

IT in Chemistry Teaching

How to Get the Most Out of Chemistry Practical Work

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Introduction

Bristol Chemical Laboratory Sciences (Bristol ChemLabS) is one of the few Centres for Excellence in Teaching and Learning (CETLs) in science in the UK. It was funded by the Higher Education Funding Council for England (HEFCE) with the aims of raising standards in the teaching and learning of practical chemistry to create a major national resource for the teaching and

learning of practical experimental science and also to engage with, and enthuse, students of all ages. The philosophy behind this project is that practical work must form an essential part of teaching and learning in chemistry.

Through Bristol ChemLabS we wished to transform the student experience of practical chemistry, setting a new standard for laboratory-

based learning. This was done through (a) the development of state-of-the-art professional-standard teaching laboratories equipped with research-grade instrumentation (b) the creation of e-learning and e-assessment, as well as more conventional teaching methods to improve student experience and (c) establishment of a wide-ranging programme of outreach and public engagement regionally, nationally and internationally.

Traditional chemistry labs at undergraduate level are often considered boring, repetitive and may not be relevant to 21st Century. There is a strong need to enthuse modern students, sometimes called the 'Wii Generation', by making the practical experience fun, more enjoyable and interesting.

Many chemistry teachers will remember their own undergraduate practical classes as perhaps often arriving at the laboratory without a clear idea of the practical techniques to be used and it was only after the laboratory, during the lengthy write up, that the point of the practical was understood and at the same time wishing that a fundamental question had been asked of the demonstrator at the time or realising that a critical dilution had been missed out!

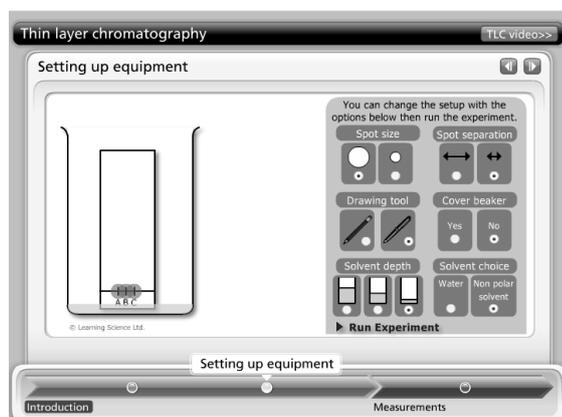


Figure 1 A screenshot of the Thin Layer Chromatography (TLC) simulation

It is clear that trainee chemists will clearly get much more from the laboratory experience if they know what they are doing in advance of entering the laboratory. One of the main ideas in Bristol ChemLabS has been to shift the balance of work outside the laboratory to *before* rather than *after* the practical class, so that students are much better informed and more confident and that practical

skills are developed and assessed *in situ*. This makes for better use of valuable lab time. All this work is supported by an e-learning tool called the Dynamic Laboratory Manual (DLM). This concept has been applied to pre-university level chemistry practical work in a software package called A Level Chemistry LabSkills.

LabSkills software contains the full range of practical techniques and skills required of 'A' level chemistry, IB and other pre-university courses (see Table 1). Each of the techniques contains a brief introduction to the technique, a simulation intended to allow students to rehearse practical skills and to find out what is the correct way to set up or use apparatus with error messages explaining the error of students' ways. In this way students can break as much virtual glassware as they like. Once the student has mastered the simulation, there is the opportunity to see video clips of the state-of-the-art apparatus being used, which are broken down to bite-sized pieces, each with the sort of comments that a teacher or demonstrator would give. Following on from this is an interactive section on safety. Just to check the students have been through the whole section there are a few multiple choice/multiple completion questions that the students can print out and hand in to the teacher already marked or uploaded to the school's virtual learning environment. If the school has not got a virtual learning environment an alternative version is available (see breaking news).

Reflux	Titration
Recrystallisation	Titration curves
Filtration	Collection of a gas
Distillation	Enthalpy change of combustion
Solvent extraction	Enthalpy change in solution
Melting point	Colorimetry
Thin layer chromatography	Electrochemical cells

Table 1 Preparation, Purification and Quantitative analysis

The resource includes fourteen self-contained modules covering the main lab techniques commonly used at this level. Each module contains a mix of simulations, videos, safety resources and multiple choice tests (Table 1). Sixteen additional modules consider core laboratory competencies covering basic skills, lab

calculations, and chemical tests. Each module contains structured questions with hints and feedback and multiple choice tests (Table 2).

Tests and Observations	Basic skills
Tests for inorganic compounds	Weights and measures
Tests for organic compounds	Preparing solutions
Transition metal compounds	Heating

Table 2 Tests and Basic Laboratory Skills

Five tutorials on laboratory calculations and 5 tutorials on instrumental analysis (Table 3) are included. Each of the latter is explained using simulation of the techniques and photo-tours of the instrumentation. There are twenty widely performed experiments at Post 16 covering preparative, qualitative and quantitative practicals common to most exam boards.

Lab calculations	Instrumental techniques
Stoichiometry and yield	Mass spectrometry
Quantities and concentration	IR spectroscopy
Errors and significant figures	NMR spectroscopy
Reaction rates	GC analysis
Equilibrium constants	HPLC analysis

Table 3 Laboratory calculations and instrumental techniques

These support teachers' own practical scripts (Table 4). There are also drop down reference resources: Equipment glossary with descriptions of commonly used equipment, reagent glossary of descriptions of reagents commonly used at this level, lab health and safety comments, a scientific calculator and of course a Periodic Table.

Figure 2 A screenshot of the titration simulation

Oxidation of alcohols	Enthalpy of hydration (Hess's Law)	Enthalpy change of neutralisation
Enthalpy change of combustion	Preparation of an ester	Multi-stage synthesis – aspirin
Preparation of an alkene	Hydrolysis of an ester	Investigating reaction equilibria
Nitration of an aromatic	Preparation of a halogenoalkane	Preparation of chrome alum
Acid / base titration	Iron (II) / permanganate titration	RMM of a volatile liquid
Reaction of iodine and propanone	Iodine / thiosulfate titration	Iodine clock
Identification of an unknown	Preparation of an organic acid	

Table 4 The twenty experiments outlined in the software

Figure 3 A screenshot of one of the chemical calculation tutorials

Using this resource

How can this resource be used? Several opportunities have been identified. The originally-intended use is that students should be directed to work through specific sections in the lead up to a practical class or assessed practical work. This supported self-study may be used as homework, with the students submitting printed test results. A second use is in the demonstrating of techniques on a white board during class time with the interactive elements being used for whole class review and group discussion. This may be more

desirable in schools without virtual learning environments (VLEs) or Management Learning System (MLS). Any lab with computer access during the practical session can run the software as an *aide memoire*, with the glossaries on equipment and common chemicals likely to be of assistance. The resource can also be used as an effective way for students to actively revise practical work away from the laboratory or when repeating a missed practical session is not an option.

The resource is not intended as an e-text book or to replace practical work. This is a software tool, which promises to revolutionise the way pre university practical chemistry is taught, it can enable chemistry students, trainee and newly qualified teachers to carry-out pre-work ahead of practical classes, so maximising the quality of the time they spend in the laboratory. It is an effective leaning resource as it requires students to actively participate in their own learning process. The high level of interactivity requires the students to continually test their understanding of the science and learn from their successes and their mistakes. Instant feedback is given to at every stage which supports students, whatever their level of knowledge and understanding. It has already been hailed as 'A groundbreaking computer program' by the *Times Educational Supplement* (TES).

A Level LabSkills for schools and colleges is now the extended course that replaces the AS Chemistry LabSkills previously reported in this journal (Harrison & Shallcross, 2008; Harrison *et al*, 2009). Chemistry LabSkills software is not just having an impact on UK schools in supporting A level and International Baccalaureate (IB) chemistry. Firstly the Royal Society of Chemistry is working with Pfizer on the Discover Chemistry initiative, which centres on the skills needed to ensure the chemical industry continues to thrive in the UK. As part of this initiative Discover LabSkills has seen around 1100 trainee chemistry teachers presented with either AS Chemistry or A Level chemistry LabSkills over the last two years, to support their teaching development during their PGCE courses. Secondly, universities in Australia, Canada, South Africa and the Far East

are either already using or are about to use a version of the software 'Foundation Chemistry LabSkills. They are very interested in using it as they have large numbers of first year undergraduates whose starting point for practical skills development is at a similar point to Post 16 UK students.

Breaking News

As a consequence of discussing Chemistry LabSkills with teachers at the conference in Limerick in 2009 it was decided to produce a version of the software resource that does not rely on a school having a virtual learning environment available. Instead the Chemistry LabSkills Teacher Edition has been produced, where the software runs from a memory stick allowing teachers to use the resource in a whiteboard mode. For more information please see www.labskills.co.uk web site.

A practical skills revision version for students, the LabSkills Student Edition, which has reduced functionality, is available through www.amazon.co.uk.

References

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