Position Statement

Practical Chemistry Education:
A vision for practical chemistry in 5-19 education

Last reviewed: May 2024

Summary

Practical chemistry is an essential part of the chemistry discipline because it supports the understanding of the subject as an empirical science and is core to understanding the question 'How do we do chemistry?'.[1] The skills developed through practical work can be used by young people in their future studies and careers in the sciences and beyond. Practical chemistry can also introduce students to the real-life application of the sciences and develop an understanding of hazards and risks.

We believe it is crucial that **all** learners should have access to relevant and regular practical chemistry activities throughout their chemistry education, which are sustainable, inclusive, accessible and have a clear purpose. However, we are concerned that there are barriers to practical chemistry across all UK nations due to the lack of science technicians; lack of funding; insufficient time within the science curriculum to teach practical chemistry and inadequate subject specific professional development available for science teachers.

Introduction

We believe that the purposes of practical chemistry activities are:[2]

1 To learn and develop practical skills (manipulative, procedural, scientific enquiry, and wider skills) that may be useful in future study or employment.
2 To improve understanding of scientific theory.
3 To increase motivation and engagement of students.

All practical chemistry activities are valuable, and the purposes of practical chemistry can be achieved by undertaking activities such as following lab procedures and techniques; designing, planning and running investigations; watching teacher demonstrations and experiencing phenomena.[3]

Practical skills should be developed over the course of a young person's 5-19 education. They can be divided into four areas:[4]

1 Manipulative skills: setting up and using laboratory equipment; taking measurements; using computational simulations.

2 Procedural skills: being safe in the laboratory; following a scientific method; choosing suitable equipment.

3 Scientific Enquiry skills: making observations; making predictions; identifying variables; asking questions; analysing data; collecting data; interpreting data; drawing conclusions; pattern seeking; identifying, classifying and grouping; using secondary sources; writing lab reports; presentations.

4 Wider skills: time-management; teamwork; organisation; communication; confidence; numeracy; using software such as Microsoft Excel to plot graphs and present data; researching; referencing.

Some skills are possible to develop by completing a variety of desk-based activities, such as analysing data from a textbook. However, these should complement but not replace hands-on practical chemistry activities.

Key Messages

We believe that students should take part in direct, first-hand, and often hands-on practical experiences and activities to support them in developing their practical skills, their understanding of theoretical concepts and increase their motivation and enjoyment of chemistry. All learners should be able to access relevant and regular practical activities during their chemistry education and educators should receive support to integrate accessibility and inclusion when designing practical chemistry lessons.

Practical chemistry activities should be appropriately risk assessed by schools. Guidance for undertaking risk assessments is provided by the Consortium of Local Educational Authorities for the Provision of Science Services (CLEAPSS) in England, Wales and Northern Ireland, the Scottish Schools Education Research Centre (SSERC) in Scotland and the Health and Safety Authority (HSA) in the Republic of Ireland.

Considering young people's identity within practical chemistry lessons can be a way to foster engagement and help young people feel that chemistry can be for them.[5] [6] Additionally, when considering accessibility, schools should consider SEND students' needs within the classroom and ensure that laboratory equipment and practical chemistry tasks are accessible, so that they can gain as much first-hand experience as possible.[7] [8]

It is important that teachers know why young people are undertaking practical activities and clear aims for these activities should be identified and explained to students. Whether learning a theoretical concept, a practical skill, or both, it is important that students have enough prior knowledge to help them link the purpose of the learning to the practical chemistry activity.[9] As practical chemistry is often considered to be learning about science as well as learning to do science, a 'hands-on minds-on' approach could be adopted.[10]

There is evidence that practical activities can foster short term engagement and there is widespread acknowledgement amongst teachers that pupils generally enjoy taking part in practical work.[11] There are also studies where young people convey that practical activities supported their motivation and engagement with science. [12] [13]

Our research has shown that teachers in the UK and Ireland find the following issues a barrier to running practical chemistry activities: insufficient time for practical to be taught alongside theory; challenging student behaviour; the cost of consumables and chemicals; lack of equipment; no time for training or practising and understaffing of science technicians.[14]

To ensure that practical activities remain a core part of the chemistry discipline in the UK and Republic of Ireland, we recommend that:

1 There is sufficient time within the curriculum to run a variety of practical chemistry activities. This would enable young people to develop a breadth of practical skills and improve their understanding on a wider range of scientific theories.

2 Schools are supported to provide hands-on practical activities as a part of their curriculum through sufficient funding for consumables and equipment as well as enough[15] science technicians.[16]

3 Teachers and school science technicians should have access to subject specific professional learning and development opportunities to increase their expertise and confidence when teaching and/or supporting practical chemistry activities.

4 Practical chemistry activities must have a clear purpose and be related to the learning aims of the lesson.

5 Practical chemistry activities must promote an equitable chemistry education and be designed with consideration to inclusivity and accessibility.

6 The sustainability of practical activities should be considered at all stages, to aid with budget constraints and reduce the environmental footprint of practical chemistry in classrooms. Sustainability of practical chemistry can be improved through the consideration of the amount and type of chemicals used in the classroom and the type of experiments conducted.[17]

For any queries relating to this position statement, please contact the Education Policy team: EducationPolicy@rsc.org

Endnotes

[1] Our curriculum framework *The elements of a successful chemistry curriculum: The Royal Society of Chemistry's vision for 11–19 chemistry education* explains how this question fits into the wider chemistry discipline.
[2] Adapted from: Holman, J (2017), *Good Practical Science*, good-practical-science-report.pdf (gatsby.org.uk)
[3] SCORE (2008). *Practical work in science: A report and proposal for a more strategic framework*. https://www.stem.org.uk/system/files/elibrary-resources/2021/12/27103-Full%20report.pdf
[4] Adapted from: Cramman, H., Arenas, B., Awais, R., Balaban, C., Cropper, C., Dennis, F. M., Vaughan, H. L. (2023). *Post-16 students' experience of practical science during the COVID-19 pandemic and the impact on students' self-efficacy in practical work*. https://doi.org/10.35542/osf.io/gx2jh
[5] A students' personal circumstances can play a key role in how students develop a relationship with chemistry. Royal Society of Chemistry (2020), *Is Chemistry Accessible For All? Learning from five years of outreach to widen participation*. https://www.rsc.org/globalassets/22-new-perspectives/talent/is-chemistry-accessible-for-all/rsc-is-chemistry-accessible-for-all.pdf
[6] One way to engage more students with chemistry, is to foster the science capital teaching approach. See: https://discovery.ucl.ac.uk/id/eprint/10080166/1/the-science-capital-teaching-approach-pack-for-teachers.pdf
[7] Schools have a responsibility towards disabled students and their accessibility provision as outlined in: the Equality Act 2010 (England and Wales); The Education Additional Support for Learning Act 2009 (Scotland), The Special Educational Needs and Disability Order 2005 (Northern Ireland) and the Education for Persons with Special Educational Needs Act 2004 (Republic of Ireland).
[8] The *Science for Secondary-aged Pupils with Special Educational Needs and Disability (SEND) by CLEAPSS* guide could be used to access a variety of strategies for English and Welsh secondary schools.
[9] Ofsted (2023), *Research and Analysis: Finding the Optimum: The Science Subject report,* https://www.gov.uk/government/publications/subject-report-series-science/finding-the-optimum-the-science-subject-report--2#main-findings
[10] A 'hands-on minds-on' approach helps students link observations from a practical activity to the chemical concepts behind it. See: Millar, R. and Abrahams I. (2009). *Practical work: making it more effective*, School Science Review, 91 (334), 59-64.
[11] Abrahams (2009) *Does practical work really motivate?* International Journal of Science Education, 31, 2335-2353.
[12] Wellcome (2020), *Young people's views on science education, Science Education Tracker 2019 Wave 2,* https://wellcome.org/sites/default/files/science-education-tracker-2019.pdf
[13] ASPIRES Research. (2022). *ASPIRES 3 Project Spotlight 2: "Make it more relevant and practical": Young People's Vision for School Science in England*. London: IOE, UCL's Faculty of Education and Society, https://discovery.ucl.ac.uk/id/eprint/10157406/2/9872%20UCL%20Young%20People%20Report%20AW2.pdf
[14] Royal Society of Chemistry (2024). *The Science Teacher Survey 2023*, https://www.rsc.org/policy-evidence-campaigns/chemistry-education/education-reports-surveys-campaigns/the-science-teaching-survey/
[15] The Association for Science Education's minimum service factor (total technician contracted working hours per week divided by the total weekly hours of science teaching) is 0.65. We advise that schools should have technician support equal to or above this minimum service factor. See: https://www.rsc.org/globalassets/22-new-perspectives/talent/nfer-science-technicians-workforce-report-1.pdf
[16] In England, Wales and Northern Ireland. Science technician roles are not a standard in Irish secondary schools.
[17] An example of reducing costs and improving sustainability, is to use microscale chemistry for some practical chemistry activities.