The Royal Society of Chemistry's response to the Curriculum and Assessment Review (England)

November 2024

The Secretary of State for Education commissioned an independent panel review of the existing national curriculum and statutory assessment system in England, to ensure they are fit for purpose and meeting the needs of children and young people. This is our response to the call for evidence, whose purpose was to gather evidence on what is working well in the current system in England, and what could be improved (and how).

Unanswered questions are omitted for clarity.

Section 2 – General views

Q10 What aspects of the current a) curriculum, b) assessment system and c) qualification pathways are working well to support and recognise educational progress for children and young people?

a) A strength of the current curriculum is that the majority of students study all three main sciences disciplines (biology, chemistry and physics) up to the age of 16, usually with equal teaching time for each discipline. This is the case for both the combined (double) science route and the separate sciences ("triple science"). Ensuring that students study all three sciences to this age is important as it keeps options open for all learners.

b) Assessment of practical chemistry at GCSE and A level ensures that at least some practical activities occur in lessons. Teachers have told us that unless something is assessed, it won't be covered. However, we are concerned that barriers to practical work (see our responses to questions 14 and 26) are preventing some young people from experiencing sufficient hands-on practical chemistry activities.

c) A levels and GCSEs are long established qualifications and are generally well regarded and understood by universities and employers. Higher education chemistry departments know what to expect from students who have studied chemistry A level and plan their courses accordingly (it is worth noting, that the same can be said for International Baccalaureate).

Q11 What aspects of the current a) curriculum, b) assessment system and c) qualification pathways should be targeted for improvements to better support and recognise educational progress for children and young people?

Our guiding principles for (chemistry) curriculums are that they should have clear progression, encourage understanding of fundamental principles, and incorporate procedural knowledge and skills (including practical skills). Any final chemistry curriculum offer also needs appropriate alignment with the wider curriculum, should have a level of demand that is aspirational but also inclusive of all, and has a considered amount of prescribed content. We believe the current science/chemistry curriculum does not satisfy a number of these principles and essential features.

Our most recent Science Teaching Survey 2024 data indicates that many teachers feel the current secondary science curriculum is overcrowded, and this is having a detrimental impact on student learning outcomes [1]. Due to the heavy content demands of the curriculum many schools are beginning the KS4 science curriculum in year 9 [2], potentially compressing and limiting their KS3 experience.

Curriculum content is also increasingly viewed as outdated [3] and young people are becoming less engaged with their science education, feeling it lacks relevance to their lives [4]. For example, young people and educators have previously told us that they want to see more climate change and sustainability content in the curriculum, as they feel it is important and relevant to future careers [5], but new undergraduate students have told us that their climate change education in school was “non-existent” [6]. We’re currently exploring how more climate change and sustainability content could be incorporated into the [chemistry] curriculum. This is being informed by the 2023 edition of our Science Teaching Survey where teachers told us possible strategies could include having the content in an interdisciplinary module (32% of respondents) or making the real-life applications [of sustainability and climate change] within each discipline explicit (33% of respondents) [7].

There is evidence that practical activities can foster short term engagement and there is widespread acknowledgement amongst teachers that pupils generally enjoy taking part in practical work [8]. There are also studies where young people convey that practical activities supported their motivation and engagement with science [9, 3]. However, the RSC’s Science Teaching Survey 2023 shows many students are experiencing barriers to a good practical science education, limiting opportunities to practice these key skills [10]. Employers in the chemical sciences have told us that a practical skills deficit exists in those entering the workforce, and so it is crucial that students have more opportunities for practical science education throughout ages 5-19 [11]. For primary science, we recommend that all students should have access to a minimum level of practical experiences [12]. In secondary science and chemistry, students should take part in direct, first-hand, and often hands-on practical experiences and activities to support them in developing their practical skills, their understanding of theoretical concepts and increase their motivation and enjoyment of chemistry [13]. It is important that teachers know why young people are undertaking practical activities and clear aims for these activities should be identified. Whether learning a theoretical concept, a practical skill, or both, it is important that students have enough prior knowledge to help them link the purpose of the learning to the practical chemistry activity [14].

Our 11-19 chemistry curriculum framework progresses coherently through primary and secondary schooling, by examining the evidence on best education practice and drawing on the expertise of a diverse range of representatives from the chemical sciences community [15]. The framework is designed to allow learners to encounter a wide range of modern chemistry, to demonstrate both its impact on everyday life and its potential to address some of the major problems facing society in the 21st century. It represents what we see as the core of an ideal chemistry curriculum, but by no means its totality. While our ideas about good curricula should always be reviewed in the light of evidence and experience, we aimed to present something that is enduring and can be used flexibly in different education systems and types of qualification. We would therefore welcome opportunities to discuss these ideas further with the panel as subject experts, and to engage with any subsequent curriculum development.

The current GCSE-level science options 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 [16].

If schools select which route learners follow, they risk creating a selective two-tier system where learners associate those who are ‘good at science’ doing the triple science route, and those who are ‘not clever’ or ‘bad at science’ completing the double science route [17]. This perception of qualification ‘difficulty’ can limit a learner’s confidence, and consequently limit what they see as their options for progression.

We are recommending that the sciences to GCSE should be taught as a single course based on the three separate sciences, followed by the vast majority of students. We expect it to be the default route for all students unless there is a good reason that they cannot follow a common GCSE pathway. The existing separate science route has several beneficial features, such as separate timetabling of the three sciences, taught by dedicated teachers and specified separately – these should be retained within a more manageable GCSE qualification or suite of qualifications. Our recommendation will allow all students to experience those features. It is these features, rather than the additional content, that provide the benefits and improved outcomes of the existing “triple science” route – including better progression rates to A-levels.

[1] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[2] Education Endowment Foundation (2023), "What works at Key Stage 4 in terms of improving GCSE outcomes, two or three years of study?". https://educationendowmentfoundation.org.uk/projects-and-evaluation/projects/what-works-at-key-stage-4-two-or-three-years-of-study

[3] 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, https://discovery.ucl.ac.uk/id/eprint/10157406/2/9872%20UCL%20Young%20People%20Report%20AW2.pdf

[4] Royal Society (2023), "Science Education Tracker 2023". https://royalsociety.org/news-resources/projects/science-education-tracker/

[5] Royal Society of Chemistry (2022), "Green Shoots: A sustainable chemistry curriculum for a sustainable planet". https://www.rsc.org/globalassets/22-new-perspectives/sustainability/sustainability-curriculum/green-shoots-a-sustainable-chemistry-curriculum-for-a-sustainable-planet.pdf

[6] Unpublished RSC research on undergraduate students' attitudes to climate change and sustainability education.

[7] Royal Society of Chemistry (2023), "Science Teaching Survey 2023 – teachers recommend curriculum changes", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/teachers-recommend-curriculum-changes/

[8] Abrahams (2009) Does practical work really motivate? International Journal of Science Education, 31, 2335-2353.

[9] Wellcome (2020), 'Young people's views on science education, Science Education Tracker 2019 Wave 2', https://wellcome.org/sites/default/files/science-education-tracker-2019.pdf

[10] Royal Society of Chemistry (2023), "Science Teaching Survey 2023 – underfunding is having a negative impact on science teaching and learning", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/negative-impact-of-underfunding/#barriers-to-practical-work-table

[11] Royal Society of Chemistry (2024), "Future Workforce and Educational Pathways". https://www.rsc.org/policy-evidence-campaigns/discovery-research-and-innovation/discovery-research-innovation-reports-surveys-campaigns/future-workforce-and-educational-pathways/

[12] RSC, IOP, ASE and RSB (2024), "Developing a Primary Science Curriculum: Recommendations based on the primary curriculum advisory group's framework", https://www.rsc.org/globalassets/07-news-events/rsc-news/news-articles/2024/08-august/stem-primary-curriculum-recommendations.pdf

[13] Royal Society of Chemistry (2024), "Practical Chemistry Education: A vision for practical chemistry in 5-19 education", https://www.rsc.org/globalassets/22-new-perspectives/education/policy-change-for-11---19-education/a-policy-position-on-the-royal-society-of-chemistrys-vision-for-practical-chemistry-in-5-19-education.pdf

[14] Ofsted (2023), Research and Analysis: Finding the Optimum: The Science Subject report, https://www.gov.uk/government/publications/subject-report-series-science/finding-the-optimum-the-science-subject-report--2#main-findings

[15] Royal Society of Chemistry (2020), "The elements of a successful chemistry curriculum", https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

[16] Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: Young people's science and career aspirations, age 10-19. London: UCL Institute of Education.

[17] Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2016). Stratifying science: a Bourdieusian analysis of student views and experiences of school selective practices in relation to 'Triple Science' at KS4 in England. Research Papers in Education, 32(3), 296–315. https://doi.org/10.1080/02671522.2016.1219382

Section 3 – Social justice and inclusion

Q12 In the current curriculum, assessment system and qualification pathways, are there any barriers to improving attainment, progress, access or participation (class ceilings) for learners experiencing socioeconomic disadvantage?

The fact that there are two main routes through the sciences (Combined (double award), and separate sciences (Biology, Chemistry and Physics)) at GCSE, is a barrier to progress, access and participation for learners experiencing socioeconomic disadvantage.

Although both the combined, and the separate science ("triple science") routes share much of the same content and are designed to allow progress to each of the sciences at A level, the experience of learning in each route can be very different.

Our research [1], based on a survey of 513 schools in 2018, found that students taking GCSE combined science were less likely to be taught by specialists in each of the three sciences disciplines than those taking triple science. 38% of schools reported that fewer than three teachers were allocated to typical combined science classes compared with 13% of for triple science groups. Having fewer than three teachers increases the likelihood that the individual disciplines are not all taught by subject specialists.

The same research found that schools viewed the combined science routes to be less in need of disciplinary expert teachers. For schools which offered both routes, triple science was likely to be prioritised when it came staffing decisions. This involved allocating teachers in line with their main area of science subject expertise, as well as more experienced teachers such as heads of department, to triple science classes. 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 good subject and pedagogical content knowledge.[2] Consequently, this practice of teacher allocation means that triple science students are more likely to experience high quality teaching which could be disadvantaging those on the combined science GCSE route.

Inequalities also exist in young people's access triple science. Many learners' choices about the science courses they take at GCSE, are constrained by educational 'gatekeeping' practices.[3] Schools often decide which qualifications are offered to which learners. Our research has identified examples of factors 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%), learner decision (37%).[4] This creates the 'illusion of choice'; although multiple routes exist, not all routes are open to all learners which leads to inequitable access.

Having two routes to science A levels is sustaining class inequalities. Perception of qualification 'difficulty' may limit learner confidence and expectation of what can be achieved, and consequently their options for progression. For example, students who are not 'selected' for triple science, may assume that they're not clever enough to study the sciences at A level. This is seen born out in the relatively low progression from combined science to A levels and degrees in the sciences. Analysis from FFT Education Datalab found that 81% of those entering A level chemistry had taken the separate science chemistry GCSE [5].

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.[6]

Similarly, the ASPIRES project (a longitudinal research study investigating young people's science and career aspirations) found that only 22% of year 11 learners in their survey from the least advantaged backgrounds studied Triple Science, compared to 71% of learners from the most advantaged backgrounds.[7]

In primary science, the curriculum could be improved to support learners experiencing socioeconomic disadvantage, by providing more opportunities for teachers to choose real life contexts that are familiar and/or engaging to their pupils. This can help them identify with the sciences, build their science capital,[8] and improve their knowledge base. Similarly, explicitly including 'essential experiences' [9] within the curriculum would ensure that all children have opportunities to relate their new learning to personal experiences. We recognise that this is a fundamental equity issue, as concrete experiences form the basis from which children will draw evidence for their ideas and develop their knowledge and conceptual understanding. Not only can this ensure parity of esteem between children in different areas and provisions, but also prepares them for many more abstract concepts that will be presented to them in later stages of their science education.

[1] Science timetable models research, Shift Learning, 2019, *https://www.iop.org/sites/default/files/2019-06/shift-learning-science-timetable-models-research.pdf*

[2] What makes great teaching? Review of the underpinning research. Coe, R., Aloisi, Sutton Trust report, 2014 What makes great teaching? - Sutton Trust

[3] ASPIRES 2: Young people's science and career aspirations, age 10-19, Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J., London: UCL Institute of Education, 2020, *https://discovery.ucl.ac.uk/id/eprint/10092041/15/Moote_9538%20UCL%20Aspires%202%20report%20full%20online%20version.pdf*

[4] Science timetable models research, Shift Learning, 2019, *https://d25f0oghafsja7.cloudfront.net/sites/default/files/2019-06/shift-learning-science-timetable-models-research.pdf*

[5] Are A-level entry requirements higher for some subjects than others? Plaister, N., 2023 *https://ffteducationdatalab.org.uk/2023/05/are-a-level-entry-requirements-higher-for-some-subjects-than-others/*

[6] Triple science teaching arrangements in schools, Teacher Tapp, 6 December 2022. *https://teachertapp.co.uk/articles/triple-science-teaching-arrangements-in-schools/*

[7] ASPIRES 2: Young people's science and career aspirations, age 10-19, Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J., London: UCL Institute of Education, 2020, *https://discovery.ucl.ac.uk/id/eprint/10092041/15/Moote_9538%20UCL%20Aspires%202%20report%20full%20online%20version.pdf*

[8] The primary science capital teaching approach – Teacher handbook. Primary Science Capital Project *https://discovery.ucl.ac.uk/id/eprint/10136335/14/9746%20UCL%20PSCTA%20Teachers%20science%20pack%20Interactive%202022%20AW1.pdf*

[9] Essential experiences are a key part of the 'Primary Science Curriculum Framework' developed by the Primary Curriculum Advisory Group (a group of experts brought together by the Royal Society of Chemistry (RSC), the Royal Society of Biology (RSB), the Institute of Physics (IOP) and the Association for Science Education (ASE). See: *https://www.rsc.org/globalassets/07-news-events/rsc-news/news-articles/2024/08-august/stem-primary-curriculum-recommendations.pdf*

Q13 In the current curriculum, assessment system and qualification pathways, are there any barriers to improving attainment, progress, access or participation which may disproportionately impact pupils based on other protected characteristics (e.g. gender, ethnicity)?

A good chemistry education effectively portrays the practice of science, including the people that carry it out. This practice is based on historic contributions to scientific discovery across different cultures and geographical locations. Chemistry education should also reflect how science is a global endeavour [1]. However, current chemistry curriculums contextualise scientific discovery with examples of scientists that lack diversity, leading to representations that are predominantly white and male. Science is a global endeavour, but the curriculum is currently biased towards individual western contributions to, and achievements in, chemistry.

Many students don't identify with chemistry as we currently present it. Reinforced stereotypes and assumptions of who can be a chemist lead to many learners feeling that chemistry is "not for people like me" [2]. Students should be able to relate to, and identify with, people and contexts within this modern representation of science. If students feel that their identity aligns with a subject, that it is for people like them, they are more likely to pursue that subject further [3]. Often a young person's trajectory in STEM, e.g. whether to follow a chemistry pathway at university, is strongly shaped by the alignment between their identity and that discipline.

[1] Royal Society of Chemistry (2020) 'Inclusion and Diversity strategy to 2025'. https://www.rsc.org/policy-evidence-campaigns/inclusion-diversity/strategy/

[2] Royal Society of Chemistry (2020) 'Is chemistry accessible for all?' https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-is-chemistry-accessible-for-all.pdf

[3] Archer, L., DeWitt, J., Godec, S., Henderson, M., Holmegaard, H., Liu, Q., MacLeod, E., Mendick, H., Moote, J. and Watson E. (2023) ASPIRES3 Main Report. London, UCL

Q14 In the current curriculum, assessment system and qualification pathways, are there any barriers in continuing to improve attainment, progress, access or participation for learners with SEND?

Practical science education is an essential part of the chemistry discipline, and all learners should be able to access regular and relevant practical chemistry activities throughout their chemistry education. However, in our Science Teaching Surveys, 48% of teachers said that insufficient support for students with special educational needs and disabilities was having a detrimental effect on student learning outcomes [1] and that the cost of consumables and chemicals (34%) and a lack of equipment (33%) were barriers to practical science education [2]. It is imperative that the barriers mentioned here are addressed, so that laboratory equipment and practical chemistry tasks can be accessible to all learners including those with SEND [3].

[1] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[2] Royal Society of Chemistry (2023), "Science Teaching Survey 2023", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[3] Royal Society of Chemistry (2024), "Practical Chemistry Education: A vision for practical chemistry in 5-19 education", https://www.rsc.org/globalassets/22-new-perspectives/education/policy-change-for-11---19-education/a-policy-position-on-the-royal-society-of-chemistrys-vision-for-practical-chemistry-in-5-19-education.pdf

Section 5 – Curriculum & qualification content

Q22 Are there particular curriculum or qualifications subjects* where: a) there is too much content; not enough content; or content is missing; b) the content is out-of-date; c) the content is unhelpfully sequenced (for example to support good curriculum design or pedagogy); d) there is a need for greater flexibility (for example to provide the space for teachers to develop and adapt content)? Please provide detail on specific key stages where appropriate.

A & b) In RSC's The Science Teaching Survey 2022, 73% of teachers in England, Wales and Northern Ireland said that the amount of curriculum content was 'too much' across all sciences [1]. In the 2023 edition of our survey, we followed this up by asking what curriculum changes, if any, should be made [2]. The changes that teachers recommend remove concepts that they feel most students do not need to learn. Reducing the amount of content in the science curriculum could alleviate some of the demands on teachers' time and create additional opportunities for practical experiments and to contextualise learning.

For example, in the case of ceramics and composite materials (a GCSE chemistry-only topic), 44% of teachers agreed that it should be removed from the curriculum entirely. Some teachers commented that the topic was not relevant to students studying chemistry post-16. With this data, alongside our curriculum framework [3] the RSC would be able to recommend evidence-based curriculum changes for chemistry that would reduce the content burden and free up time for teachers.

Additionally, in the Science Teaching Survey 2023, 60% of teachers in England told us that insufficient time was a big barrier to running practical work, higher even than other factors such as poor behaviour and lack of equipment [4]. Practical chemistry activities are an essential part of an engaging, inspiring and relevant chemistry education. We believe it is crucial that all learners should have access to relevant and regular practical chemistry activities throughout their chemistry education, which are sustainable, inclusive, accessible and have a clear purpose [5].

From our 'Green Shoots' research [6], we know that four in five educators see climate change and sustainability topics as a priority for the chemistry curriculum. We must equip young people with the knowledge to understand these global issues so that they can participate in efforts to tackle them. In The Science Teaching Survey 2023 [2], we asked teachers what they thought was the best way to incorporate climate change and sustainability into GCSE Science, with teachers in England being evenly split between delivering the content via an interdisciplinary module, or through making the 'real-life applications' within each discipline explicit.

We are in the process of gathering more evidence around sustainability and its place within the chemistry/science curriculum. As part of this we have early evidence from new undergraduate students in England who tell us that their sustainability education in secondary school was 'non-existent' [7].

c) At GCSE the teaching order is often driven by the specification of the qualification being followed. Some schools choose to teach content in a different order that they feel is more appropriate for effective learning.

Overall, we are looking for curriculum design to be more coherent and interconnected, moving away from disjointed topics. We want the curriculum to make the fundamental principles of, and about, chemistry more explicit, and better integrate learning about the applications and impacts of chemistry, including using up-to-date examples. The curriculum should also have a better progression of learning through the educational stages [3].

d) There should be more space in the curriculum to include up-to-date and relevant contexts. The use of contexts to help students understand how chemistry is applied in the real world is vital. It helps students to understand the relevance of the ideas studied, how the discipline is evolving, develop scientific literacy, and appreciate what chemistry brings to our society. We recommend that contexts are chosen for national, regional and local relevance to enrich the curriculum and support maximum engagement. Structuring the curriculum in this way means that over time, different contexts and applications can be chosen to illustrate these core ideas without the need for future full-scale curriculum reform [3].

We also recommend that there is sufficient time within the curriculum to run a variety of practical chemistry activities. This would enable young people to develop a breadth of practical skills and improve their understanding on a wider range of scientific theories [5].

[1] Royal Society of Chemistry (2022), "Science Teaching Survey 2022 – too much content, not enough time", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2022/too-much-content-not-enough-time/

[2] Royal Society of Chemistry (2023), "Science Teaching Survey 2023 – teachers recommend curriculum changes", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/teachers-recommend-curriculum-changes/

[3] Royal Society of Chemistry (2020), "The elements of a successful chemistry curriculum", https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

[4] Royal Society of Chemistry (2023), "Science Teaching Survey 2023 – underfunding is having a negative impact on science teaching and learning", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/negative-impact-of-underfunding/

[5] Royal Society of Chemistry (2024), "Practical Chemistry Education: A vision for practical chemistry in 5-19 education", https://www.rsc.org/globalassets/22-new-perspectives/education/policy-change-for-11---19-education/a-policy-position-on-the-royal-society-of-chemistrys-vision-for-practical-chemistry-in-5-19-education.pdf

[6] Royal Society of Chemistry (2020), "Green shoots: a sustainable chemistry curriculum for a sustainable planet", https://www.rsc.org/globalassets/22-new-perspectives/sustainability/sustainability-curriculum/green-shoots-a-sustainable-chemistry-curriculum-for-a-sustainable-planet.pdf

[7] Unpublished RSC research on undergraduate students' attitudes to climate change and sustainability education.

Q23 Are there particular changes that could be made to ensure the curriculum (including qualification content) is more diverse and representative of society?

Teaching chemistry with stories, contexts and examples enriches learning for students and fosters a connection to a subject that is conceptually rich and can therefore sometimes seem abstract. The use of contexts helps students understand how chemistry is applied in the real world, both locally and globally. It helps students to understand the relevance of the ideas studied and how the discipline is evolving, to develop scientific literacy, and to appreciate what chemistry brings to our society [1]. But students should also see what society brings to chemistry – the diversity of the people that carry it out and who introduce new viewpoints, fresh ideas and different ways of thinking [2]. We believe that representation and inclusivity in chemistry education are critical to the learning experience and will help to ensure that pathways in the chemical sciences are open and attractive to all.

We are calling for more diverse exemplification of scientist contributions in chemistry curriculums, and increased global perspectives in the chemistry curriculum, to show how a diverse society participates in science and delivers innovative solutions that make a difference to lives locally and globally.

In practice this would result in young people, over the course of their studies, being regularly exposed to more diverse global perspectives, through examples of both historic and contemporary contributions from a wider range of nations, as well as situated knowledge and practices of a wider range of communities. Ideally, contemporary science developments would be presented as collaborative efforts involving intersectoral, interdisciplinary and intercultural working within diverse teams [3]. Better cultural contextualisation will help shape students' understanding of how science is done, and help prepare them for a potential future in chemistry that will involve working with people from different backgrounds.

Ideally, more diverse exemplification is embedded into chemistry curriculums and subsequent exam specifications, rather than treated as an 'add on'. Teachers are supported to tackle stereotypes in chemistry education. By reflecting different identities in their chemistry teaching and showing the diversity of chemistry careers and in turn the people who work in them, more students see representations of working scientists they can identify with - people who look like them and have similar backgrounds [4].

By making these curriculum changes to include richer context and representation, more students will feel inspired and see themselves as scientists [5], encouraging wider participation in the sciences [6]. Students will see the benefits of working as diverse teams and develop a richer view of what chemistry can do, along with better considering the impact of issues on different parts of the world. Students will also appreciate science as a collaborative process where people can both benefit from scientific breakthroughs and contribute to them. They can be inspired by global scientific collaboration that is tackling global challenges and where all contributions are valued [7], and aspire to be part of it.

[1] Royal Society of Chemistry (2020), 'The elements of a successful chemistry curriculum', https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

[2] Berkeley, University of California (2024) The scientific community: diversity makes the difference. Available at: https://undsci.berkeley.edu/understanding-science-101/the-social-side-of-science-a-human-and-community-endeavor/the-scientific-community-diversity-makes-the-difference/

[3] Alison J. Trew, Craig Early, Rebecca Ellis, Julia Nash, Katharine Pemberton, Paul Tyler, Caroline Skerry, Lucy Bird, Naomi K.R. Shallcross, Timothy G. Harrison & Dudley E. Shallcross (2023) Can current science research in the biological sciences be used in primary school children's scientific enquiry? Journal of Biological Education, 57:3, 455-468, DOI: 10.1080/00219266.2021.1924229

[4] Barnardo's Education Community, 'Representation matters in promoting positive mental health'. https://www.educators-barnardos.org.uk/resources/m-a-representation-matters

[5] Chemistry World (2023), 'Big Manny's viral science content is making chemistry relatable and accessible'. Royal Society of Chemistry. Available at: https://www.chemistryworld.com/careers/big-mannys-viral-science-content-is-making-chemistry-relatable-and-accessible/4018322.article

[6] Archer, L., DeWitt, J., Godec, S., Henderson, M., Holmegaard, H., Liu, Q., MacLeod, E., Mendick, H., Moote, J. and Watson E. (2023) ASPIRES3 Main Report. London, UCL

[7] OECD, 'International collaboration in science'. Available at: https://www.oecd.org/en/topics/sub-issues/international-collaboration-in-science.html

Q24 To what extent does the current curriculum (including qualification content) support students to positively engage with, be knowledgeable about, and respect, others? Are there elements that could be improved?

There are elements within the current science curriculum that could be developed so that students are supported to engage with, be knowledgeable about and respect others.

Within the primary phase, it is important that any new curriculum introduced includes an emphasis on global citizenship. In our 'Developing A Primary Science Curriculum' document [1], we highlight the importance of ensuring children develop the knowledge, skills and values needed to be global citizens [2] through helping them engage with societal, environmental and social issues within science.

Within the secondary phase, we believe that it is important for young people to understand the potential impacts of chemistry. As mentioned in our 11-19 curriculum framework 'Elements of a Successful Chemistry Curriculum' [3], a new curriculum should focus on how decisions about uses of chemistry are subject to social, economic, environmental and political influences and should also include the importance of drawing on evidence and having an awareness of the potential implications of chemistry at individual, local, national and global level.

The chemical sciences will play a pivotal role in solving the challenges associated with sustainability and developing a more circular economy. However, currently, there is an insufficient focus on sustainability and climate change challenges that are impacting our planet within the curriculum. In our Green Shoots survey [4], 79% of young people said that climate change and sustainability is a priority for the chemistry curriculum. Additionally, two thirds of 11-19 educators and nine in ten primary educators told us that there is too little content in the chemistry or science curriculum that directly links to climate change and sustainability. Therefore, within a new curriculum, it is imperative that sustainability is a strand that runs throughout both primary and secondary chemistry curriculums, offering young people the opportunity to focus on solving the challenges facing us globally so that they can positively engage with issues impacting others.

[1] RSC, IOP, ASE and RSB (2024), "Developing a Primary Science Curriculum: Recommendations based on the primary curriculum advisory group's framework", https://www.rsc.org/globalassets/07-news-events/rsc-news/news-articles/2024/08-august/stem-primary-curriculum-recommendations.pdf

[2] The PCAG Primary Science Curriculum Framework (an extract of which is included in our Developing a Primary Science Curriculum: Recommendations based on the primary curriculum advisory group's framework' document) defines global citizenship as individuals and communities who take responsibility for their actions, and work towards making the world a more equitable and sustainable place.

[3] Royal Society of Chemistry (2020), "Elements of a Successful Chemistry Curriculum", https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

[4] Royal Society of Chemistry (2021), "Green shoots: a sustainable chemistry curriculum for a sustainable planet", https://www.rsc.org/globalassets/22-new-perspectives/sustainability/sustainability-curriculum/green-shoots-a-sustainable-chemistry-curriculum-for-a-sustainable-planet.pdf

Q25 In which ways does the current primary curriculum support pupils to have the skills and knowledge they need for life and further study, and what could we change to better support this?

With the introduction of a new curriculum, we could further support primary pupils to gain the skills and knowledge they need for further life and study.

As mentioned in our recommendations document, 'Developing a Primary Science Curriculum: Recommendations based on the primary curriculum advisory group's framework' [1], we believe that a new science curriculum should support young people to understand their role as global citizens and develop their knowledge and skills to help them engage with global issues, as mentioned in Q24.

It is also crucial to focus on pupils' acquisition of knowledge and skills through using real-life contexts, so they can identify with the sciences and, therefore, be supported to make informed decisions impacting them personally.

Finally, we believe that a new primary curriculum could help pupils understand how modern science is conducted in the real world by teaching young people about the diverse nature of scientific research and highlighting the importance of global scientific collaborations in science [2].

[1] RSC, IOP, ASE and RSB (2024), "Developing a Primary Science Curriculum: Recommendations based on the primary curriculum advisory group's framework", https://www.rsc.org/globalassets/07-news-events/rsc-news/news-articles/2024/08-august/stem-primary-curriculum-recommendations.pdf

[2] Unpublished RSC, 'Global Perspectives and Diverse Representation in Chemistry Education'

Q26 In which ways do the current secondary curriculum and qualification pathways support pupils to have the skills and knowledge they need for future study, life and work, and what could we change to better support this?

Our evidence suggests that there is need to update the curriculum to prepare young people for a future world of work. Our Future Workforce and Educational Pathways project [1] predicts that the chemistry workforce will grow at a faster rate than the wider economy over the next decade. This research, which examined job adverts, identified an increasing requirement for green skills and knowledge as well as transferable skills (such as communication skills) and digital skills, in the chemistry using workforce.

Young people and educators have told us that climate change and sustainability are a priority for science education. [2] We recommend that the curriculum is updated to emphasise climate change and sustainability and prepare our future workforce for green jobs in a green economy. When asked about how these topics should be incorporated in the curriculum, the most popular options selected by teacher in England were, ‘make the real-life applications within each discipline explicit’ (33%) and by ‘introducing an interdisciplinary module (biology, chemistry and physics), focussing on solving the problems of the future’.[3]

71% of teachers in England who responded to our most recent Science Teaching Survey [4] told us that an overloaded curriculum in the sciences had a detrimental effect on student learning. Our 2023 version of the survey asked teachers if some specific chemistry topics in the current combined science and chemistry GCSEs, should be removed for the curriculum, kept without change or revised. This identified several topics which should be revised, including the Earth’s water resources and obtaining potable water, and life cycle assessment and recycling, as well as a couple of topics which should be removed.

Practical chemistry is an essential part of the chemistry discipline because it supports the understanding of the subject as an empirical science and is core to understanding the question ‘How do we do chemistry?’.[5] The skills developed through practical work can be used by young people in their future studies and careers in the sciences and beyond. Practical chemistry can also introduce students to the real-life application of the sciences and develop an understanding of hazards and risks. We believe it is crucial that all learners should have access to relevant and regular practical chemistry activities throughout their chemistry education, which are sustainable, inclusive, accessible and have a clear purpose. However, we are concerned that there are barriers to practical chemistry in England due to the lack of science technicians; lack of funding; insufficient time within the science curriculum to teach practical chemistry and inadequate subject specific professional development available for science teachers.

In 2023, 60% of teachers from mainstream secondary schools in England who responded to our survey said that insufficient time for practical to be taught alongside theory was a barrier to them running practical work in their school. [6]

[1] Royal Society of Chemistry (2023), “Future Workforce and Educational Pathways project”. https://www.rsc.org/policy-evidence-campaigns/discovery-research-and-innovation/discovery-research-innovation-reports-surveys-campaigns/future-workforce-and-educational-pathways/

[2] Royal Society of Chemistry (2020), “Green shoots: a sustainable chemistry curriculum for a sustainable planet”, https://www.rsc.org/globalassets/22-new-perspectives/sustainability/sustainability-curriculum/green-shoots-a-sustainable-chemistry-curriculum-for-a-sustainable-planet.pdf

[3] Royal Society of Chemistry (2023), “Science Teaching Survey 2023”. https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/teachers-recommend-curriculum-changes/#sustainability-curriculum-content-table

[4] Royal Society of Chemistry (2024), “Science Teaching Survey 2024”. https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[5] Our curriculum framework The elements of a successful chemistry curriculum: The Royal Society of Chemistry’s vision for 11–19 chemistry education, explains how this question fits into the wider chemistry discipline. https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

[6] Royal Society of Chemistry (2023), “Science Teaching Survey 2023”. https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/negative-impact-of-underfunding/#barriers-to-practical-work-table

Q27 In which ways do the current qualification pathways and content at 16-19 support pupils to have the skills and knowledge they need for future study, life and work, and what could we change to better support this?

Skills analysis done as part of our work looking at the requirements of a future chemistry workforce, [1] identified the need for transferrable skills, such as communication and interpersonal skills, on top of technical skills to enable people to work effectively in STEM jobs.

Such skills are already developed to an extent in chemistry and science pathways at 16 -19, particularly through hands-on practical chemistry activities. But, to better prepare students for future study, life and work, further opportunities to improve young people's transferable skills should be incorporated. Additionally, science and chemistry curriculums, need to cover real-world concerns and interests that will bring students into STEM and help them see a place for themselves in scientific careers.

[1] Royal Society of Chemistry (2023), "Future Workforce and Educational Pathways", https://www.rsc.org/policy-evidence-campaigns/discovery-research-and-innovation/discovery-research-innovation-reports-surveys-campaigns/future-workforce-and-educational-pathways/

Section 6 – Broad and balanced

Q29 To what extent do the current secondary curriculum and, qualifications pathways support pupils to study a broad and balanced curriculum? Should anything change to better support this?

In the existing two-tier system for science qualifications, "triple science" ought to be taught on about 30% of curriculum time, e.g. through the use of a subject option block. This is at the expense of being able to study other, non-science, subjects that provide important breadth in the curriculum. If a student wishes to study a broader curriculum their only choice (if they have one [1]) is to opt for the combined science route. This has some inherent disadvantages, such as that the three disciplines may not be distinguished and it is often the case that the topics will be shared between two teachers. Therefore, much of the teaching comes from an out-of-field teacher (especially in physics).

We are recommending that the sciences to GCSE should be taught as a single course based on the three separate sciences (biology, chemistry and physics). This course will be followed by the vast majority of students. We expect it to be the default route for all students unless there is a good reason that they cannot follow a common GCSE pathway. It will occupy between 20% and 25% of curriculum time to allow students to study a variety of other subjects. The amount of content will be chosen accordingly, and the level of content will be unchanged, i.e. the trimmed specifications will be narrower rather than shallower. There will be sufficient content and challenge to prepare candidates for A-levels in the sciences. Although each of the science qualifications will have less content, this will be made up for in the greater breadth of the curriculum as a whole with the advantage that students will develop broader and more varied knowledge and capabilities. Our Science Teaching Survey 2023 [2] also revealed that many teachers would be in favour of removing some single science-specific content from the curriculum all together, suggesting the additional breadth found in the separate sciences is not highly valued.

[1] There is only an illusion of choice because, although multiple routes exist, not all routes are open to all students. Schools without a physics teacher and schools in more deprived areas are more likely to teach the double science route. And, even in schools that teach both routes, students are often allocated to a route rather than being given a free choice.

[2] Royal Society of Chemistry (2023), "Science Teaching Survey 2023 – teachers recommend curriculum changes", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/teachers-recommend-curriculum-changes/

Section 7 – Assessment and accountability

Q39 Is the volume of assessment required for GCSEs right for the purposes set out above? Are there any changes that could be made without having a negative impact on either pupils' learning or the wider education system?

Assessment exclusively via terminal examinations has been the approach taken in England for science GCSEs since 2017. This results in a high exam burden on pupils at 16, with most pupils sitting 7.5 hours of science examinations and around 30 hours of examinations in total.

In the Royal Society of Chemistry's Science Teaching Survey 2024 [1], teachers were asked if they could make one change to chemistry assessment, what would it be. The most common response, at 25% of participants, was a reduction in course content. It is important to note that a reduction in course content would not directly lead to a reduction in the volume of assessment, but it could be used as a starting point to do so. Indeed, in several of the open responses to the same question, some teachers indicated that they would like to see shorter or fewer exams.

In the same survey, teachers in England also reported concerns about the high-stakes nature of terminal examinations, and many (66%) are in favour of a return to modular exams, citing reasons such as: reducing pressure for pupils; allowing greater depth of knowledge and understanding of chemical concepts; and better understanding of pupil progress.

[1] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

Q40 What more can we do to ensure that: a) the assessment requirements for GCSEs capture and support the development of knowledge and skills of every young person; and b) young people's wellbeing is effectively considered when assessments are developed, giving pupils the best chance to show what they can do to support their progression?

As stated in our Curriculum Framework, The Royal Society of Chemistry is in favour of assessments that allow all pupils to demonstrate their understanding and knowledge [1]. Currently science GCSEs are assessed exclusively by terminal examinations in England. Our most recent Science Teaching Survey results [2] showed that the majority of teachers in England are in favour of written examinations, either terminal or modular (52% and 66% respectively).

However, in the open responses of our 2024 survey, teachers have raised concerns that a restrictive assessment system does not give a wide understanding of a pupil's competencies in chemistry. Some students may perform poorly at summative written examinations and so not get the chance to demonstrate their strength at skills that may be just as relevant to the subject. This was seen to be of greater importance in schools with >30% of pupils on free school meals or in an area of High Socioeconomic Deprivation. In areas of High Socioeconomic Deprivation, 70% of teachers responded in favour of modular written exams. This is compared to teachers in independent schools where 51% were in favour of modular written exams.

In the RSC's Curriculum Framework [1], we suggest the use of "a broad range of assessments to cater for cover a variety of competences, cater for diverse learners, and minimise any negative impacts associated with particular tasks". Our Science Teaching Survey 2024 assessment question data shows that, whilst a majority of teachers are in favour of a written examination - citing the benefits of standardisation, fairness and accessibility, there is also significant appetite amongst chemistry teachers for a wider variety of assessment methods. The most popular suggestions being a form of externally marked controlled assessment (30% of participants) and a practical exam – 30% favour teacher marking and 31% favour it to be externally marked. We asked participants how practical skills should be assessed. 54% of teachers chose written exam questions based on a series of required practical activities; 54% believe practical skills are about demonstrating competency; and 43% believe that there should be a practical exam. The very small numbers that did not know (1%), or did not feel as though practical skills should be assessed (6%), indicates the perceived importance of practical skills in science subjects.

[1] Royal Society of Chemistry (2020) "The elements of a successful chemistry curriculum", https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

[2] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

Q41 Are there particular GCSE subjects where changes could be made to the qualification content and/or assessment that would be beneficial for pupils' learning?

As stated in our previous response to Q11, the Royal Society of Chemistry is in favour of a single route GCSE for basic secondary education to 16. Biology, chemistry and physics would be taught separately but with a reduction in content. This would allow the benefits of specialist teachers and ease of timetabling, with a more manageable GCSE qualification for all pupils whilst maintaining high standards. This means, in short, an updated curriculum with fewer topics but studied to the equivalent depth that they are currently.

In our Science Teaching Survey 2024 [1], participants were asked " What balance of assessment objectives (AO) do you want to see in science assessments at age 16?". Currently, the weighting of each assessment objective is: AO1 demonstrate/recall 40%; AO2 apply 40%; and AO3 analyse, interpret, explain 20%. Averaging the responses from participants in the survey the weighting for each AO shifts to AO1 36.2%; AO2 36.5%; AO3 27.3%.

Participants were also asked for one change to assessments and the highest coded response, with 25% of participants, was for a reduction of content. In the open responses, some reasons that were given included greater teaching time and flexibility; and an increase in the development of relevant skills such as those in practical science. One respondent told us "Reducing down the curriculum, this would mean they can really become experts in the science they learn. It leaves teachers with greater time to go off on tangents around the curriculum that often pop up (from students) during lessons. You could also include more practical work and real-life examples of the science they are learning. This would help them see the relevance of it and have much more enjoyment of the subject. It would also help them develop the transferable skills needed for studying science beyond 16 but also the transferable skills needed for life in general."

The second most common response (24%) was for modular examinations. In the open responses, teachers were able to give their reasons and for many, it was to allow for continuous monitoring of progress, stress reduction, and the ability to check for deeper understanding of content.

[1] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

Q42 Are there ways in which we could support improvement in pupil progress and outcomes at key stage 3?

Research commissioned into the timetabling of the sciences at KS4 by the RSC, RSB, IOP, ASE and RS [1] show that the majority of schools start teaching GCSE sciences in Year 9. This leads to compression of the Key Stage 3 curriculum into two years and has the potential to disproportionately affect students that are lower attaining or come from disadvantaged backgrounds. In some schools, GCSE content is being introduced before pupils secure understanding of the necessary prior knowledge required in key stage 3 [2]. Therefore, we recommend that key stage 3 should remain taught over three years. In our Science Teaching Survey 2024 [3], 71% of secondary school teachers in England told us that an overloaded curriculum was having a detrimental effect on their students, and we recommend that as well as ensuring that the key stage 3 content is taught over 3 years, content should be reduced in Key Stage 4.

The Science Education Tracker 2023 [4] found that enjoying practical work was the top reason for feeling encouraged to learn science, with 52% of students in years 7–9 selecting it as a motivating factor. The RSC believe it is imperative that all students should have access to practical science education from ages 5-19 and believe that practical experiences support students to develop a breadth of skills, such as scientific enquiry skills [5]. We believe that these practical experiences should be first-hand and often hands-on. Learning practical skills in key stage 3 can help with pupils' progress and outcomes in key stage 3 and key stage 4, as students are required to develop their practical skills which are assessed within GCSE exams. However, the percentage of students who undertake hands on or teacher demo practical work from 2019 to 2023 has decreased (73% to 65% for Y7; 63% to 55% for Y8; 52% to 42% for Y9) [4]. For young people to be able to access hands on practicals and teacher demos at key stage 3, it is crucial that the barriers to practical work are removed. In our Science Teaching Survey 2023 [6], teachers told us that: insufficient time for practical to be taught alongside theory; challenging student behaviour; the cost of consumables and chemicals; lack of equipment; no time for training or practising and understaffing of science technicians were all barriers to practical science education.

Some students have lower science aspirations due to having lower science capital. Students' 'science capital', defined in the 'ASPIRES 2' research [7] as 'all the science-related interests, attitudes, resources, behaviours and social contacts that a person might have'. A focus on developing young people's STEM identities and capital should support pupil progress and outcomes in the sciences at key stage 3. By making the curriculum focus on real-life contexts, which link to young people's everyday lives, science becomes more relevant and accessible to young people [8].

[1] Shift Learning (2018), "Science timetable models research", https://www.iop.org/sites/default/files/2019-06/shift-learning-science-timetable-models-research.pdf

[2] Ofsted (2023), "Finding the optimum: the science subject report", https://www.gov.uk/government/publications/subject-report-series-science/finding-the-optimum-the-science-subject-report--2#secondary

[3] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[4] Verian, The Royal Society and Engineering UK (2024), "Science Education Tracker 2023", https://royalsociety.org/-/media/policy/projects/science-education-tracker/science-education-tracker-2023.pdf

[5] To find out more about our position on practical chemistry, please read our Practical Chemistry Education position statement, https://www.rsc.org/globalassets/22-new-perspectives/education/policy-change-for-11---19-education/a-policy-position-on-the-royal-society-of-chemistrys-vision-for-practical-chemistry-in-5-19-education.pdf

[6] Royal Society of Chemistry (2023), "Science Teaching Survey 2023", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[7] Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: Young people's science and career aspirations, age 10-19. London: UCL Institute of Education, https://discovery.ucl.ac.uk/id/eprint/10092041/15/Moote_9538%20UCL%20Aspires%202%20report%20full%20online%20version.pdf

[8] 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, https://discovery.ucl.ac.uk/id/eprint/10157406/2/9872%20UCL%20Young%20People%20Report%20AW2.pdf

Section 8 – Qual pathways 16-19

Q47 To what extent does the range of programmes and qualifications on offer at each level meet the needs and aspirations of learners? a) Level 3 b) Level 2 c) Level 1 and entry level

Level 3:

It is important that a range of qualification pathways are open at 16 to 19 to cater for different student preferences. Applied science qualifications are disproportionately taken by students from less advantaged backgrounds. Before the recent landscape changes these qualifications were achieved by around 25,000 students each year; a level of participation that the new T-levels are currently nowhere near meeting. As an example, there is only one provider of the science T-level within a 24-mile radius of Cambridge, despite the city being a leading hub in the UK for life sciences. There also continues to be concerns around difficulties in accessing industrial placements.

We continue to be concerned that removing funding from applied science qualifications will worsen equity, diversity and inclusion in our sector; undergraduate chemistry students already tend to be from more advantaged social backgrounds than the wider student population.

Q48 Are there particular changes that could be made to the following programmes and qualifications, and/or their assessment that would be beneficial to learners: a) AS/A level qualifications b) T Level and T Level Foundation Year programmes c) Other applied or vocational qualifications at level 3 d) Other applied or vocational qualifications at level 2 and below

a) Chemistry and other science A Levels are widely perceived as being more difficult than many other A Level subjects. There is statistical evidence to suggest that grading standards across subjects are not aligned, meaning that chemistry is one of the hardest A Level subjects to achieve high grades in [1]. This leads to many sixth forms setting higher entry requirements to study chemistry and other sciences than other subjects at A Level [2]. Chemistry A Level should be reviewed to ensure students are not disadvantaged by choosing the subject.

b) We welcomed the introduction of T Levels as a progression route directly into specialised occupations such as laboratory technician and still wish to see them succeed. We have provided support and input into the development of this route. We were also supportive of the Department for Education's aims for a technical qualification landscape that is coherent, with qualifications that are relevant and high quality, and which offer good preparation for employment or further study, while meeting the needs of young people.

However, T Levels are seemingly not currently meeting the needs of students who want an alternative route to A Levels [3] and their success in supporting progression into higher education, higher apprenticeships and technical training, and the workplace is still unclear [4].

We would like to see T Level assessment become less exam-focused, so that they provide a genuine alternative to A Levels and provide a route for young people who struggle to express their competence and potential through formal exams.

[1] Ofqual (2018), "Inter-subject comparability technical report science", https://assets.publishing.service.gov.uk/media/5bf433a2e5274a2afa5a9cef/Inter-subject_comparability__-_technical_report_science_.pdf

[2] Royal Society of Chemistry (2020), "Chemistry for all", https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-is-chemistry-accessible-for-all.pdf

[3] Ofsted (2023), "T-level thematic review: final report", https://www.gov.uk/government/publications/t-level-thematic-review-final-report/t-level-thematic-review-final-report

[4] Edge Foundation (2024), "What do students really think about T-levels", https://www.edge.co.uk/documents/505/What_do_students_really_think_about_T_Levels.pdf

Q49 How can we improve learners' understanding of how the different programmes and qualifications on offer will prepare them for university, employment (including apprenticeships) and/or further technical study?

The Gatsby career benchmarks act as a useful framework for careers education, indicating the key features needed for careers guidance and provision to be 'good' by international standards [1]. There is evidence to suggest that currently some of these benchmarks are not consistently being met – our Science Teaching Survey 2024 data on teacher awareness of skills employers are looking for, suggest that 'learning from career and labour market information' is not consistently being met by the current chemistry/science curriculum, with only 1 in 5 teachers being aware of the skills that chemical employers are looking for [2]. Without that knowledge, teachers are likely going to find it more difficult to 'link curriculum learning to careers'.

Students would benefit from progression pathways through the sciences being more clearly defined and with the support of all key stakeholders (including education providers and employers).

The Royal Society of Chemistry's 'Chemistry for All' programme aimed to engage with students from less advantaged backgrounds who might not necessarily consider careers within chemistry [3]. The programme encompassed diverse activities and events aimed to provide enrichment and enhancement to complement the national curriculum. By the end of the Chemistry for All programme, students stating that they intended to choose A-level chemistry recognised that chemistry qualifications provide opportunities later in life. The focus on future opportunities by Chemistry for All provided a positive reach towards disadvantaged students; this focus on the extrinsic benefits of post-16 qualifications proved particularly effective in helping students to align their future selves with chemistry which might not have been otherwise possible. Several recommendations were made that could be applied directly to curriculum and qualifications, with the aim of improving understanding and uptake of pathways into chemistry/further study.

Awareness and advocacy of all post-16 routes is not consistent. The 2023 edition of our Science Teaching Survey shows A-levels are still the best supported route with 94% of mainstream state secondary teachers in England advocating for the qualification [4]. In contrast T-levels are not well advocated for, with only 12% of teachers stating they are aware of and advocate for this option [4]. Additional support could be provided to teachers to encourage better advocacy of a wider range of post-16 options. Alongside this all post-16 destinations should be given equal credit when it comes to measuring school performance. This should be promoted to schools and parents, so that teachers don't feel that they have to encourage all students to go to university. In our 2023 Science Teaching Survey, 33% of teachers in England reported not advocating for vocational pathways due to their school's focus on academic pathways [5].

Space should be left in the curriculum to include up-to-date and relevant contexts. The use of contexts to help students understand how chemistry is applied in the real world is vital. It helps students to understand the relevance of the ideas studied, how the discipline is evolving, develop scientific literacy, and appreciate what chemistry brings to our society. We recommend that contexts are chosen for national, regional and local relevance to enrich the curriculum and support maximum engagement. Structuring the framework in this way means that over time, different contexts and applications can be chosen to illustrate these core ideas without the need for ongoing tweaking or reform of curriculum content [6].

[1] The Gatsby Charitable Foundation (2014) "Good career guidance", https://www.gatsby.org.uk/education/focus-areas/good-career-guidance

[2] Royal Society of Chemistry (2024), "Science Teaching Survey 2024". https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/

[3] Royal Society of Chemistry (2020) "Chemistry for all", https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-cfa-report.pdf

[4] Royal Society of Chemistry (2023) "Science Teaching Survey 2023 – Teachers recommend curriculum changes", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/teachers-recommend-curriculum-changes/

[5] Royal Society of Chemistry (2023) "Science Teaching Survey 2023 – barriers to advocating for vocational pathways", https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/2023/teachers-recommend-curriculum-changes/#barriers-to-advocating-vocational-pathways-table

[6] Royal Society of Chemistry (2020) "The elements of a successful chemistry curriculum", https://www.rsc.org/globalassets/22-new-perspectives/talent/chemistry-curriculum-framework/chemistry-curriculum-brochure.pdf

Q51 Are there additional skills, subjects, or experiences that all learners should develop or study during 16-19 education, regardless of their chosen programmes and qualifications, to support them to be prepared for life and work?

16-19 education is a key period for young people to develop skills for employability and future success, whether they intend to pursue higher education or go straight into the workforce. Our recent research programme on the future chemistry workforce and skills has been exploring the skills and knowledge sought by employers, focusing on the chemical sciences sector [1]. We have identified several skills demands from employers for the future workforce which are transferrable and could apply across sectors, as reflected by other recent studies of the wider future workforce [2]. Our research shows employers place high value on transferrable skills such as professional skills, communication and problem solving [1]. Universities are also trying to build these wider skills into courses through greater "real-world experience" in a degree.

Additionally, our research identified the need for the future workforce to possess more secure digital skills such as data analysis, automation and higher levels of basic computer literacy. This shift towards digital skills will require policymakers to align curriculums with evolving digital demands and ensure we are equipping young people with the right skills to navigate a rapidly evolving technological landscape.

Every young person should understand climate change and sustainability topics as these are crucial to today and tomorrow's world, environment and policy decisions, affecting how we live as well as work. Employers are also increasingly looking for people possessing these green skills, knowledge and abilities [1]. Curriculums should be designed flexibly to emphasise sustainability and climate change, while being careful not over-burden students and educators with excess content. Many educators in our sustainability survey identified a lack of time as a barrier to teaching about climate change [3]. There is an opportunity to review the curriculum and reduce the emphasis on certain topics that are becoming less relevant, such as fossil fuels, while increasing the emphasis on climate change and sustainability. This includes considering how all students can access climate education at 16-19 regardless of the subject pathways they have chosen.

For those young people who choose a chemistry pathway, 66% of 17- and 18-year-olds would like more detailed coverage of sustainability and climate change in their chemistry lessons. Additionally, 90% of chemistry educators think that climate change and sustainability teaching should be integrated within relevant subjects at 16-19 [3].

These identified skills and knowledge areas would be welcome additions to a reformed 16-19 chemistry curriculum that ensures young people who choose this pathway are being equipped with the skills and knowledge needed for the future, including interpersonal skills and digital literacy – achieved via a relevant and engaging education with a strong focus on sustainability and the exploration of chemistry through hands-on practical activities. However, many of these skills we have identified extend far beyond chemistry, applying to many other subjects, and could also feature more broadly as part of enrichment activities carried out by 16-19 year olds.

[1] Royal Society of Chemistry (2023) "Future workforce and educational pathways", https://www.rsc.org/policy-evidence-campaigns/discovery-research-and-innovation/discovery-research-innovation-reports-surveys-campaigns/future-workforce-and-educational-pathways/

[2] Bocock, L., Del Pozo, J. and Hillary, J. (2024). "Rethinking skills gaps and solutions. Working Paper 4 of The Skills Imperative 2035: Essential skills for tomorrow's workforce" Slough: NFER. Available at: https://www.nfer.ac.uk/publications/the-skills-imperative-2035-rethinking-skills-gaps-and-solutions/

[3] Royal Society of Chemistry (2022), "Green Shoots: A sustainable chemistry curriculum for a sustainable planet", https://www.rsc.org/globalassets/22-new-perspectives/sustainability/sustainability-curriculum/green-shoots-a-sustainable-chemistry-curriculum-for-a-sustainable-planet.pdf

Section 9 – Other issues

Q54 Do you have any further views on anything else associated with the Curriculum and Assessment Review not covered in the questions throughout the call for evidence?

The chemical sciences are entering an era of unprecedented discovery and impact. They will be essential for finding paths to sustainable prosperity. It is vital that chemistry education is fit for the future, and prepares young people for the challenges they will face. Science is also a core subject at key stages 1 to 4, and the evidence we have presented here shows that major changes are needed to ensure the science (and chemistry) curriculum is fit for purpose. As such the sciences should be a key focus for subsequent stages of this curriculum and assessment review. We would like to see coherent mechanism for curriculum and assessment development in each subject, bringing together experts in curriculum and assessment design as well as subject specialists. We recommend the formation of a curriculum oversight body that can operate at a subject level.

The Royal Society of Chemistry is well placed to feed into this process as in recent years we have convened experts to develop curriculum frameworks for chemistry at 11 to 19 and primary science. [1] We have also collected a large amount of data from practicing science teachers through our annual Science Teaching Survey, giving us timely insights into key challenges and issues in science teaching. This puts us in a good position to contribute to chemistry curriculum development.

We understand the review body are emphasising "evolution not revolution", however, our experience and evidence presented in this review, suggests that teachers of chemistry and science acknowledge that it is time for the chemistry and science curriculums to be updated.

Curriculum change can put addition pressure on teachers. We strongly recommend that sufficient funding and time is allocated to support teachers prepare for any changes that come about as result of this review.

[1] See our work to develop ideal secondary chemistry and primary science curriculums:

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

And; RSC, IOP, ASE and RSB (2024), "Developing a Primary Science Curriculum: Recommendations based on the primary curriculum advisory group's framework", https://www.rsc.org/globalassets/07-news-events/rsc-news/news-articles/2024/08-august/stem-primary-curriculum-recommendations.pdf