teachers thought their workload was unacceptable.¹⁷ 'Workload' is the reason most often cited for why teachers leave.¹⁸ The results of our *Science Teacher Survey 2022* reinforce these findings as stress, exhaustion/burnout as well as high workload and lack of work/life balance were the most common reasons teachers gave for considering leaving the profession.¹⁹ In recent years the Government have made efforts to reduce teacher workload and there has been some improvement in this area. However, working hours remain higher for teachers than for other graduates.²⁰ Working excessively long hours is not sustainable for most teachers. Those who feel overworked and are unhappy with their work life balance, are more likely to consider leaving. DfE needs to do more to enable schools to further reduce teachers' workload to help retain the existing workforce and make teaching a more attractive profession for potential new recruits.
17. One way to reduce the workload, particularly for early career teachers is to encourage schools to implement 'sympathetic timetabling' for beginner teachers in secondary schools. This simple idea reduces workload associated with lesson planning by allowing teachers to teach the same topic to more than one class in the same week or fortnight. This is particularly important for teachers of the sciences who often have the added pressure of having to prepare for lessons outside their main area of disciplinary expertise, especially when teaching combined science GCSE classes.²¹ The Royal Society of Chemistry recommends that schools allow new teachers to focus primarily on teaching their specialist science discipline. These steps could help improve the retention and is supported by evidence from the USA, which found that first year teachers who were given a less challenging course load and taught a single subject were less likely to leave.²²
18. The Department for Education's recent research found that teachers who worked flexibly in some way were more likely to report being satisfied with their job most or all of the time.²³ The DfE should work with schools to explore how different flexible working options can be embedded in schools.

¹⁷ *Working lives of teachers and leaders – wave 1 Research report*, DfE (2023), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1148571/Working_lives_of_teachers_and_leaders_-_wave_1_-_core_report.pdf

¹⁸ *Retaining and developing the teaching workforce*, National Audit Office. (2017), <https://www.nao.org.uk/wp-content/uploads/2017/09/Retaining-and-developing-the-teaching-workforce.pdf>

¹⁹ <https://www.rsc.org/new-perspectives/talent/the-science-teaching-survey/2022/burnout-and-workload/#reasons-for-leaving>

²⁰ McLean, D., Worth, J. and Faulkner-Ellis, H. (2023). *Teacher Labour Market in England: Annual Report 2022*. Slough: NFER https://www.nfer.ac.uk/media/5286/teacher_labour_market_in_england_annual_report_2023.pdf

²¹ *Science timetable models research*, Shift Learning (2019), https://www.rsb.org.uk/images/science_timetable_models_report_ASE.pdf

²² *The Price of Misassignment: The Role of Teaching Assignments in Teach For America Teachers' Exit From Low-Income Schools and the Teaching Profession*, M. Donaldson & S. Johnson, Educational Evaluation and Policy Analysis 32: 299 (2010), <https://journals.sagepub.com/doi/abs/10.3102/0162373710367680>

²³ *Working lives of teachers and leaders – wave 1 Research report*, DfE (2023), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1148571/Working_lives_of_teachers_and_leaders_-_wave_1_-_core_report.pdf

19. Teaching requires a complex set of skills and an individual teacher's effectiveness is dependent on a wide range of factors. However, evidence suggests that the most effective teachers have deep subject and pedagogical content knowledge.²⁴ Teachers' own education and experiences before they start their post-graduate Initial Teacher Training (ITT) can vary considerably and there is not enough time during ITT programmes to address fully specific gaps in individual trainees' subject knowledge and pedagogical content knowledge. This means that secondary school teachers of the sciences enter the profession with differing levels of expertise across the three disciplines,²⁵ yet as mentioned above, many schools require them to teach across the sciences from the very start of their career, often without ensuring that they have had the opportunity to develop the appropriate knowledge. This is not only detrimental to young people's education in the sciences but can also have an impact on teacher recruitment and retention.
20. To realise our goal for every child to have an unbroken chain of experts²⁶ teaching them the sciences throughout their school education:
- High-quality²⁷ subject-specific training and development should be an ongoing entitlement²⁸ for all teachers, whatever stage they are in their teaching career. It should:
 - Meet the needs of a broad range²⁹ of teachers to account for differing prior knowledge, and
 - Include professional development opportunities to help teachers with a background in one science discipline, gradually gain the expertise needed to teach curriculum content in one, or both, of the other school science disciplines.³⁰
 - Schools should be able to demonstrate that their teachers have sufficient expertise for the curriculum and classes they are required to teach. This could be through records of qualifications or other forms of diagnostic assessment, or reflective CPD/professional learning records. We would also welcome the implementation of a "credentials/badging" system³¹ as a transparent way for teachers' subject expertise to be recognised and recorded.
 - DfE should collect and record information about teachers' subject-specific expertise within the sciences. They should use this to inform their workforce planning decisions (e.g. in regard to recruitment and retention incentives or funding for subject-specific teacher support).

²⁴ *What makes great teaching? Review of the underpinning research.* Coe, R., Aloisi, Sutton Trust report (2014) <https://www.suttontrust.com/wp-content/uploads/2014/10/What-Makes-Great-Teaching-REPORT.pdf>

²⁵ For example, a biology-trained teacher (with a biological sciences degree) might have stopped studying physics or chemistry at the age of 16 or a physics trained teacher might have ended their biology and chemistry education as soon as they were allowed to.

²⁶ Here 'expert' is used to describe a teacher with appropriate subject knowledge and pedagogical content knowledge for the curriculum and classes they are required to teach.

²⁷ To help school leaders and teachers assess the quality of subject-specific professional development courses, we are supportive of nationally recognised quality assurance systems.

²⁸ This entitlement for teachers should be a statutory requirement.

²⁹ Including teachers who want/need to develop expertise in a science discipline outside of the one in which they initially trained, or even non-science trained teachers who have been asked to teach science to younger secondary school pupils.

³⁰ This could be achieved through provision of short courses each focusing on a different curriculum area and/or age range.

³¹ In recent years, digital badges have been introduced in areas such as medicine and catering that allow the recording of course content and linkage to traceable standards. We envisage that for education in the sciences the badges might be awarded in 6-8 broad topic areas in each science, and for a specific age range e.g. 5-7, 16-19, etc.