ROYAL SOCIETY OF CHEMISTRY

SUSTAINABILITY

Green shoots part 3

How to integrate sustainability and climate change into chemistry education

The perspectives series

In a world where global challenges and advances in technology bring both uncertainty and new possibilities, the chemical sciences have a critical role to play. But what will that role be? How can we maximise the impact we make across academia, industry, government and education? And what actions should we take to create a stronger, more vibrant culture for research that helps enable new discoveries?

Our perspectives series addresses these questions through four lenses: talent, discovery, sustainability and science culture. Drawing together insights and sharp opinion, our goal is to increase understanding and inform debate – putting the chemical sciences at the heart of the big issues the world is facing.

Sustainability

Our planet faces critical challenges – from plastics polluting the oceans, to the urgent need to find more sustainable resources. But where will new solutions come from? How can we achieve global collaboration to address the big issues? And where can the chemical sciences deliver the biggest impacts?

Science Culture

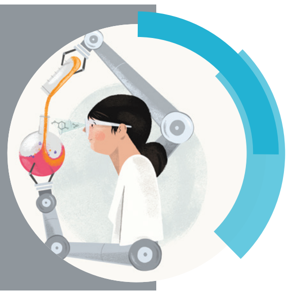
Scientific research and innovation is becoming increasingly multidisciplinary and collaborative. How do we create the open, inclusive, dynamic environments that will allow scientists to thrive and make their maximum contribution to global prosperity? And how should we recognise and incentivise the breadth of skills and diversity of people, contributions and achievements that enable new discoveries and breakthroughs?

Talent

Talent is the lifeblood of the chemical sciences. But how do we inspire, nurture, promote and protect it? Where will we find the chemical scientists of the future? And what action is required to ensure we give everyone the greatest opportunity to make a positive difference?

Discovery

Chemistry is core to advances across every facet of human life. But where do the greatest opportunities lie? How will technology and the digital era shape the science we create? And what steps should we take to ensure that curiosity-driven research continues to unlock new opportunities in unexpected ways?



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Front cover illustration: Amelia Flower, Folio Art

Executive summary

A high quality chemistry education that integrates climate change and sustainability helps young people to become scientifically informed global citizens. It can inspire learners to pursue careers in the chemical sciences and equip them with the knowledge and skills needed to contribute to a greener economy.

However, our research shows that sustainability and climate change issues are not sufficiently emphasised in the chemistry curriculum. Students often do not recognise existing content as relevant to these global challenges, and teachers report that some topics need updating to reflect current scientific and societal priorities.

CURRICULUM

Governments should embed contemporary sustainability and climate change content and contexts throughout national chemistry curriculums. This includes making clear connections between chemistry topics and other disciplines.

ASSESSMENT

Exam boards should include sustainability and climate change contexts in chemistry assessments. This will encourage teaching that connects their chemistry knowledge to real-world applications.

SUSTAINABILITY CONSIDERATIONS FOR PRACTICAL ACTIVITIES

Students should be supported to consider the environmental impact of practical work in school-level chemistry. This approach promotes sustainable scientific practice and aligns school-level learning with real-world sustainability decision-making in academia and industry.

This report brings youth voice on sustainability and climate change in education to the forefront and develops expert recommendations in response. It is based on research conducted by the Royal Society of Chemistry in 2024–2025 which captured the perspectives of undergraduate students reflecting on their experiences at school, alongside practitioners and sector specialists who shared their expertise and tested emerging themes. Bringing these two strands together allowed us to develop a balanced understanding that reflects both lived experience and professional expertise.

This work builds on our 2021 **Green shoots part 1 and 2 reports**. Our recommendations were developed with our 11–19 curriculum framework, **The elements of a successful chemistry curriculum** and **Recommendations for a future primary science curriculum**, in mind.

Recommendations

Based on the findings contained within this report, and building on our previous research – Green shoots part 1 and 2 reports, our curriculum framework The elements of a successful chemistry curriculum and findings from the Science teaching survey – the Royal Society of Chemistry recommends that we need the following changes.

Recommendation 1: Governments should encourage the linking of relevant regional, national and global contexts related to sustainability and climate change (including examples of workable solutions and mitigations), to appropriate chemistry curriculum topics.

Recommendation 2: Governments should ensure that contemporary sustainability and climate change content is included within their national chemistry curriculums.

Recommendation 3: Exam boards should include climate change and sustainability contexts within some exam questions. This should include both instances where the question is framed within a relevant context, and opportunities for students to demonstrate their knowledge of real-world examples in their answers.

Recommendation 4: Governments should adopt a holistic and coordinated approach to embedding climate change and sustainability within their national curriculums. This includes making clearer connections within the chemistry curriculum and across related subject areas, enabling students to build a more integrated and meaningful understanding of sustainability.

Recommendation 5: Exam boards should ensure that content within chemistry and combined science specifications makes clear the connections between different ideas. These connections should build towards an overall story of how chemistry contributes to solving global challenges.

Recommendation 6: Governments should embed consideration of the environmental impacts of practical chemistry activities within national secondary science and chemistry curriculums. This will ensure students develop the skills and awareness needed to conduct experiments responsibly and sustainably, in line with the developing expectations in academia and industry.

Recommendation 7: Exam boards should embed environmental evaluations within their assessment frameworks for older students, ensuring sustainability considerations are integrated into their scientific learning and practice.

Recommendation 8: Microscale practical activities can reduce cost and waste and make some practical chemistry activities more sustainable and less environmentally damaging. Exam boards should reassure teachers that their students will not be disadvantaged if they have experience of a microscale rather than a full-scale practical experiment.

Introduction

Climate change and the unsustainable use of natural resources are pressing global challenges. Chemistry plays a critical role in addressing these issues, for example through the development of low-carbon technologies, the design of recyclable, biodegradable and reusable materials, pollution prevention, water treatment, and innovations in carbon dioxide capture and utilisation.

Learning about sustainability and climate change issues, and the solutions chemistry can offer, helps students understand how chemistry contributes to solving environmental problems. It provides young people with the agency to be responsible global citizens who strive to make the world a more sustainable place, while also giving them knowledge and skills for jobs in the green economy.

In recent years, the RSC has been listening to young people, teachers and other experts to help develop our thinking on how sustainability and climate change education can be best reflected in school-level chemistry.

In our ***Green shoots part 1*** survey, 81% of young people told us that they feel it is important to be taught about climate change and sustainability in school or college.[1] Our recent ***Future workforce and educational pathway***s report also found that employers and learners are keen to see sustainability given greater emphasis, with statistics showing the demand for green skills is eight times higher for chemistry roles than for the wider UK economy.[2]

Educators responding to our 2023 ***Science teaching survey*** told us that they wanted climate change and sustainability topics within the chemistry curriculum revised, with many citing the need for the content to demonstrate relevance, value or both.[3] A Students Organising for Sustainability (SOS-UK) survey found that the general public also agrees on the importance of preparing children and young people for environmental issues at school, with 76% agreeing that it is important to teach climate change in schools.[4]

In this report we have built on what we have learnt from educators, young people and industry representatives, and we have developed recommendations for governments and exam boards on how sustainability and climate change education should be better embedded into chemistry curriculums and assessments.

1 Royal Society of Chemistry (2021), Green shoots: A sustainable chemistry curriculum for a sustainable planet, https://www.rsc.org/policy-and-campaigning/policy-library/green-shoots-part-1

2 Royal Society of Chemistry (2025), Future Workforce and Educational Pathways. https://www.rsc.org/policy-and-campaigning/discovery-and-innovation/future-workforce-and-educational-pathways

3 Royal Society of Chemistry (2024), Science teaching survey 2023, The science teaching survey 2023: a summary of the findings

4 SOS-UK (2022), Perspectives on young people, education and environmental issues survey with the general public. https://sos-uk.org/research/perspectives-on-young-people-education-and-environmental-issues/

Our approach

There were four stages to our approach, which included a variety of workshops, roundtables and a focus group.

Stage 1 – initial undergraduate workshops

In Autumn 2024 we conducted four workshops with predominately first-year chemistry undergraduates at universities in England, Wales and Scotland. We asked them about their experiences of learning about sustainability and climate change at school and what changes they would like to see.

Stage 2 – first expert roundtable

In January 2025, we held a roundtable of representatives from industry, higher education, initial teacher education, school and further education, science and geography associations, and young people who were involved in SOS-UK. The participants, who had a wide range of expertise, discussed the findings from the youth workshops as well as their own thoughts on sustainability and climate change education in the chemistry curriculum. They suggested areas to explore with young people for stage three.

Stage 3 – undergraduate focus group

In March 2025 we convened a focus group of undergraduates to further develop the key themes identified during the first roundtable discussion. We asked participants whether they remembered their chemistry teachers using local, national or global contexts to exemplify climate change or sustainability topics; the importance of practical skills and whether sustainability was considered as part of their school practical chemistry activities.

Stage 4 – second expert roundtable

The expert roundtable met again in March 2025. They considered the findings from stage three to begin scoping out recommendations to better integrate sustainability and climate change into chemistry education.

The full methodology can be found in Appendix 1. All of our sessions helped us to form the recommendations in this report.

Findings and recommendations

A strong message from our workshops with undergraduates (stage one of our approach) was that sustainability and climate change was important to them.

When asked "What does sustainability and climate change mean to you?" young people from England, Scotland and Wales responded using words such as: "critical", "important", "stressful", "serious" and "taking care of nature".

Figure 1: This diagram shows responses to the question "What does sustainability and climate change mean to you?" which was asked to young people at our workshops with undergraduate students. Font size is not representative of quantitative responses.

Chemistry skills to tackle climate change and sustainability challenges

Our undergraduate workshop participants overwhelmingly viewed sustainability and climate change education as important for their future careers.

They also identified many of the skills developed through school-level chemistry – such as teamwork, communication and critical thinking skills – as also being helpful for combatting climate change and sustainability challenges. Some of these skills have previously been identified as important for jobs in the green economy.[5]

"Solutions to climate change are chemistry based most of the time. Analytical thinking, interpretation."

"Disseminating findings is very important. Difficulty with this is that only a small minority of the population are chemistry (science) specialists, so we need to be able to communicate findings to the lay person."

"Language skills that mean we can appeal to somebody's human desire to combat climate change. Being able to communicate with those industries that contribute massively to climate change – and government."

Q1. What are some examples of skills that you think are learnt by studying chemistry in school/college/sixth form?

1. Mathematical/data analysis skills
2. Teamwork
3. Time management
4. Critical thinking
5. Problem solving
6. Practical chemistry skills
7. Communication skills
8. Research skills
9. Academic writing

Q2. How can chemistry skills (e.g. teamwork, following a method, taking measurements, analysing data) be helpful in combatting climate change and sustainability issues facing our planet?

Through the use of:

1. Teamwork
2. Communication (of scientific research/knowledge)
3. Critical thinking
4. Practical chemistry skills
5. Data analysis skills
6. Research skills

Figure 2: Thematic analysis of skills question (free text answers were grouped by theme).

Our expert roundtable participants highlighted the importance of critical thinking skills and of offering young people space to analyse data and misinformation. In the same discussion, industry experts told us that computational skills were becoming increasingly important within the workplace, and that young people need to develop a better understanding of using computational models and computer programmes to collect and analyse data. Learning about sustainability and climate change can provide good opportunities for students to develop these skills, which in turn have been identified as being important to help tackle the issues.

5 Royal Society of Chemistry (2024), Future Workforce and Educational Pathways. https://www.rsc.org/policy-and-campaigning/discovery-and-innovation/future-workforce-and-educational-pathways

Curriculum – updated content and relevant contexts

When we asked young people to describe their experiences of climate change and sustainability in the chemistry curriculum, they reported that this was not a key part of their learning.

Figure 3: How would you describe your experiences of sustainability and climate change in the chemistry curriculum when you were at school/college/sixth form? Responses from undergraduate workshop participants. Font size is not representative of quantitative responses.

Relevance of climate change and sustainability topics

Young people were asked how relevant they found a range of sustainability topics, and how much chemistry in school, sixth form or college helped them to understand the topic. These results give insight into curriculum areas which might need to be refreshed. Climate change and sustainability content in the chemistry curriculum must reflect appropriate scientific developments which are as up to date as possible. This should be done with care as part of the curriculum reform/refresh cycle to avoid overloading the curriculum.

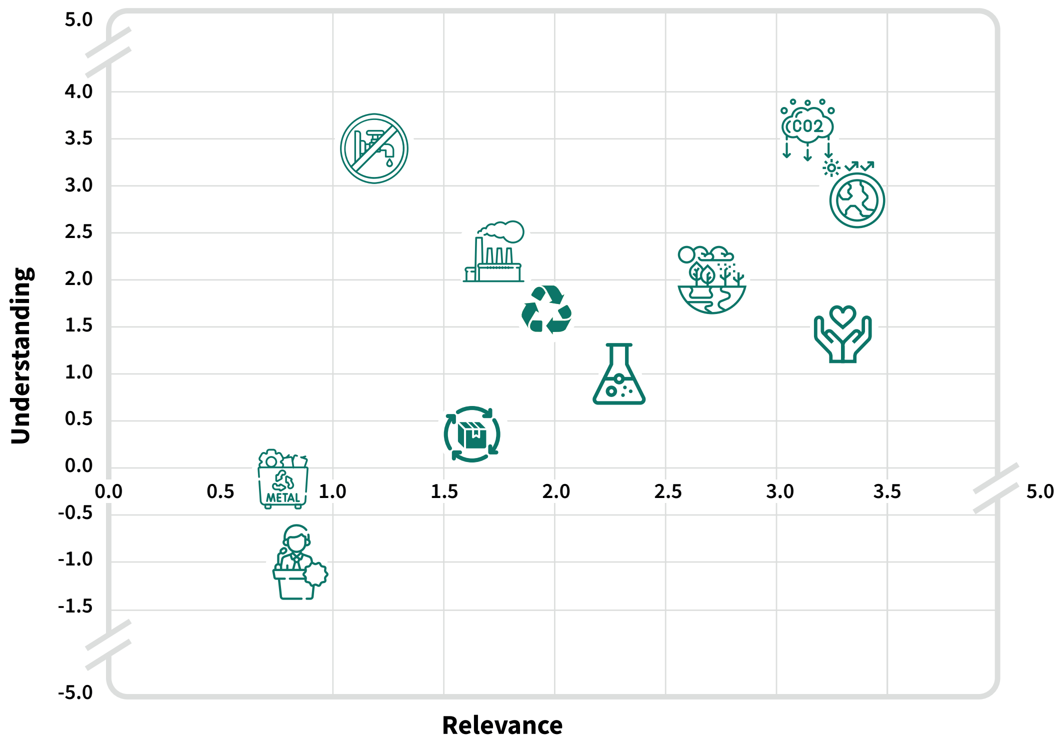


Figure 4: A breakdown of topics by relevance and understanding. Undergraduate students were asked to plot each topic on how relevant it was to them as a young person in school/college and how much they felt their school/college chemistry education supported their understanding of each topic. Understanding of potable water and water treatment was very high but young people did not feel that it was relevant to them. Atmospheric pollutants and their role in pollution and the greenhouse effect were well understood and young people found these topics very relevant to their lives. Personal and societal responsibilities related to climate change and sustaibability was very relevant to young people, but did not understand it very well. The role of chemistry in understanding and addressing climate change and sustainability issues was not understood very well, but young people felt that it was somewhat relevant to them. Young people didn't understand lifecycle assessments of a product very well and did not feel that was particularly relevant to them - even though this is on the GCSE specification for chemistry in England and Wales. The viability of recycling certain materials such as metals also scored low on how well they understood it and felt it was relevant to them. The role of politics in decision-making and the way information on these topics is sometimes presented and sometimes misrepresented was not understood in school at all. Young people felt there was a slight relevance of this.

- Human causes of climate change
- Atmospheric pollutants such as carbon dioxide and methane and their role in environmental pollution
- The greenhouse effect
- Potable water and water treatment
- Environmental impacts of industrial processes
- Life-cycle assessments of a product
- The viability of recycling certain materials, e.g. metals
- Energy and related issues such as cost, production storage and recycling
- Personal and societal responsibilities related to climate change and sustainability
- The role of politics in decision-making and the way information on these topics is presented and sometimes misrepresented
- The role of chemistry in understanding and addressing climate change and sustainability issues

Using local, national and global contexts and examples

At our first roundtable event, the invited experts identified areas that they wanted to hear more on from youth voices. One such area was the use of contexts or examples in their lessons, so we included this topic in our youth focus group at stage three of our iterative approach.

When we asked them about **contexts**, only half of the young people at our focus group told us that they learnt topics on climate change and sustainability in their chemistry lessons through local, national or global contexts that were relevant to them.

Some of the examples of context they gave were:

“learning about potable water and how to make water safe to drink”

“we were offered to participate in a river study to analyse phosphorus waste in rivers”

“our teachers tried to tie topics we learnt to sustainability, for example hydrolysis of esters can help breakdown plastic clothing”

“learning about waste-water treatment and the mechanisms by which greenhouse gases effected the environment”

“chemical recycling”

Teaching using contexts does not in itself require new chemistry concepts to be covered in lessons. Instead, it involves linking core chemistry knowledge to sustainability and climate change challenges through the use of contexts and examples.

Members of our expert roundtable emphasised the importance of teacher autonomy when it came to using contexts.

They advocated for teachers to be given agency and time to be able to apply and use contexts within their teaching.[6]

6 Some examples can be found here in Education in Chemistry. https://edu.rsc.org/eic/collections/sustainability-in-chemistry

CASE STUDY

Bringing contexts into chemistry change

"As a chemistry teacher in Port Talbot, sustainability teaching begins right outside our lab windows. The skeletons of South Wales' last two blast furnaces, which are now closed, offer the perfect visual aid to explore the chemistry of carbon emissions and the decision to retire them. I label their silhouette directly on the glass, sparking discussion on industrial impacts and the science of change.

"Students are especially intrigued by the upcoming electric arc furnace, due to be built locally before the decade ends, marking the shift to steel recycling and a more sustainable future. Our town is a hub of transformation. From wind farms across the valley to solar panels on our school roof, and the exciting announcement of an offshore wind project off the Welsh coast, with turbines manufactured and shipped from Port Talbot.

"These real-life examples turn abstract GCSE concepts into meaningful discussion. Students become more engaged and confident when they see science in action around them. Across our department, colleagues value how local contexts spark curiosity, deepen understanding, and foster pride in how chemistry shapes the future of our own community."

EURIG THOMAS, TEACHER

Photo credit: Eurig Thomas

The use of local, national and global contexts (both historic and contemporary) to exemplify climate change and sustainability content can help students connect chemistry to their lives and the wider world.[7]

Using contexts to support students' learning in these areas is a key component of implementing teaching through a 'global citizenship' lens. This approach involves designing and delivering education in a way that helps students understand their roles and responsibilities in an interconnected world. It encourages learners to think critically about global issues, appreciate cultural diversity, and act ethically and sustainably.

This relates to our finding from the youth workshops: content focused on 'personal and societal responsibilities' in school felt relevant to them, but they did not feel that their chemistry education fully supported their understanding in this area.

OXFAM SEES THE GLOBAL CITIZEN AS SOMEONE WHO:

- is aware of the wider world and has a sense of their own role as a world citizen
- respects and values diversity
- has an understanding of how the world works
- is passionately committed to social justice
- participates in the community at a range of levels, from the local to the global
- works with others to make the world a more equitable and sustainable place
- takes responsibility for their actions[8]

Our expert roundtable participants highlighted the value of using contexts to exemplify the need to care for the environment, and talked about the role of education in, about and for the environment. Participants also discussed the importance of role models and of bringing examples of green career opportunities to the forefront, which can help students feel empowered.

> "Green careers are developing rapidly across many areas of science, so introducing young people to these opportunities and exciting developments can truly inspire them. Engaging with bright young innovators empowers students by showing them that they could one day be the imaginative scientists tackling climate change and biodiversity loss – and that chemistry can help them get there."

BECKY PARKER, ROUNDTABLE PARTICIPANT

7 See the Royal Society of Chemistry's position on 'Global perspectives and diverse representation in chemistry education. https://www.rsc.org/policy-and-campaigning/policy-library/global-perspectives-and-diverse-representation-in-chemistry-education

8 Science and Global Citizenship: Guidance for taking a global perspective to teaching science. https://policy-practice.oxfam.org/resources/science-and-global-citizenship-guidance-for-taking-a-global-perspective-to-teac-620818/)

Systems thinking

Experts at our first roundtable wanted to know whether young people picked up on the connections between school subjects when learning about sustainability and climate change.

When asked whether they saw **connections between chemistry and other subjects** regarding climate change and sustainability issues, 61% of young people said they saw the connections some of the time, and 22% saw them most of the time. The subject they saw a link with the most was geography, followed by biology.

> "Systems thinking emphasises the interdependence of components of dynamic systems. In the context of chemistry, systems thinking moves beyond isolated consideration of reactions and processes to consider where materials come from, how they are transformed and used, and what happens at the end of their life span. It draws attention to a need to balance the benefits and impacts of chemical substances and the role they play in societal and environmental systems."

IUPAC

> "The chemistry of sustainability, climate change and the environment has no boundaries, and neither should the chemistry learning of our young people. Understanding the vast, dynamic and interconnected processes of our planet – and the full chain of consequences that everyday decisions can have – requires a systems-thinking mindset. A chemistry education that moves beyond simple cause and effect, and explores chemistry's relationship with other scientific disciplines through a systems-thinking lens, is essential for preparing young people for their future lives and careers."

HELEN HARDEN, ROUNDTABLE PARTICIPANT

Systems thinking, which recognises the interdependence of components within dynamic systems, is essential for deepening students' understanding of sustainability. It can enable learners to make meaningful connections between concepts, whether across disciplines or within chemistry itself, supporting a more holistic and integrated approach to climate change and sustainability education.

These connections should be made more explicit within chemistry curriculums. For instance, when exploring exothermic and endothermic reactions, students can be encouraged to think beyond the reaction itself and consider how the energy released or absorbed fits into a broader system. They might consider how using heat from exothermic reactions could power other processes in a closed-loop system. Similarly, linking the sustainability of chemical processes to the use of catalysts can lead to discussions about the properties of transition metals, which often function as effective and reusable catalysts. These conceptual links should be clearly reflected in curriculum documentation to support coherent and connected learning experiences for all students.[9]

Some of the existing sustainability topics within the chemistry curriculum lend themselves to a more interdisciplinary systems-thinking approach. For example, when studying product life-cycle assessment and recycling, students can learn about the sometimes conflicting environmental, ethical, economic and political considerations and trade-offs.

9 Some of these links are highlighted in our chemistry curriculum framework. The elements of a successful chemistry curriculum. https://www.rsc.org/policy-and-campaigning/education/chemistry-curriculum-framework

Using contexts in assessments

Some of our experts felt that unless contexts are part of an exam, they may not be prioritised in teaching. To address this, we recommend that chemistry and science exams should include climate change and sustainability contexts within some questions. Students should be given the opportunity to demonstrate their knowledge of real-world examples in their answers.

For example, a proportion (around 10%) of questions at GCSE/National 5 level could include opportunities for young people to think critically about the mitigation of and solutions to climate change and sustainability problems. Teachers could be supported with a bank of example national and global contexts to reduce their workload, but they should also have the autonomy to identify local contexts relevant to their learners.

> "With the range of responsibilities that teachers undertake it's often difficult to find time to research new scenarios and contexts for the curriculum, a bank of examples of contexts will really support teachers to embed sustainability and climate change into their teaching and assessment."

AMY HERBERT, ROUNDTABLE PARTICIPANT

Practical chemistry – sustainability considerations

Practical chemistry is an essential part of school-level chemistry education. We believe that all learners should have regular access to relevant and purposeful practical activities. Our policy position *Practical chemistry education: A vision for practical chemistry in 5-19 education*,[10] explores this in more detail.

In our initial workshops with undergraduates, the participants reported that they thought that practical chemistry skills were important to help tackle climate change and sustainability issues. Our roundtable experts wanted to explore this further, so in our stage three focus group, we asked students to rank practical skills[11] from most important to least important to develop in school/college or sixth form to combat climate change and sustainability issues. The top five most important skills for tackling sustainability and climate change issues were identified by young people as:

1. **identifying, classifying and grouping results**
2. **analysing data**
3. **setting up and using laboratory equipment**
4. **drawing conclusions from an experiment**
5. **being safe in a laboratory**

Aside from considering the importance of practical skills in preparing young people for roles in the green economy, our roundtable experts were also interested in the extent to which schools and their students consider the environmental impact of their own chemistry practical activities.

There are currently no requirements for students to consider the environmental impact of practical activities they undertake as part of their chemistry A-level/ Higher or GCSE/National 5 qualifications.[12] This is reflected in our research where the majority (65%) of undergraduate participants in our final focus group said that sustainability was rarely or never considered as part of their school/college practical chemistry learning.

Higher education institutions are increasingly considering environmental impacts, using frameworks such as the Laboratory Efficiency Assessment Framework (LEAF)[13] and My Green Lab[14] and incorporating aspects of green and sustainable chemistry, for example by following The 12 Principles of Green Chemistry[15],[16]. Introducing some of these concepts into 11–19 education would encourage young people to critically consider how practical activities can be designed to minimise environmental impact, while also giving them a glimpse into what working in chemistry entails.

This knowledge will be increasingly valuable as sustainability becomes a central focus in scientific careers and industry practices.

10 Royal Society of Chemistry (2024) Practical chemistry education: A vision for practical chemistry in 5 – 19 education. https://www.rsc.org/policy-and-campaigning/policy-library/practical-chemistry-education

11 The list of practical skills was identified from our definition of practical chemistry in our practical chemistry policy position. RSC (2024) Position statement, Practical Chemistry Education: A vision for practical chemistry in 5-19 education https://www.rsc.org/policy-and-campaigning/policy-library/practical-chemistry-education

12 In some cases, exam boards recommend that students consider environmental impact, but it is not a formal assessment criterion (as of September 2025)

13 UCL's Laboratory Efficiency Assessment Framework (LEAF). https://www.ucl.ac.uk/sustainable/take-action/staff-action/leaf-laboratory-efficiency-assessment-framework

14 My Green Lab Certification for Lab Sustainability. https://www.mygreenlab.org/green-lab-certification.html

15 American Chemical Society, 12 Principles of Green Chemistry, developed by Paul Anastas and John Warner in Green Chemistry: Theory and Practice (1998). https://www.acs.org/green-chemistry-sustainability/principles/12-principles-of-green-chemistry.html

16 Aspects of green chemistry are often included in chemistry A Level and Higher syllabuses, without necessarily being linked to students' own laboratory work.

Environmental impacts, and how to mitigate them, could be taught to students aged around 11–14 when exploring hazard symbols, or introduced during practical science activities as part of a discussion. Another example could be during a practical activity and discussing the possible implications of throwing chemicals down the sink without diluting them, or thinking about why it is favourable to use minimal amounts of reagents in a reaction.

For slightly older students, it was suggested that there could be simple "environmental evaluation" form which young people could complete.[17] There was also a recommendation that students aged 16–19 could benefit from writing their own environmental evaluation when carrying out practical chemistry activities. This could be incorporated into practical assessments such as a part of Common Practical Assessment Criteria (CPAC) practical endorsement at A-level or practical/project assessments at Higher/Advanced Higher, or required practical activities at GCSE/assignment at National 5 level). This would help students to think critically about the environmental impacts when designing their experiments and to consider possible ways to mitigate these. It could also help foster an awareness of the possible environmental impacts of practical activities.

"Thinking about environmental impact and resources is really important for scientists. At my institute, we talk about LEAF every week – it goes into all our funding reports and is something we're constantly referring to. I think it could easily be brought into assessments. For example, a question about designing a practical could require thinking about sustainability, like the energy used to filter water or how waste is disposed of."

MOLLY SCRASE-KINGS, ROUNDTABLE PARTICIPANT

The sustainability of practical chemistry can be enhanced by:

- carefully selecting the type and quantity of chemicals used
- minimising single-use plastics
- optimising energy and water consumption of laboratory instruments
- prioritising the reuse and recycling of materials
- systematically designing experiments to reduce environmental impact[18]

All of these points will still need to adhere to relevant health and safety guidance. Schools may be able to reduce the environmental footprint of some practical activities by using microscale set-ups for some experiments.[19] In addition, these activities can support discussions around sustainability and help students think critically about the potential impacts of practical chemistry.

Exam boards are generally supportive of microscale equipment being used for some of their specified required practicals,[20] but anecdotally, many teachers assume that their students will be disadvantaged in exams if they don't have experience of the full-scale version of an experiment.

17 An example of what this could look like can be seen in part of this Royal Society of Chemistry resource designed to support teachers in Wales: Chemistry in Curriculum for Wales: chemistry skills template (progression step 4), with the question: What impact does this reaction have on our world around us? Consider significance, usefulness, sustainability, pollutants and energy requirements for reaction, https://edu.rsc.org/curriculum-support/chemistry-in-curriculum-for-wales-planning-support/4013517.article

18 Additionally, experiments can be designed to ensure that process or measurement is carried out only as many times as is needed (this links to competence in statistics and data).

19 Microscale practical activities use small amounts of reagents and simple equipment. The Royal Society of Chemistry provides resources to help teachers use microscale chemistry activities. See: https://edu.rsc.org/resources/collections/microscale-chemistry

20 For example, see OCR's 'Purposeful Practicals' which include microscale alternatives which meet the DfE requirements for apparatus and techniques: https://www.ocr.org.uk/Images/716261-purposeful-practicals-menu-guide.pdf

CASE STUDY

Environmental impact of school practical chemistry activities

"Sustainability is part of chemistry practice everywhere, and we need to build in time in lessons to help young people consider it. They should understand the whole life cycle of the chemicals they use – where they come from and where they go. It's important for students to look beyond the practical itself and think about what happens to the substances before and after the lesson.

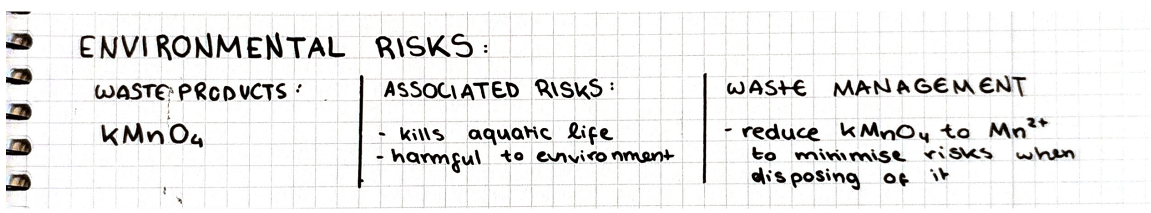
Photo credit: Richmond Park School

"With my Year 9 class in Bristol, I used a simple grid to identify potential environmental hazards, why they occur, and how to dispose of materials safely. Spending just five to ten minutes on this at the start of a practical helped students understand why, for example, we dilute solutions before putting them down the drain, how neutralisation reactions can be useful during waste disposal, why we reduce volumes and concentrations of reagents or why not everything should go down the drain in the first place.

"I drew on the LEAF framework and the principles of green chemistry to guide the activity. It was a good scaffold, for the GCSE required practical on investigating pH using calcium hydroxide and hydrochloric acid, and I now use the same approach with my International Baccalaureate Year 12 students during serial dilutions using transition metals and colorimetry. Doing the grid pushed them to look up information and consider what happens to chemicals afterward — something they admitted they usually 'just leave to the technician.'

"It really starts meaningful discussion: why we dispose of chemicals the way we do, what alternatives exist, and where recycling opportunities might be. Not every practical needs it, but some lend themselves especially well: acids and bases, for example, are accessible and easy to explore. I now provide more prompts and often set the grid as homework so we have more time to talk in class. Giving students space to think about these issues helps them see the wider picture, not just the experiment in front of them."

AYLIN OZKAN, CHEMISTRY TEACHER AND CONTINUOUS PROFESSIONAL DEVELOPMENT COORDINATOR



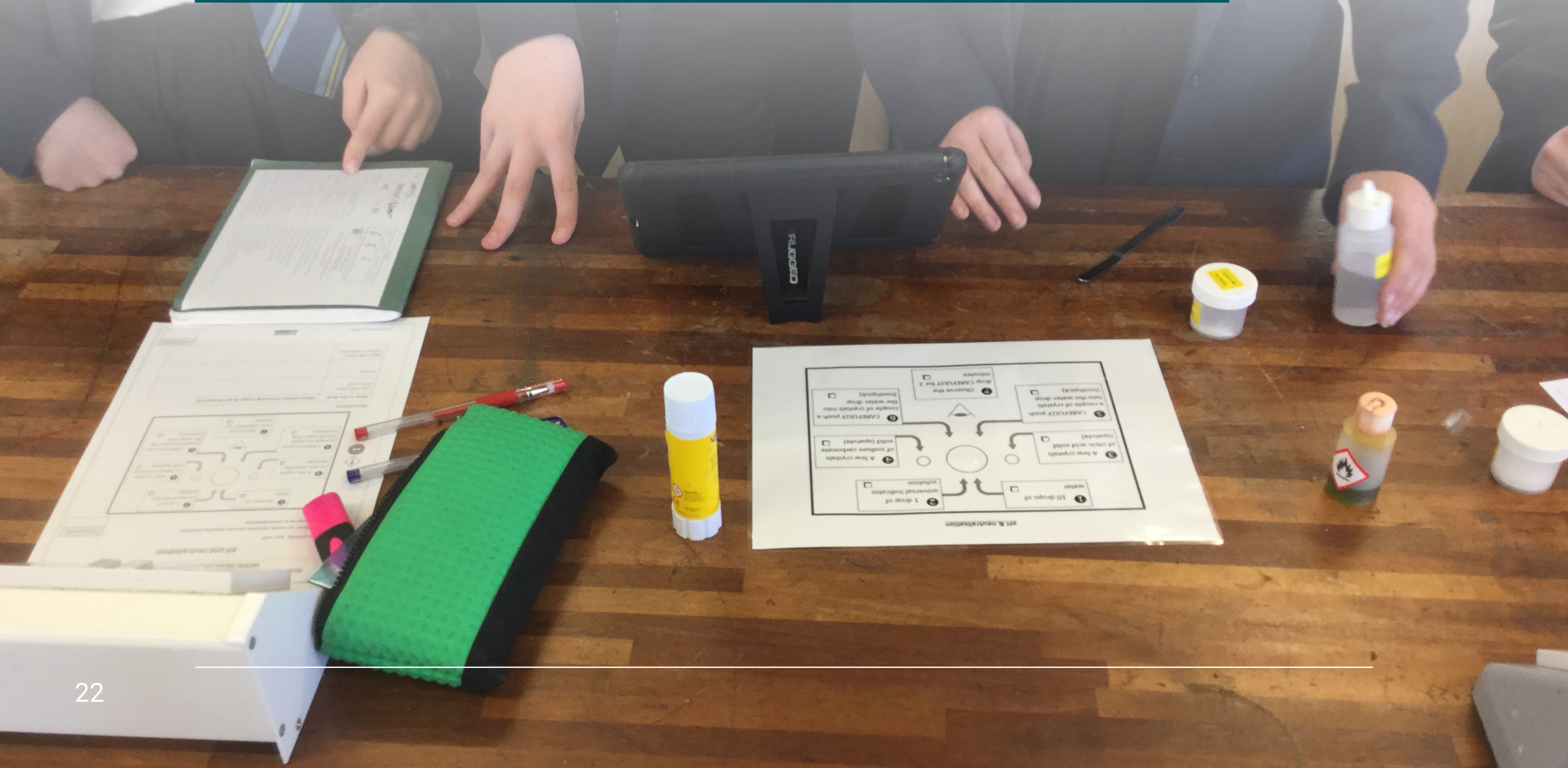
Using microscale to make practical chemistry more sustainable

"Microscale is the scaling down of reactions inside the classroom – and smaller is better for the environment, cheaper for us, more sustainable, and reduces the cognitive load for the students. As a department we've been using microscale for about eight or nine years, slowly over time building up kits of resources, expanding the range we offer. It's amazing the chemistry you can do on a laminated sheet of paper – some of my favourites are displacement of halogens, displacement of metals, Hoffman electrolysis, and atmospheric pollutant testing.

"Doing experiments in different ways gets the students to think more about what they're actually trying to look for, rather than just following a list of instructions. It gives us an opportunity to discuss why we're doing things in a certain way and how that links into sustainability or lab safety. For example, whenever we're using metals in particular it allows a conversation about which metals are better to recycle than others and why using less is better than just using the same amount and recycling it.

"Microscale practical lessons are more efficient due to reduced set up and clearing away time, which gives us more space in lessons to apply what students have observed to the theory. The experiments themselves are carefully designed and clearly presented and so often work better than macro scale practicals, alongside being safer and requiring fewer resources."

HARRY LORD, ASSISTANT HEAD TEACHER AT HASLINGDEN HIGH SCHOOL, LANCASHIRE



Teacher support

Many teachers told us that the amount of time they undertook subject-subject professional development in chemistry was insufficient.[21] Teachers are likely to need time and support to embed sustainability and climate change education effectively into their practice.[22]

Support provided by the Royal Society of Chemistry:

Add sustainability to your lessons with activities, ideas and curriculum-linked resources developed by teachers

Our **professional development** courses often include opportunities to explore more sustainable approaches to practical work, such as through microscale techniques. We also provide topical online **teacher support sessions**— for example, our previous session on *Climate change education in chemistry* — with further sessions planned to help teachers build confidence in teaching these themes.

Alongside this, our education coordinators deliver in person professional development across the UK and Ireland, working directly with groups of schools, multi-academy trusts and local authorities. They offer a suite of hands on workshops that already includes microscale, and we are currently developing a dedicated workshop to support teachers with teaching sustainability and climate change in chemistry.

To support classroom delivery, we also provide a range of high-quality teaching resources, including curated collections of activities and real-world examples to help teachers introduce sustainability and climate change through chemistry concepts. These include our **climate change and sustainability teaching resources** and our collection of **microscale chemistry practicals**.

21 Royal Society of Chemistry (2025), Science Teaching Survey 2025, The Science Teaching Survey 2025. https://www.rsc.org/policy-and-campaigning/education/the-science-teaching-survey

22 See our policy statement on Secondary school science teachers' deployment according to their subject expertise in the sciences which include our recommendations about subject-specific professional development. https://www.rsc.org/policy-and-campaigning/policy-library/teacher-expertise

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Professor Sylvia Knight, Royal Meteorological Society

Elaine Lennox, Council for the Curriculum, Examinations and Assessment (CCEA)

Dr Colin McGill, Edinburgh Napier University

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Molly Scrase-Kings, Students Organising for Sustainability UK

Dr Lucy Wood, King's College London

Appendix

Appendix 1: Methodology

While developing this report, it was important that youth voices were brought to the forefront. This report was developed through an iterative process and based upon the findings from youth workshops and focus groups conducted between October 2024 and March 2025, and two expert roundtable discussions which took place in January and March 2025. Both the youth workshops and expert roundtable discussions were built upon our findings from our **Green shoots survey** and **Science teaching survey 2023**.

Breakdown of research activities

Research activity	Participants	Details
Youth workshops (October and November 2024)	24 university students from English, Welsh and Scottish universities	Four facilitated, mixed method, in-person workshops. These explored young people's views on which green skills should be a focus in schools. They also explored how well young people understood sustainability and climate change topics while in school, and whether they found these relevant to their lives.
Expert roundtable discussions	17 experts in chemistry and science education, from industry, academia and education, including young people	Two facilitated expert roundtable discussions.
Youth focus group (March 2025)	20 undergraduate students from an English university	Use of Slido software to run a survey to further develop the key themes identified during the first roundtable discussion on sustainability and climate change education in chemistry.

In the development of this report, we also consulted CLEAPSS, a number of examination boards, the Royal Society of Chemistry's Education Community Council, and our Directors of the Undergraduate Chemistry Teaching Group.

Appendix 2: Results

From stage one: initial undergraduate workshops

How important do you think sustainability and climate change education is for your future career?

Rating (1-5) with 1 being least important and 5 being most important	Number of responses
1	0
2	0
3	1
4	9
5	12

Looking back to your chemistry education in secondary school/sixth form/college, did you ever learn topics on climate change and sustainability through local, national or global contexts that were relevant to you? i.e. recycling, potable water

If you answered yes, what contexts can you remember coming across at school/ sixth form/college?

- We were offered to participate in a rivers study to analyse phosphorus waste in rivers
- Ozone
- Breakdown of ozone layer
- Our teachers tried to tied topics we learnt to sustainability (e.g. hydrolysis of esters can help down plastic clothing.) Feedstock, mechanical, chemical recycling Global context, was quite general
- Learning about potable water and how to make water safe to drink
- Recyclable products goes in recyclable bin -the green one
- 1. Hydrocarbons, 2. Polymers being non-biodegradable.
- Potable water
- Potable water and plastics
- Learning about waste water treatment and the mechanisms by which greenhouse gases effected the environment
- Water treatments
- Potable water
- Rechargeable batteries

Do you think sustainability was ever considered as a part of your school/sixth form/college practical chemistry activities?

All of the time
0%

Most of the time
15%

Some of the time
20%

Rarely
45%

Never
20%

Which practical skills from below do you think are the most important to develop in school/sixth form/college to combat climate change and sustainability issues? Please rank them from most important to least important.

1. Identifying, classifying and grouping results
11.50

2. Analysing data
10.78

3. Setting up and using laboratory equipment
10.56

4. Drawing conclusions from an experiment
10.33

5. Being safe in the laboratory
10.28

6. Seeking patterns in data
9.94

7. Identifying variables
9.83

8. Choosing suitable equipment
9.72

9. Asking questions
9.56


10. Interpreting data
9.33
11. Making predictions
8.72
12. Use of computational simulations
8.56
13. Using software such as Microsoft Excel to plot graphs and present data
7.22
14. Following a scientific method
7.00
15. Collecting data
6.67
16. Making observations
6.39
17. Being able to use communication
6.22
18. Being able to use secondary resources, e.g. actual data
6.06
19. Being able to manage time
5.50
20. Being able to write lab reports
5.22
21. Developing confidence
4.94
22. Being able to research
4.94
23. Being able to take measurements
4.56
24. Being able to work in a team
4.11
25. Numeracy skills
3.89

26. Being organised

3.50

27. Being able to present

2.33

When thinking about your understanding of climate change and sustainability issues whilst in school/sixth form/college, did you see the connections between chemistry and your other subjects?

All of the time

6%

Most of the time

22%

Some of the time

61%

Rarely

0%

Never

11%

When thinking about climate change and sustainability issues, what connections, if any, did you notice between chemistry and your other subjects in school/college/sixth form? Please include the subjects in your answer.

- Repurpose
- Reduce
- In maths and further maths we had graphs modelling climate change. We applied our knowledge of differentiation and integration on them
- Reuse
- Recycle
- Geography
- Biology
- Geography had a lot of links to chemistry, more of we studied the context and impact of the theory we done learned in chemistry, they weren't taught to us as links but we could see the connections between them
- I studied geography – most of the subject revolved around climate change. When it came to physical geography a lot of it linked to chemistry
- Geography – mining and climate change, design and technology – the 5 Rs
- Physics
- Biology and geography
- Geography
- Geography, biology
- Geography

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