



TALENT

Is chemistry accessible for all?

Learning from five years of
outreach to widen participation

Acknowledgements

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Introducing our new 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 research 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.

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?



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?



Research Culture

Globally, scientific research in academia and industry fuels both progress and innovation. But how do we create more inclusive, diverse and vibrant environments for research, that lead to better, more open science? And how should we recognise the breadth and diversity of the people, contributions and achievements that enable new discoveries?



Find out more at www.rsc.org/new-perspectives



Studying chemistry changed my life. It took me from a council estate in north London to a world of opportunities that I could not have imagined existed. I now know there are countless satisfying chemistry-using careers out there, and I firmly believe that these opportunities should be available to anyone, regardless of their background.

Unfortunately, our five-year Chemistry for All research project has shown that this is not yet the case. Too many people have their horizons limited by the misfortune of the educational opportunities available to the community they are born into and grow up in.

It is vital that we understand the barriers that are blocking people from taking up the opportunities that the chemical sciences have to offer, and then apply ourselves to helping them overcome these. By working with schools with high numbers of less advantaged students and several universities providing different outreach programmes, this project addresses both of these challenges.

If chemistry is to transform people's lives as it did mine, analysing the problem will not be enough on its own – although it is necessary for progress. That's why we're offering suggestions of what you can actually do to help make chemistry accessible to everyone, whether you are reading this report as a policymaker, outreach provider, teacher or parent. This report is a wake-up call – and a call to action – for all of us.

Professor Tom Welton President, Royal Society of Chemistry



Science is not equally accessible to all – this is a well-documented fact. But evidence was lacking to demonstrate whether, and how, educational outreach can help to address the inequalities in progressing in chemistry. That was the problem that Chemistry for All set out to explore and I am delighted to be able to share our insights with you.

We have structured our report into sections for outreach providers, education policymakers, schools and teachers, and parents. You will find practical suggestions for actions you can take to address the challenges we know exist. We are publishing separately the full report by the team at University College London who carried out the research, where you can find much more detail about every aspect of the study.

Chemistry is essential to help solve global problems, and we need talented chemical scientists in all sectors to make a difference to the world. As the UK's professional body for chemistry, the Royal Society of Chemistry is passionate about the progression of students through their chemistry education and into the wide range of careers chemistry offers.

The action plan you see here is our commitment to change, and to working with partners to deliver on it over the coming years. This research will change the work that we do and, I hope, result in a greater diversity of young people considering a career in chemistry and sharing our excitement about how our amazing discipline can help to make the world a better place.

I am grateful to all the researchers, outreach providers, teachers and students who have all worked so hard over the course of five years to produce this research. The COVID-19 pandemic presents education in the UK with its greatest challenge for a generation, and the insights provided by your work couldn't be more timely.

Sarah Robertson, Director of Education and Professional Practice, Royal Society of Chemistry

Our action plan

The Royal Society of Chemistry's seven-point action plan is guiding our response to the Chemistry for All study findings.

We commit to:

1. Use the findings from Chemistry for All to inform a review of all of our outreach activities, to be implemented from 2022
2. Share the findings widely with outreach providers, and call on them to act on the recommendations
3. Fund next-generation outreach projects that remove socio-economic barriers
4. Launch an RSC “Outreach Hub” for effective outreach guidance and a growing library of resources
5. Celebrate high-impact outreach and engagement with new recognition mechanisms
6. Highlight relevant role models to put them at the heart of careers support we provide through our *A Future in Chemistry* resources
7. Support schools with a high proportion of free school meals to help them meet the *Gatsby Careers Benchmarks*

We're now asking the UK government, university and school leaders, and others to join us in tackling the disparity between the demographics of the chemistry undergraduate population and that of the wider population. Chemistry currently isn't 'for all' and that needs to change if we are to build an inclusive and prosperous society.

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Choosing to study chemistry, at school through to university, opens doors. It offers multiple career paths and job roles that contribute to our national and global prosperity.

The Royal Society of Chemistry believes that everyone should have access to high quality chemistry education, and yet there are barriers preventing many young people from participating.

Science is often considered less accessible by, and for, people from certain backgrounds. Relatively few girls, few children from families with less advantaged circumstances, and few children from some ethnic backgrounds have studied non-compulsory science subjects at upper-secondary school (ages 16-18) and at university.¹

These social inequalities are compounded by the perception that only 'naturally clever' people can study chemistry, and by a lack of role models to help students feel that chemistry can be for 'people like me'.

As a society we're failing some young people in helping them to realise their potential, and failing to increase diversity in our future workforce.

We want everyone to have the choice to study chemistry, with equality of opportunity for all.

Chemistry uptake varies by socio-economic background

Currently, there are multiple routes into chemistry.

At secondary school, there is the study of 'triple science' or 'double science'. Triple science is the study of the three separate sciences – chemistry, biology, physics – with a distinct GCSE award for each. 'Double science' is where students are awarded two GCSEs for studying all three sciences.

Students then have the option to go on to AS-levels, A-levels, BTEC or an apprenticeship. Each year, over 20,000 students choose Applied General qualifications in Applied Science (mainly BTECs) as their route to higher education. And in the 2018/19 academic year over 400 laboratory-based technician apprenticeships were started, which provide essential skills for the chemical sciences.

The current education system, which bases student selection for GCSE routes primarily on prior attainment,

means that the choices of many young people are being constrained. Educational gatekeeping practices are impacting the most socio-economically disadvantaged students in particular.

It's clear that social and economic factors widen the participation gap in chemistry.

A recent report by the Sutton Trust showed that students eligible for free school meals (FSM) in state-funded schools in England were significantly more likely than non-FSM eligible students to be entered into GCSE Combined Science ('double science').²

By comparison, non-FSM eligible students were more likely to be entered for the triple science GCSEs.

At A-level, chemistry students were more likely to be from the most socially advantaged backgrounds than those studying other subjects at A-level (25% vs 19%)³. They were also more likely to have high science capital compared with all other A-level students, including those studying physics and biology (14.1% compared with 2.7% for all other A-level students).⁴

The figures on the next page show the significant gap in undergraduate chemistry study between the most advantaged and disadvantaged students. Students from socio-economically advantaged backgrounds are more likely to study chemistry at undergraduate level than socio-economically disadvantaged students, with the least advantaged group numbering less than a fifth of the most advantaged group, despite occupying more of the total UK population (see figure).

It's important to recognise that students are not at fault if they do not choose chemistry post-16 or follow a chemistry-using career. The underlying issue is to provide and maintain support so that science/chemistry studying and careers can be consistently considered to be feasible and achievable, removing any barriers so that free and informed choices can be made.

¹ Elias, Jones, & McWhinnie, 2006; Homer, Ryder, & Banner, 2014; Institute of Physics, 2014; Royal Society, 2008; Royal Society of Chemistry, 2018.

² Burgess & Thomson, 2019. Making the Grade: the impact of GCSE reforms on the attainment gap between disadvantaged pupils and their peers.

³ Archer, Moote, MacLeod, Francis, & DeWitt, 2020. ASPIRES 2: Young people's science and career aspirations, age 10-19. London: UCL Institute of Education.

⁴ Moote & Archer, 2019, *Contextualising Chemistry Choices: Analysis of A level Chemistry students' aspirations, attitudes and choices in the ASPIRES 2 Year 13 dataset*: Unpublished report for the Royal Society of Chemistry. London, UCL.

Who studies chemistry at university?

This data shows the socio-economic family background of undergraduates in chemistry versus all subjects and the UK wider population (UCAS⁵)



Higher managerial and professional occupations
eg finance manager, chief executive



Lower managerial and professional occupations
eg teacher, accountant, scientist



Intermediate occupations
eg secretary, call centre, nursery nurse



Small employers and own account workers



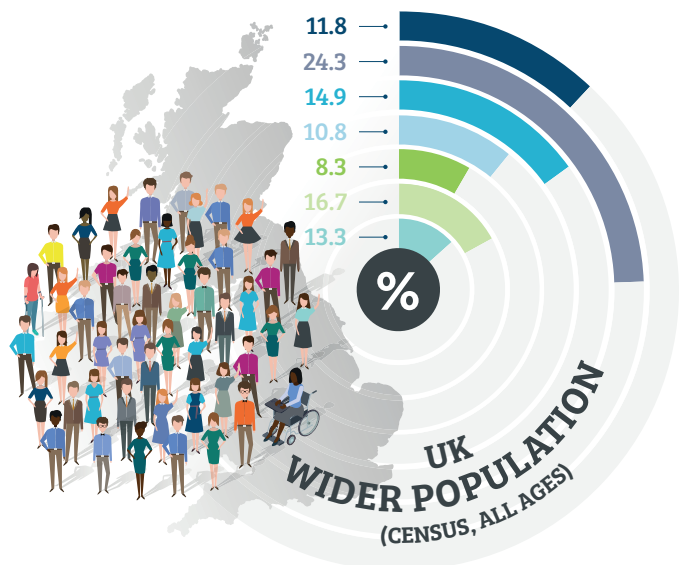
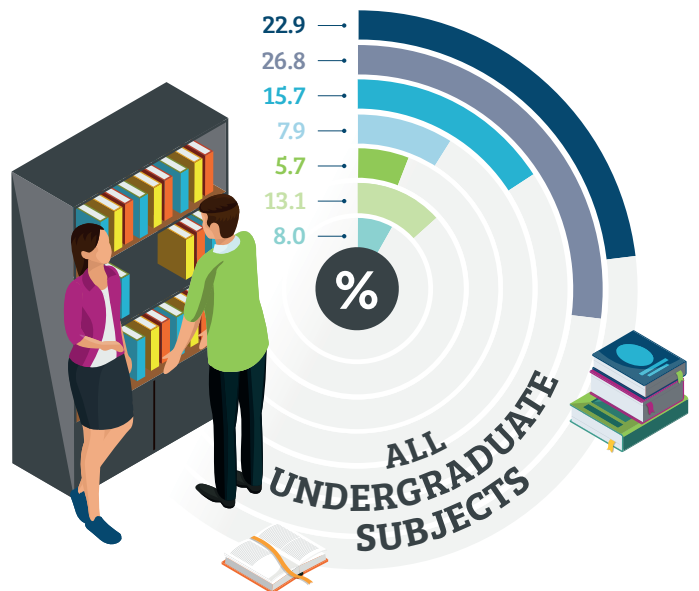
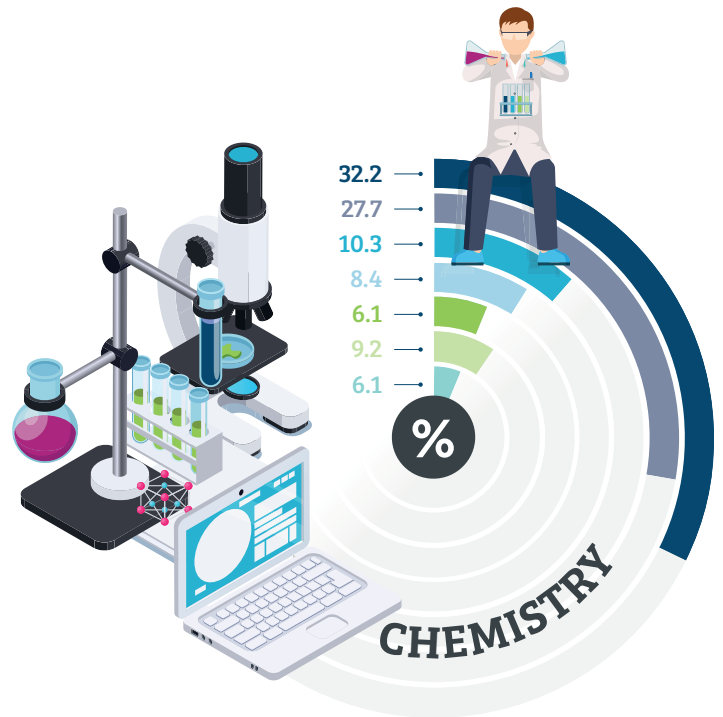
Lower supervisory and technical occupations eg motor mechanic, plumber, gardener



Semi-routine occupations
eg postal worker, security guard, sales assistant



Routine occupations
eg HGV driver, cleaner, bar staff



⁵ Student numbers are based on UCAS data purchase via the EXACT service (EXACT_003700 and EXACT_003704); Student numbers are for application cycle 2019 and numbers shown are End of Cycle Acceptances and as such reflect final places that students accepted to attend; Student numbers are subject to rounding according to UCAS disclosure controls; Students with SocioEconomicGroup2010 of 'Not applicable' are not included in the plots or percentage calculations (these correspond to students with non-UK Domicile); Because there are differences in the way that the Census and UCAS include and classify groups which are not in the first 7 SocioEconomicGroups (corresponding to unemployed, students, and un-classified jobs) we only include the first 7 SocioEconomicGroups and omit the following from display and the percentage calculation; UCAS SocioEconomicGroup2010 values of 'Not classified / unknown': Census SocioEconomicGroups values of "8. Never worked and long-term unemployed"; Census SocioEconomicGroups values of "L15 Full-time students"; UK Census data 2011 was downloaded from NOMIS at <https://www.nomisweb.co.uk/query/select/getdatasetbytheme.asp?theme=75&subgrp=UK+Quick+Statistics> (Overall SEC: QS607UK - NS-SeC)

About Chemistry for All

In 2014, the Royal Society of Chemistry set out to explore and address the barriers to participation in post-16 UK chemistry education through its five-year research and outreach study, Chemistry for All.

Funded by the Royal Society of Chemistry, the objectives of the study were to:

- contribute knowledge of the methodologies for studying the impact of long-term outreach interventions (whether neutral, positive or negative) on students from disadvantaged backgrounds
- provide insights into the success (or otherwise) of the outreach interventions in overcoming barriers to progression in chemistry
- raise awareness within the UK government, university and school leadership of the barriers to progression in chemistry.



Engaging with extra-curricular activities has been found to link with young people's attitudes and aspirations towards science.

This is especially powerful in the years preceding Key Stage 4 (ages 14 to 16) when young people have to make decisions about the subjects that will define their future studies and, potentially, their career.

With Chemistry for All, we set out to answer these questions:

- ?** **WHICH** outreach interventions increase participation in chemistry both post-16 and at university?
- ?** **WHAT** are the relative efficacies of these interventions in increasing participation in chemistry?
- ?** **TO WHAT** extent do these effective interventions have differential effects on particular student groups (eg by ethnicity, gender, socio-economic status)?
- ?** **HOW**, if at all, do these interventions depend on teacher and school characteristics and on the ages of students?

While the full Chemistry for All research report deals with these in depth, the purpose of this summary is to highlight the key findings and calls to action for the audiences we believe have a role in making chemistry more accessible to all.

Few long-term studies of this nature and scale have been undertaken which is why Chemistry for All represents an important step forward in our understanding of the barriers faced by young people from disadvantaged backgrounds to studying chemistry post-16.

How the study was conducted

Three university-based outreach providers conducted a programme of intervention activities in schools designed to engage with students from less advantaged backgrounds who might not normally consider and/or continue with chemistry.

Nottingham Trent University, Liverpool John Moores University and a partnership of the Universities of Reading and Southampton, recruited 17 schools from across the East Midlands, North West and the South East of England. Six other schools were recruited to provide a comparison, to establish whether or not Chemistry for All achieved any benefits.

Two cohorts of students received the Chemistry for All programme during Year 8, Year 9, Year 10 and Year 11 (from September 2014 until the end of the school year in 2019).

The programme encompassed diverse activities and events. For example, demonstrations delivered in chemistry lessons in schools, after-school clubs, careers lectures within schools, online careers and homework resources, visits to schools by ambassadors, visits to industrial companies, and activity days at universities. The type and extent of the activities and events could potentially vary over time and across providers.

All of the activities and events were intended to be contextualised to the schools – which broadly encompassed

many students with less advantaged socio-economic circumstances – and to the students as they progressed through secondary education. Initial activities and events, for example, often involved practical experiments, demonstrations and lectures that aimed to be enjoyable and inspirational, while subsequent events in later years often involved workshops to support revision and examination attainment.

The primary method of evaluating the effectiveness of the interventions was conducted via an annual survey to students at the Chemistry for All and comparison schools. Across the schools that received the programme, 6,367 students completed a questionnaire on at least one occasion.

Some students were also invited to be interviewed each year, to consider their views about their educational experiences, about science/chemistry, and their experiences of the Chemistry for All programme (if they were in schools that received the programme).

The interviews form the basis of the case studies and the twelve personas we use in the full report (and the quotes in this summary report) to underline the human impact of the inequality of opportunity that is afforded to underrepresented groups.





The outreach providers and programmes

In discussion with the Royal Society of Chemistry, the universities designed their own programmes of outreach activity to enrich the students' learning and complement the National Curriculum. The primary goal of the study was to understand barriers to progression in chemistry, however, not to evaluate specific models of intervention.

The universities were selected based on criteria that included:

- the design of their programme
- their understanding of the role of science enrichment and enhancement, specifically in relation to widening participation
- their understanding of the challenge of maintaining interventions long-term
- their ability to manage funding and partnerships
- the qualifications and experience of their teams.

Nottingham Trent University

Nottingham Trent University's CHEMWORKS programme was wide-ranging and included:

- chemistry resources for use in STEM (science, technology, engineering and maths) clubs
- annual 'chemistry challenge' days on-campus
- activities for KS3 with parallel teacher CPD sessions
- Come Alive With Science for KS3, based around inquiry and curiosity, with collaborations between artists, scientists, teachers and students
- Lab 13, a school-based space with a scientist in residence, where children's inherent curiosity could be let loose
- Creative Sparks, a bursary for Year 12 students to advance chemistry knowledge and curiosity which also involved working with a mentor
- Creative Approaches for Teachers CPD run by Ignite! with the aim of developing teachers' thinking and creative approaches to chemistry in schools.

The programme was bolstered by activities already funded through STEMworks, part of Nottingham City's Growth Plan. These included STEMNET ambassadors, pop-up informal family experiences run by Ignite!, speed careers networking, teacher continuous professional development (CPD) run by the education department, online school resources and some activities and STEM clubs already running in the participating schools.

Liverpool John Moores University

Liverpool John Moores' programme was designed to provide regular, half-termly in-school activities for the whole student year cohort, along with supplementary activities such as STEM clubs.

The university launched their Chemistry for All programme with a drama event run by undergraduate students during school assemblies.

Running activities within a timetabled slot during lessons enabled the university to support a wider range of practical activities than the participating schools might otherwise have been able to support due to restrictions on consumables, technical support and specialist chemistry teachers.

Schools were asked to bid for money to set up STEM clubs, which were available for any students wanting to attend.

Home-based events provided online resources for flexible use beyond school.

During each year of the project, the cohort students took part in hands-on chemistry sessions at the university's laboratories.

Universities of Reading and Southampton partnership

Chemistry youth clubs called the Chemistry Crew Club were central to the partnership's outreach activities.

The youth clubs went beyond the standard STEM club format, focusing on parental involvement, improving university related employability skills, fostering teamwork and a sense of belonging.

The content of the activities progressed with the students, and engagement with local primary schools helped to inspire younger students towards chemistry.

School-based speakers from the universities provided demonstrations ("Wow" lectures) and curriculum relevant talks, which were embedded through preparation and follow-up activities.

University-based days were held for years 8, 10 and 12 to avoid major examination periods and to act as an incentive for the students attending the Crew Club.

A Science Fair event at each school showcased the activities and students' achievements, with judging of 'products' by teams from the universities. These days would increase parental involvement.

The schools

Twenty three schools took part in the study across England (17 schools received the Chemistry for All programme and six other schools provided a comparison).

All of the schools had a higher percentage of students eligible for free school meals and eligible students with special education needs support, and lower average grades at GCSE (General Certificate of Secondary Education) or equivalent, than all secondary schools across England.

Each university used its own criteria for recruiting schools and students, usually in line with that set by its own outreach department. However, there was a minimum set of criteria based on a range of widely used indicators of disadvantage that each school had to fulfil.

Over the course of the five-year study, the changing views of students across schools that did and did not receive the Chemistry for All programme were captured to reveal whether the programme achieved any benefits.



Aspirations and attitudes – key findings

The students who took part in the research study were interviewed and asked the same core questions each year, to see how their aspirations and attitudes towards chemistry changed over time. Attitudes were measured in four areas, the key findings of which are summarised here.

1

USEFULNESS OF CHEMISTRY ('UTILITY VALUE')

A student's perceived utility value of science/chemistry is how they see science/chemistry as being useful and valued for facilitating their career, job, and future opportunities in general. Questions students were asked included 'Learning science/chemistry is worthwhile for me because it will improve my chance of getting a job'; 'Science/chemistry is an important subject for me because I need it for what I want to study later on'.

Key findings

- Students were motivated to continue with chemistry because of a greater awareness of how it could inform their future prospects ('extrinsic motivation'). They saw chemistry as a potential 'door opener' when effective careers advice was provided.
- Designing outreach programmes that raise students' perceptions of how science/chemistry can benefit not only specific job roles, but careers in general will help raise their aspirations to continue studying chemistry.



Chemistry isn't for people like me



INTEREST IN AND ENJOYMENT OF CHEMISTRY ('INTRINSIC MOTIVATION')

For some young people science/chemistry is naturally satisfying and this can lead to significant positive associations with their chemistry aspirations. Questions asked included: 'I look forward to my science/chemistry lessons'; 'Science/chemistry is an interesting subject'.

Key findings

- Students' interest and enjoyment in science/chemistry was boosted by the practical elements of the Chemistry for All programme, which included demonstrations and university visits.
- When teachers used science/chemistry to help students understand the world around them it positively impacted their interest in and enjoyment of the subject.
- Providing science clubs and also ambassadors (volunteers from science-related fields who visit schools to give career talks, provide advice, and deliver demonstrations) increases students' interest in science/chemistry.

2

How is this study relevant to me?

The key findings regarding students' aspirations and attitudes tell us a lot about what action is needed to make chemistry more accessible. But influencing change requires collective effort.

So, over the next few pages of this report, we reflect on the major findings and include calls to action for the people and organisations who have the power to make a real difference.

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SELF-CONFIDENCE

Students' self-confidence in science/chemistry is an indicator of their future aspirations to study chemistry post-16. Questions asked included: 'I am good at science/chemistry'; 'I'm certain I can figure out how to do the most difficult science/chemistry tasks in classes'.

Key findings

- Ethnic minority girls in particular had issues of self-confidence, which were effectively combatted by raising awareness about the benefits of a non-compulsory chemistry qualification.
- Students' self-confidence was positively impacted by opportunities to get involved in class discussions, to attend a science/chemistry club, and their teacher using science/chemistry to help them understand the world.
- Opportunities to get involved in extra-curricular activities improve students' self-confidence, particularly if they are able to make connections with role models that help them to feel chemistry can be for 'people like me'.
- Encouragement from family and teachers positively impacts students' self-confidence, regardless of socio-economic background.

3



PERSONAL VALUE

For some students, chemistry is a valued and inherent aspect of their identity and may be important for remaining within chemistry. Questions included: 'Science/chemistry is important to me personally'; 'Thinking scientifically is an important part of who I am'; 'Being able to do science/chemistry helps me show other people who I am'.

Key findings

- Social and cultural expectations can influence what young people consider to be appropriate for themselves – they may feel that chemistry is not 'for people like me'.
- There are ways to build students' personal value in chemistry, including the use of diverse and relevant role models in school teaching, and challenging the assumption that you have to have 'natural ability' to participate in chemistry.
- Examples of successful people in chemistry who have 'worked hard' rather than rely on 'natural cleverness' help to make chemistry feel more appealing and approachable to a range of students.

4

For outreach providers



“ ”

It was having a look around the university in all the different kind of labs and stuff, and having talks about what machines and what they do and what you can do with them and what you can find out. That was really interesting.

Mixed race female

What did we learn?

The qualitative analysis has given us insights into some of the complex connections between students' experiences, their lives, and their attitudes towards science and chemistry.

While students recognised the importance and value of science, they were generally less positive about non-compulsory science/chemistry studying and careers. This disparity was even more prominent across students with different levels of socio-economic circumstances and family science capital (family members having science-related qualifications, jobs, and/or liking to talk about science).

Overall, the study shows that the perceived benefits of the outreach events and activities were higher when there was more engagement with the Chemistry for All programme.

In fact, 53.1% of students at Chemistry for All schools – and who attended more than one optional event/activity – stated an increased interest in science/chemistry compared with 28.8% of students at comparison schools. Students at Chemistry for All schools who took part in one or more optional events or activities also expressed a higher level of confidence in doing science/chemistry compared with students in the other schools.

Crucially, students from underrepresented groups (such as girls, those from certain ethnic minority backgrounds, and/or those with less advantaged socio-economic circumstances) who had attended careers-focused Chemistry for All events became more enthused about non-compulsory chemistry courses and were able to make more informed decisions about continuing with chemistry.

They were really good; they brought the energy and they were really enthusiastic, so that made us enthusiastic, as well. And, because they were young, they were university students, we could really relate to them.

Maryam, student of Bangladeshi heritage, low socio-economic background, high family science capital

What does effective outreach look like?

Although the study did not attempt to evaluate a pre-defined programme of activities, we learned which approaches worked best, and which had little impact on students and their attitudes to studying chemistry post-16.

Many aspects of the Chemistry for All programme helped to create connections between students' identities and chemistry.

Trips to outside organisations and campus-based events at the universities proved popular, giving students the opportunity to take part in practical challenges and also experience a little of what life at university is like.

The study also revealed that after-school clubs, although having a positive impact on those attending, only attract a small number of students and are dependent on support from teachers. One student in the study was unable to attend the after-school clubs as she had to collect her younger sibling from school and babysit whilst her mother worked. This is an example of how a student's personal circumstances can lead to missed opportunities for learning enrichment.

However, revision clubs worked well for students in exam classes.

One important task that the Chemistry for All programme was able to do that schools were unable to do as well was to have practical experiments that linked the relevance of chemistry to everyday life. Schools do not necessarily have extensive resources or facilities to conduct non-routine experiments and these findings illustrate how a school-outreach provider partnership can help bridge this gap.

Outreach activities run by the STEMNET ambassadors helped to build students' personal value of chemistry. The use of a female Middle Eastern international student had a positive effect on students of Muslim heritage, for example. This supports our research findings that diverse and relevant role models help students to feel that chemistry can be for 'people like me'.

Outreach programmes must be tailored to the school. As the programme went on, the university outreach providers refined some of their activities following feedback from schools and students of the first cohort. This led to changes to the original plans. For example, some schools needed more support with the curriculum so there was an increased emphasis on curriculum topics as students progressed into

Year 10, with revision classes forming the main school-based offerings in the final two years of the project.

By the end of the Chemistry for All programme, there was a firm and clear link between choosing A-level chemistry and recognising that chemistry qualifications can provide opportunities later in life.

We have written a separate report detailing lessons learned from Chemistry for All, and how these can be applied in planning more effective outreach. This, and further helpful resources, are available at rsc.li/ChemistryForAll

The challenges of working with hard to reach schools

Retaining high levels of engagement with the programme at school level proved challenging. Schools that were struggling to retain staff and where there was a high turnover of teachers were the least engaged with the interventions. A consequence of this was that the requirements for the study needed constant reinforcement. A number of schools were also impacted by staff sickness and stress which had a negative effect on intervention engagement at the school level. Teachers at one school cited heavy workloads as the school attempted to get out of the 'special measures' category.⁶

Engagement at student level presented its own challenges too. Accessing the after-school clubs was difficult for some students and highlights the missed opportunities that some young people from disadvantaged backgrounds experience.

The complex logistics of one institution managing a long-term research project alongside an activity programme was also evident. For example, while the activity providers had week-by-week contact with the schools and lead teachers, they didn't want to get involved in the collection of survey data as they felt this might compromise their relationship with the schools. However, it was often necessary for activity providers to support the research team by following up requests for data with school staff.

Engaging teachers early on and throughout an outreach programme is also crucial to its success, whether or not the programme is targeting hard to reach schools.

The study highlights the need for schools and external partners to acknowledge the role of the lead teacher which must be clearly defined, expectations set, and communicated effectively.

⁶ Ofsted may judge a school 'inadequate' which means the school either has serious weaknesses or requires special measures.

How can outreach providers respond to the findings?

The findings highlight a number of ways in which outreach providers can increase chemistry participation.

- Help give students access to high quality practical work in chemistry and exposure to the diversity of people who work with/in chemistry.
- Work with teachers in a way that does not require them to miss classes.
- Build up relationships with local schools in ways that do not rely on the enthusiasm of just one or two teachers in a school. Also, engaging with school leadership may help facilitate and ensure lasting and holistic changes within schools.
- Take active steps to ensure that your provision is not predominantly taken up by more advantaged students, such as students with families that regularly encourage them to attend optional events, and students who can attend events held off school premises.
- Provide a small number of high quality extracurricular engagements with chemistry rather than large numbers of lower quality ones.

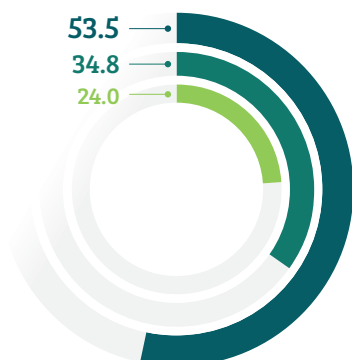
“ ”

Well, through this programme it explained quite a lot about what studying at university and studying science at university was like, how it is quite a developing line of work, and how a lot of universities are looking for students now, so it has kind of given me more confidence in applying and that I could get in.

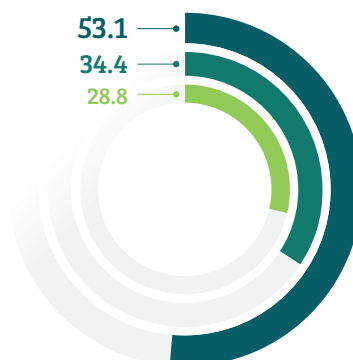
Luke, British white male, high socio-economic status, high family science capital

Perceived benefits of the Chemistry for All activities/events

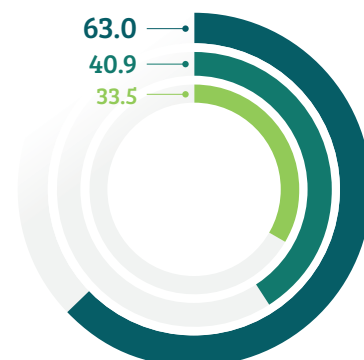
Percentage of students who expressed increased knowledge of the benefits of a non-compulsory science/chemistry qualification



Percentage of students who expressed increased interest in science/chemistry



Percentage of students who expressed increased confidence in doing science/chemistry



■ Chemistry for All school where students attended more than one optional event/activity
 ■ Chemistry for All school
 ■ Comparison schools

“ ”

It's [Chemistry for All] encouraged them to join our STEM clubs and it's encouraged their enjoyment of the science lessons, yes.

Teacher



Next steps

1

CREATE networks with your local providers/schools and establish relationships.

2

COMMUNICATE to plan impactful outreach tailored for the individual school.

3

USE our forthcoming Outreach Hub for further guidance of planning effective outreach and resources.

4

PRESENT a new discourse and practices as teachers and outreach providers around representations of chemistry and its wider role in society, pathways and grade requirements for non-compulsory chemistry, and 'natural ability' in chemistry.



Download the full report

for a deep dive into the findings.



For education policymakers, awarding bodies, professional organisations and funders

This leads to higher entry requirements being set by schools at sixth form and by sixth form colleges. As a consequence, teachers and parents may advise students away from those subjects, and students may also self-select away from chemistry, especially if they lack confidence.

Inequalities within chemistry education may continue to persist because students' personal circumstances can impact how they perceive their chemistry/science education and also play a key role in how students develop a chemistry identity and future aspirations.

For example, one student in the study indicated that she was unable to attend the after-school clubs as she had to collect her younger sibling from school and babysit whilst her mother worked. Various social inequalities can impact students in a range of ways; clearly this school did not pick up (which isn't unusual) that there could have been some students who might have liked and benefited from attending after-school clubs but were unable to do so because of personal circumstances.

This is an example of how social inequalities can lead to further widening of any initial differences in participation and/or trajectories towards or away from science. If there is no acceptance that students' personal circumstances can be barriers or facilitators of aspirations and identification, then school pedagogy and other aspects of education cannot change to help mitigate such issues.

The Chemistry for All programme has shown that targeting students from disadvantaged backgrounds can indeed draw students into the chemistry pipeline and strengthen their identification with chemistry.

Students from less advantaged socio-economic backgrounds and/or backgrounds with lower family science capital (family members having science-related qualifications, jobs, and/or liking to talk about science) were able to experience and engage with extra-curricular activities. This helped to raise their understanding about the relevance of science/chemistry to society, increased their interest and confidence in doing science/chemistry, and increased their knowledge of the different routes available to study non-compulsory science/chemistry.

What did we learn?

The Chemistry for All programme set out to reduce the aspiration gap between socio-economic groups and this appears to have been achieved.

However, issues around gender were still apparent. Ethnic minority girls, in particular, felt discouraged from considering chemistry post-16 and viewed students who were naturally good at chemistry with little effort as the only ones who could legitimately remain within the chemistry pipeline.

In contrast, boys from families with high family science capital (family members having science-related qualifications, jobs and/or liking to talk about science) were the most confident in their abilities in chemistry.

This perception that only naturally clever people can do chemistry is compounded by the fact that post-16 qualifications in the sciences are more severely graded than other subjects and there is a widespread perception that it is harder to obtain an 'A' grade in chemistry.

“ ”

... because of the programme I'm more likely to want to go into chemistry. I think it gave me a deeper knowledge into it. I think it did somewhat help influence my decision to carry on with it.

Sairah, British female of Pakistani heritage, low/medium socio-economic status, low family science capital

The Chemistry for All programme was able to raise students' awareness of the careers available with a post-16 qualification and a general interest in chemistry. Many students didn't realise the breadth of career options that a chemistry qualification can lead to.

Interventions like the STEMNET ambassadors helped to build students' personal value of chemistry. The use of a female Middle Eastern international student had a positive effect on students of Muslim heritage, for example. This supports our research findings that diverse and relevant role models help students to feel that chemistry can be for 'people like me'.

Enriching the chemistry curriculum reduces the barriers to participation

Currently, the way that chemistry is presented and portrayed does not maximise its appeal across all social groups and this needs to change.

Regular teaching will always struggle to engage certain student groups if dominant representations of chemistry are not challenged within the classroom itself. Examples of successful people in chemistry who have 'worked hard' rather than relied on 'natural cleverness' will help to make chemistry feel more appealing and approachable to a range of students.

Many students are not afforded the opportunity to experience meaningful practical work in their chemistry education and yet it is a core aim of the chemistry curriculum.

Through the practical elements of the Chemistry for All programme, students were able to learn about the relevance of chemistry to everyday life and how it contributes to society (such as helping to solve global issues for example). Indeed, the student interview narratives reflect this, with students saying that practical work helped to foster their personal value of chemistry and their interest and enjoyment of chemistry.

Schools, however, do not necessarily have extensive resources or facilities to conduct non-routine experiments. This could make it more challenging for them to convey the wider applications of chemistry. Teachers also report that there is little time within the curriculum for teachers to cover all the content required and schools may benefit from more resources and support to deliver such experiences, including opportunities for partnerships with universities and industries.

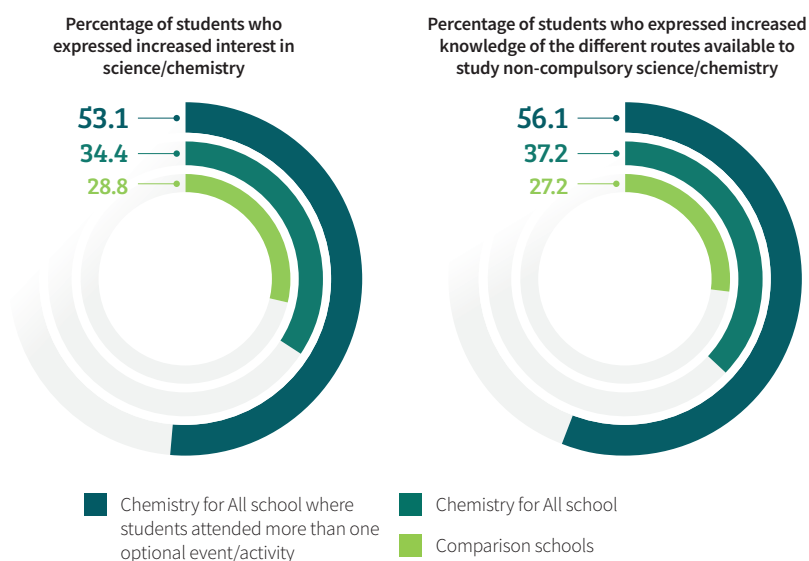
Practical work isn't the only approach to bringing chemistry to life, but policymakers should ensure that the development of practical skills remains embedded in the curriculum and that practical work in schools is supported and resourced.

How can education policymakers, awarding bodies, professional organisations and funders respond to the findings?

In order to increase the number of students who continue with chemistry post-16, and increase the numbers continuing from underrepresented groups, policy and practice needs to address a number of issues.

- Challenge the perception that chemistry is a difficult subject only suitable for 'naturally clever' students.
- Support teachers in providing examples in curricula of successful people in chemistry who have 'worked hard' rather than relied on 'natural cleverness'.
- Ensure a diverse range of people (gender, ethnicity, social background, age, etc) are portrayed as contributing to chemistry and working in it and with it.
- Careers advice and information about the range of courses and qualifications available with a post-18 chemistry qualification needs to start in early secondary school; this will help more students realise that there are a range of paths that they can take.
- Facilitate partnerships between schools and organisations (universities, professional bodies, industries) that can complement what schools do for students' learning of and engagement with chemistry.
- Keep schools engaged, particularly senior management, and reduce the demands made on their time.
- It is better to target funding on a relatively small number of schools over a period of several to many years than to target a larger number of schools for just one or two years.

Perceived benefits of the Chemistry for All activities/events



“ ”

It would be impossible [to run the sort of experiments that Chemistry for All have conducted]. The amount of funding even for the chemicals, the equipment, for some of the practicals that have been done we [the school] just haven't got the funds to be able to do that.

Teacher



Next steps

- 1** **URGENTLY** reassess long-standing barriers in education such as grading severity, inequality embedded by dual routes of study, inaccessibility and confidence.
- 2** **SUPPORT** young people's understanding of the value of chemistry to society and to their future careers. Embed this in the curriculum as an expected learning outcome, and support teachers with resources and ongoing professional development opportunities. Provide fit-for-purpose careers advice.
- 3** **FUND** effective practical work and outreach activities adequately.



Download the full report
for a deep dive into the findings.



“ ”

It's [Chemistry for All] encouraged them to join our STEM clubs and it's encouraged their enjoyment of the science lessons, yes.

Teacher

For schools and teachers

What did we learn?

There is a perception that only 'naturally clever' people can do chemistry. This becomes even more apparent within certain disadvantaged groups. Ethnic minority girls, in particular, felt discouraged from considering chemistry post-16 and viewed students who were naturally good at chemistry with little effort as the only ones who could legitimately remain within the chemistry pipeline.

In contrast, boys from families with high family science capital (family members having science-related qualifications, jobs and/or liking to talk about science) were the most confident in their abilities in chemistry.



The socially constructed phenomenon of naturally clever chemists/scientists is compounded by the fact that post-16 qualifications in the sciences are more severely graded than other subjects and there is a widespread perception that it is harder to obtain an 'A' grade in chemistry. This leads to higher entry requirements being set by schools at sixth form, teachers and parents advising students away from those subjects, and students self-selecting away especially if they lack confidence.

The qualitative findings indicate that although some students from less advantaged socio-economic backgrounds were not sure about continuing with science or chemistry at the start of the study, by Year 11 some students had developed stronger chemistry (and science) identities, where the impact of the Chemistry for All programme played a large part. Some had also chosen to take chemistry A-level. Crucially, raising ethnic minority girls' awareness about the benefits of a non-compulsory chemistry qualification helped to combat some of the issues around their confidence and the dominant discourse of 'natural ability' in chemistry.

Demonstrating the relevance of chemistry to everyday life increases students' interest in the subject

The study reveals that teachers positively impacted students' attitudes towards science/chemistry when using science/chemistry to help students understand the world around them. The findings reveal a positive shift in students':

- aspirations towards science/chemistry
- interest in and enjoyment of science/chemistry
- perceived 'utility value' (the extent to which students see the value of chemistry to their life) of science/chemistry
- self-confidence in science/chemistry
- perceived value of science/chemistry to society

Other positive predictors of students' interest in and enjoyment of science/chemistry included attending science/chemistry clubs, doing practical experiments, and having the chance to explain ideas and opinions. These areas have the potential to help foster students' attitudes and beliefs, regardless of schools applying formalised programmes of activities and events.

Almost all interviewees were aware that undertaking a post-16 chemistry qualification would be of benefit. Those who had attended Chemistry for All events that specifically talked about careers were able to become more enthused about chemistry and make more informed decisions.

Teachers also recognised and highlighted that the Chemistry for All programme raised students' interest in and enjoyment of chemistry and the sciences, which in turn raised students' wider attitudes towards science at school.

The role of the lead teacher in schools was central to the success of Chemistry for All. They were responsible for recruiting students to take part, and were the point of communication for the university activity provider and research teams. However, the teachers who took on this role did so on top of their everyday work and were not given additional time, payment or specific recognition by their schools. The findings highlight the need for schools and external partners to acknowledge the role of the lead teacher which must be clearly defined, expectations set, and communicated effectively.

“ ”

I was a little sceptical perhaps thinking it was interesting but perhaps far too difficult for someone like me, that was my initial thought ... it showed me that if you have the right teaching staff and everything it can actually be open to everyone and very possible indeed.

Mark, British White male, strong chemistry identity, high socio-economic background, high science capital



How can schools and teachers respond to the findings?

Inequalities within chemistry education will continue to persist because students' personal circumstances can impact how they perceive their chemistry/science education, and also play a key role in how students develop a chemistry identity and future aspirations. This fact needs to be acknowledged so that school pedagogy and other aspects of education can change to help mitigate such issues.

With that in mind, there are a number of ways in which schools and teachers can help with removing barriers to participation and progression in chemistry.

Tackling the dominant representations of chemistry will help students to see the relevance of chemistry, in terms of their general understanding, its contribution to society, and possible careers. Using examples of successful people in chemistry who have 'worked hard' rather than relied on 'natural cleverness' will help to make chemistry more appealing and relevant to a range of students.

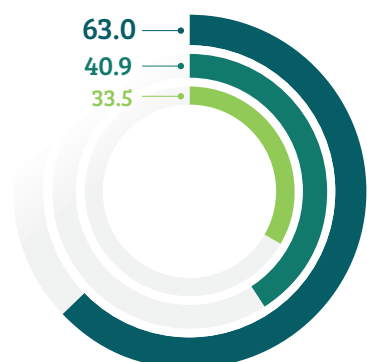
Effective outreach programmes enhance and enrich the science/chemistry curriculum. Working in partnership with an outreach provider to deliver a small number of high quality extracurricular activities can reduce barriers to progression, as long as those activities are accessible. For example, one student in the study indicated that she was unable to attend the after-school clubs as she had to collect her younger sibling from school and babysit whilst her mother worked. The school was unaware of this and highlights that there could have been some students who might have liked to attend and benefited from after-school clubs but were unable to do so because of their personal circumstances.

To help students realise that there are a range of career paths they can take, careers advice and information about post-18 courses and qualifications needs to start in early secondary school.

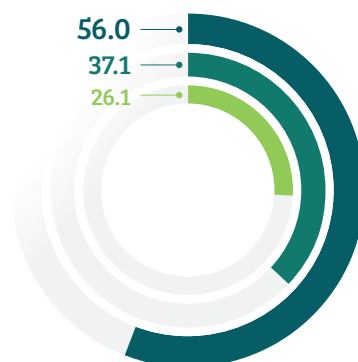
Schools can also tackle the severity of grading of post-16 qualifications, which tends to be higher than for other subjects, by reflecting on and/or lowering entrance grades.

Perceived benefits of the Chemistry for All activities/events

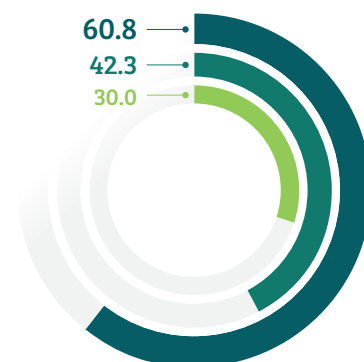
Percentage of students who expressed increased confidence in doing science/chemistry



Percentage of students who expressed increased knowledge of the benefits of a career in science/chemistry



Percentage of students who expressed increased understanding of how science/chemistry relates to everyday life



■ Chemistry for All school where students attended more than one optional event/activity
 ■ Chemistry for All school
 ■ Comparison schools

“ ”

It [the Chemistry for All programme] introduced many apprenticeship options, all of the different university courses, so it did really open that up ... with the programme we were taught about apprenticeships, and I hadn't really considered that before but it, obviously, made me realise that it is a good option.

Maryam, student of Bangladeshi heritage, low socio-economic background, high family science capital



Next steps

1

SHARE this report and discuss the findings with your colleagues.

2

PROVIDE examples of successful people in chemistry who have ‘worked hard’ rather than relied on ‘natural cleverness’. Take a look at our resources at *A Future in Chemistry*.

3

EXPLORE effective models of outreach for schools in difficult circumstances and discuss with your local university or outreach provider – you know your students best and you are an equal partner in the design and implementation of your outreach programme.

4

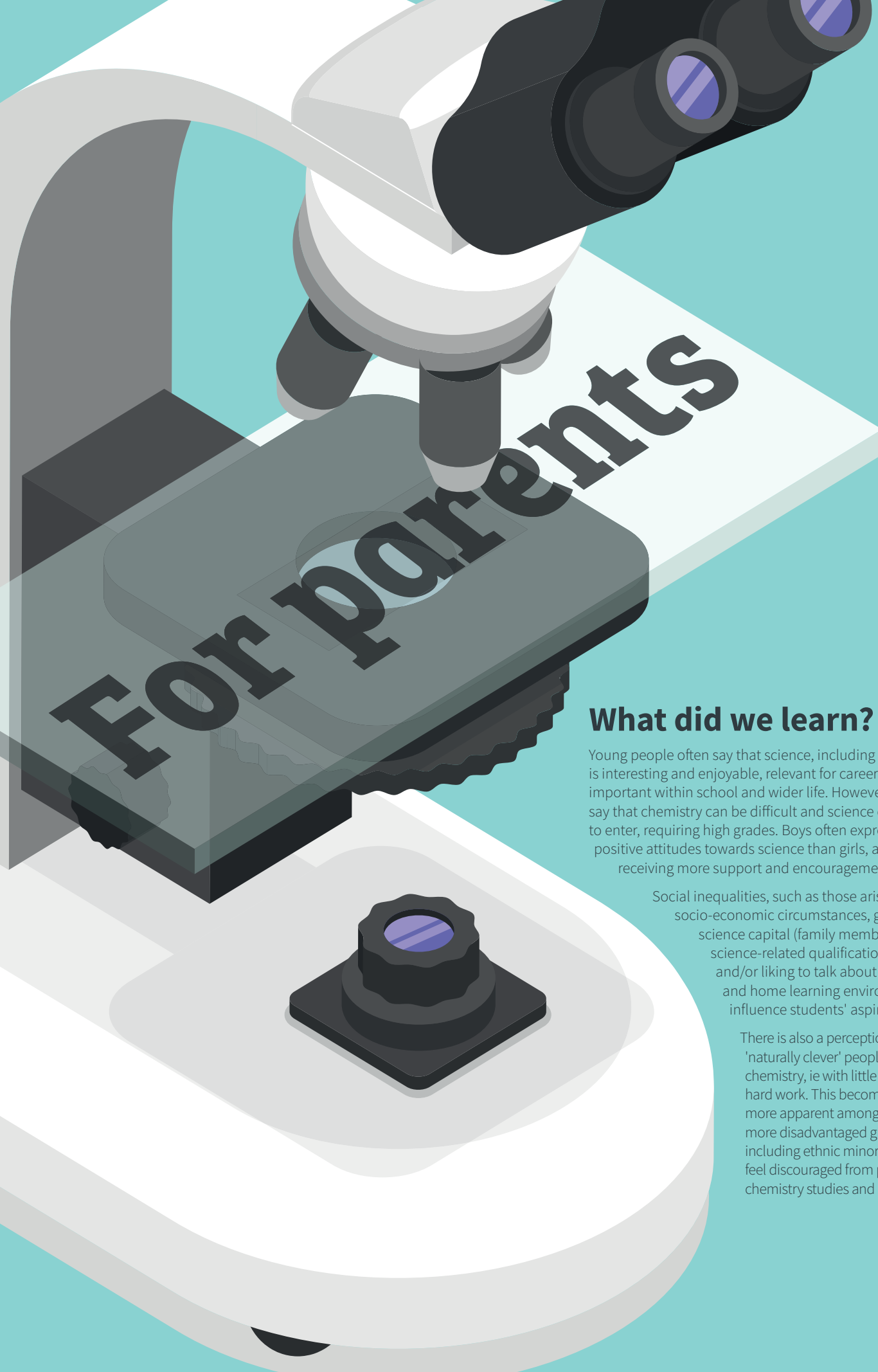
FACILITATE partnerships between your school and organisations including universities, professional bodies, and industries that can complement what you do for your students' learning of and engagement with chemistry.

5

ENSURE that the role of the lead teacher (who is critical to the success of your outreach programme) is clearly defined and communicated. The lead teacher may require extra support and development to implement activities.



Download the full report
for a deep dive into the findings.



What did we learn?

Young people often say that science, including chemistry, is interesting and enjoyable, relevant for careers, and important within school and wider life. However, they also say that chemistry can be difficult and science careers hard to enter, requiring high grades. Boys often express more positive attitudes towards science than girls, and report receiving more support and encouragement.

Social inequalities, such as those arising from socio-economic circumstances, gender, family science capital (family members having science-related qualifications, jobs and/or liking to talk about science) and home learning environments, influence students' aspirations.

There is also a perception that only 'naturally clever' people can do chemistry, ie with little effort or hard work. This becomes even more apparent among girls from more disadvantaged groups, including ethnic minority girls, who feel discouraged from pursuing chemistry studies and careers.

Yes, my dad, he wants it [me to study chemistry]. If he could do his time over again, he would try so much harder in chemistry and physics because he likes those two subjects in particular. So, yeah, he encourages me along to try my best.

Tara, British female of mixed race Black Caribbean and White heritage, strong chemistry identity, average socio-economic status, high science capital

Despite doing as well as boys and being on track to study chemistry courses, the study shows that girls are selling themselves short by removing themselves from the chemistry pipeline because they feel that they are not good enough.

In contrast, boys from families with high family science capital were the most confident in their abilities in chemistry, and were more likely to make firm decisions about continuing with the sciences at university.

With the Chemistry for All programme we set out to reduce the aspirations gap between socio-economic groups and this appears to have been achieved.

Students reported the following perceived benefits as a result of taking part in the Chemistry for All activities and events:

- increased aspirations towards science/chemistry
- increased interest/enjoyment in science/chemistry
- increased self-confidence in science/chemistry
- increased knowledge of the benefits of a career in science/chemistry
- increased understanding of how science/chemistry relates to everyday life



... there's a variety of jobs that I'm aware of now which I wasn't before in the programme and I may well pursue those in the future, yes ... Well, it definitely helped with my GCSE grades because it was, it had a deeper understanding of the sciences and so then I got good grades so I was wanting to progress towards the scientific areas so it made a difference in that respect, yes.

Mark, British white male, high socio-economic status, high science capital

The importance of role models and encouragement

The research shows that when family members and teachers provide role models it helps to make chemistry feel more accessible.

The interviews with students revealed that those who came from backgrounds with a positive home learning environment and/or family science capital, opted to study the subject further. For example, one student, Lisa, was encouraged to continue with chemistry by her father, as was her older sister who continued in the sciences. Access to work experience provided by her sister enabled Lisa to picture herself as a chemist.

Another student, Fatimah, talked about her mother being a large influence. Despite coming from a single-parent family and being of ethnic minority status, which are backgrounds

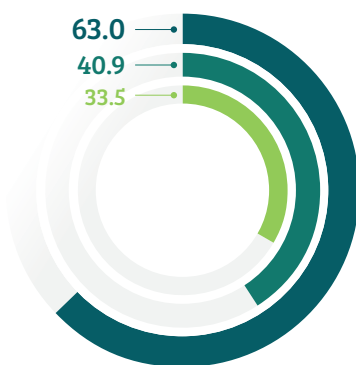
often associated with low aspiration, Fatimah had high aspirations and confidence in her own ability in chemistry. This appears to be linked to the encouragement she received from her mother and her teacher, and from taking part in the Chemistry for All activities.

Students who reported a positive home learning environment for science/chemistry (ie where their family provides help, wants to talk about science/chemistry work, and wants them to be successful in science/chemistry) expressed higher aspirations.

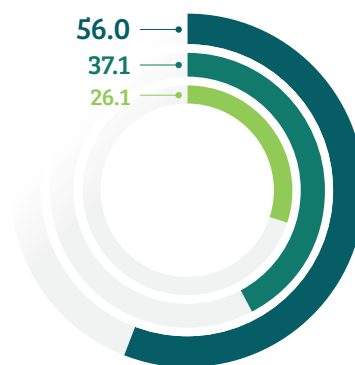
The Chemistry for All programme highlights that the provision of a diverse and long-lasting programme of activities and events has a positive impact on young people's attitudes towards their studying and career aspirations.

Perceived benefits of the Chemistry for All activities/events

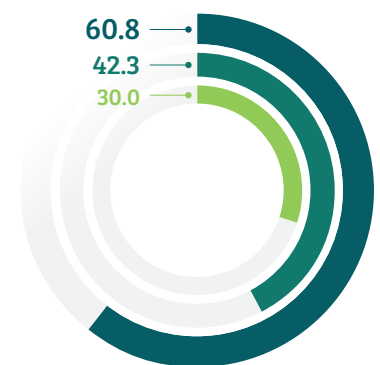
Percentage of students who expressed increased confidence in doing science/chemistry



Percentage of students who expressed increased knowledge of the benefits of a career in science/chemistry



Percentage of students who expressed increased understanding of how science/chemistry relates to everyday life



■ Chemistry for All school where students attended more than one optional event/activity
 ■ Chemistry for All school
 ■ Comparison schools


“ ”

I didn't think I would be good at chemistry when I was younger but over the years I started to realise chemistry could be for me. I found the chemistry clubs [Chemistry for All] really interesting, yeah, enjoyable. When we did stuff, I thought yeah I can do this and it's fun ... my mum tells me I need to go to the clubs after school, she says it will be good for me, for later maybe [meaning A-level choices] and it's something interesting to do.

Fatimah, low socio-economic status, single-parent ethnic minority background



How parents can help

- **ENCOURAGE** your child to think about their future and talk to them about what they like doing, what's important to them and how they like to learn.
 - **SPEAK** with your child's school about the careers advice and support they offer. What work experience do they offer? Are there any future careers events or fairs that you could attend together?
 - **ENCOURAGE** your child to enjoy chemistry outside the classroom – find out if there are extra-curricular activities in your area. Your school, local university, STEMNET (the Science, Technology, Engineering and Mathematics Network), museums and your local council are all good places to start.
 - **COMMUNICATE** to your child that everyone can succeed at learning chemistry, no matter their background. Avoid stereotypes of gender and social or ethnic background that might impact your child's self-esteem and motivation.
 - **EXPLAIN** that chemistry opens the door to many different job roles and careers, and offers good rates of pay.
 - **WATCH** the videos of real-life scientists and use the resources on our *A Future in Chemistry* website with your child.
 - **RESEARCH** available options early if your child is considering further study or an apprenticeship, as there are a lot of courses on offer. Check the entry requirements for courses and find out when and how to apply.
- 

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