CHED Committee on Computers in Chemical Education

The Dynamic Laboratory Manual: E-Learning Software to Support Practical Chemistry Skills Development

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Introduction

The problem identified with the traditional undergraduate laboratory experience was that students typically arrived at the laboratory to carry out an experiment without a clear idea of the practical techniques they would be using, the skills they would require, or the chemistry behind the practical. Experience had shown that it was often only *after* the laboratory, during a write up, that they would generally start to work out what it was they had been doing throughout their period of very expensive laboratory time. Added to this, students are often expected to perform poorly stimulating, repetitive tasks that appear to have little relevance to the skills set needed by a 21st century chemist. Students would clearly get much more from the laboratory experience if they were to know what they were going to be doing before they arrived and pre-laboratory preparation is the key to achieving this. When Bristol was awarded the grant to become the UK's Centre for Excellence in Teaching and Learning in practical chemistry this matter was addressed, along with the desire to also incorporate other aspects of e-learning and e-assessment into the laboratory experience. One of the main innovations in Bristol ChemLabS has therefore been to shift the balance of work done outside the laboratory to *before* rather than *after* the practical class so that students are much better prepared and therefore more confident in their practical work. Key to the realisation of these two main ambitions has been the development of the Dynamic Laboratory Manual (DLM).

Pre-laboratory Work

As part of the ChemLabS experience, students are now required to work through some background information about the experiment before they arrive at the laboratory (figure 1). All the information they need for a particular experiment is contained in the DLM and they do not need, for example, to have had particular lectures in advance of any given experiment. An important part of the pre-laboratory work centres around a set of multiple choice and multiple completion questions. These are assessed and form part of the overall assessment for that experiment, but also provide immediate and informative feedback on any wrong answers given. Students are given two attempts but since the questions are taken from a question bank, the second set of questions will not be same as the first. Likewise, different students will get different questions.

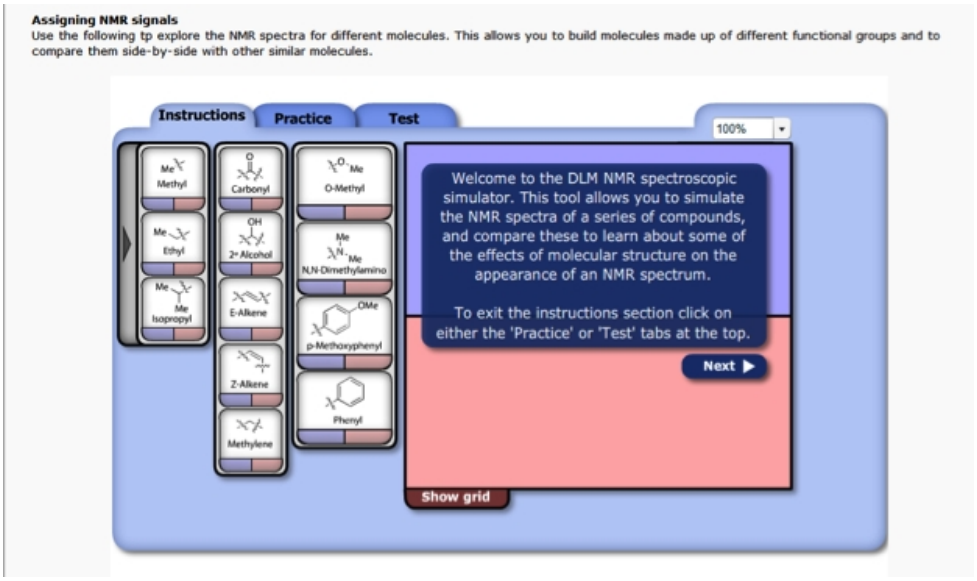

Figure 1 Tutorial on NMR where students can compare the NMR signals of a series of compounds that the student designs.

In addition, information about each experiment comes in a variety of rich formats which includes Flash-based simulations/virtual instruments and video (figure 2).

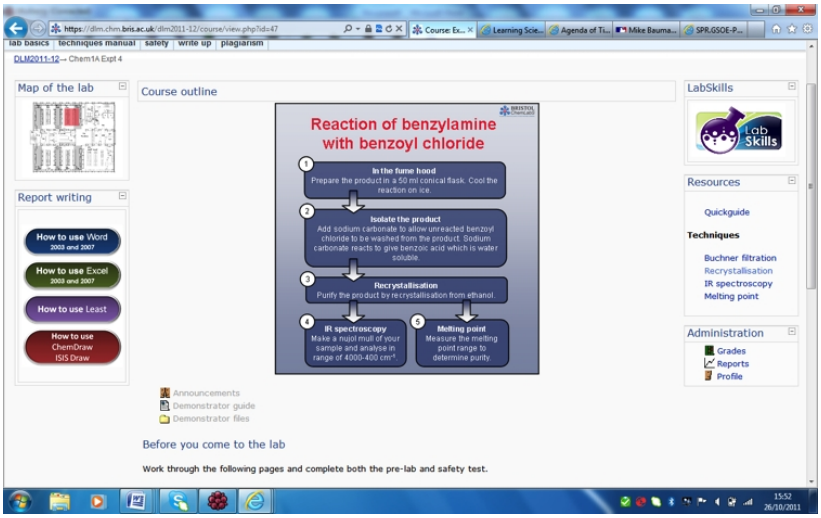

Figure 2 A screen shot of part of a first year practical showing experiment flow chart and allowing access to e-learning tools for report writing tutorials, practical techniques support and a downloadable practical outline.

In the Flash based simulations/virtual instruments a complicated piece of equipment or instrumentation is represented in a diagrammatic form which has interactive valves or switches etc. (Figure 3). The correct use of the equipment can be learned by following a set of instructions and although it is likely that many students will merely play with the valves initially, even this will educate them about the function of the apparatus. Mistakes, which might be quite serious or costly with the real equipment, can therefore be made with no adverse effects; students just start again and have another go.

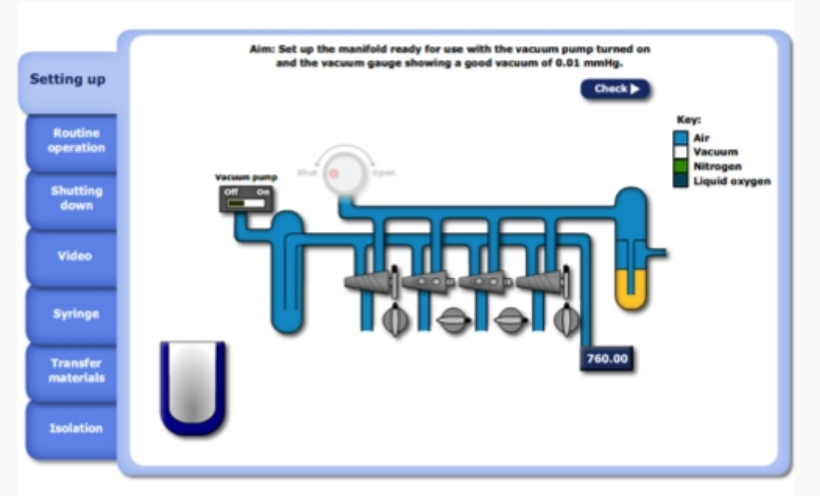

Figure 3 An animation of a Schlenk line, for working in inert atmospheres, is an example of a more advanced undergraduate simulation.

Some techniques are best illustrated with video and students find this a very useful way to get a clear idea of what they will need to do in the laboratory. Many students have limited prior experience of glassware and general laboratory apparatus and seeing, for example, how to set up a Büchner filtration gives them confidence and saves them from having to ask a demonstrator. The videos are sectioned into 20-40 second clips with a brief written explanation of why what is being done is done! Students therefore learn what a particular set of apparatus is supposed to do, have more confidence when it comes to using the real thing, and a much better idea of the chemistry that is being explored in the experiment. Moreover, demonstrators are now free to engage in more productive activities with the students such as in-lab assessment. A demonstration of many aspects of the DLM is available at http://www.chemlabs.bris.ac.uk/DLM.html.

Virtual instruments/equipment and video clips are embedded within each experiment but are also gathered together in a Techniques Manual which is available as a general resource throughout the students' time in Bristol including any periods of industrial or overseas placement. It is important to stress that video and simulation are in no way intended to replace the laboratory experience; their role is to augment it.

Laboratory safety is also addressed. In the past students have had to sign a safety form declaring that they understand the risks and hazards associated with the chemicals and apparatus for a particular experiment and the precautions which need to be taken. Unfortunately, some students were prone to taking a rather flippant attitude towards the safety form which was never a very satisfactory state of affairs. As part of the DLM, students are now asked a variety of questions, many of them scenario-based, concerning safety and the hazards associated with the chemicals used for each experiment. These questions are in the form of multiple choice or multiple completion questions and students must score a minimum of 80% before they are allowed to start the lab. Students are thus forced to think about hazards and safe practices. They are told the correct answers at the end of their attempt and they may have a second attempt but the questions are taken from a data bank and will therefore not necessarily be the same.
A list of all the undergraduate experiments may be found at: http://www.chemlabs.bris.ac.uk/undergrad-experiments.html.

The Staff/Student Interface

Using bespoke software linked to the DLM, academic staff and demonstrators are able see how the students have performed in the pre-lab and safety tests. In the case of safety data, a student who scores less than 80% has this mark in a red box whereas a student who has passed has their score shown in a yellow box or in a green box if they have scored 100%. The laboratory teaching fellows and postgraduate demonstrators can see at a glance which students need to be spoken to at the start of the laboratory and their tutors can keep a track of the development of their tutees at any point. The students can also see their individual performances throughout their degree.

DLM Developments in Postgraduate Training and Other Disciplines

The value of the DLM approach in supporting undergraduate practical work has led to an extension of the DLM concept to support research training for postgraduate students in two Doctoral Training Centres (DTCs) at Bristol. In the Chemical Synthesis DTC (http://synthesisdtc.chm.bris.ac.uk/), these include advanced tutorial packages on NMR spectroscopy, X-ray crystallography and glove box

use. For undergraduates in other disciplines, the Faculty of Medical and Veterinary Sciences at Bristol has also developed DLMs through its eBioLabs programme to support laboratory teaching in Biochemistry, Physiology and Pharmacology, and Cellular and Molecular Medicine (http://www.bristol.ac.uk/ebiolabs/).

Such is the impact of the DLM that Bristol ChemLabS won the UK-based Times Higher Education Award for Outstanding ICT Initiative of the Year in 2010.

The Future

In addition to the DLMs described above, commercial versions of the Chemistry DLM have been developed with Learning Science Ltd as the LabSkills brand including A-Level Chemistry LabSkills and Foundation Chemistry LabSkills. A-Level Chemistry LabSkills supports the practical component of A-Level chemistry (a UK-based pre-university qualification) whilst Foundation Chemistry LabSkills is designed for first year laboratory teaching at university foundation level. Details of these products can be found at http://www.labskills.co.uk/. More recently an agreement between the University of Bristol, Learning Science Ltd and Cengage Learning Inc will see LabSkills technology incorporated into online learning resources designed for freshman chemistry courses in the USA. A-Level Biology LabSkills and A-Level Physics LabSkills are under development.

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fig1p7fall2011cccenl.jpg	111.16 KB
fig2p7fall2011cccenl.jpg	184.14 KB
fig3p7fall2011cccenl.jpg	66.69 KB