The excitement of chemistry

Judy Gordon, School of Biological and Chemical Sciences, Deakin University
judyg@deakin.edu.au

Introduction

The first year Chemistry syllabus on the Burwood campus of Deakin University was changed in 2003 because of the requirements of the courses in which the students were enrolled. Of approximately three hundred students, one third had no previous experience of chemistry, while the rest had studied Chemistry at year 12 level at school. The challenge was to keep the lectures relevant and exciting for the experienced students while making sure that the less experienced students received a good grounding in the fundamental concepts at such a pace that they did not fall behind.

Two major methods were used to meet this challenge:

- organisation of the syllabus into small segments, each assessed soon after completion; and
- relevant demonstrations to illustrate and explain concepts during lectures.

First year chemistry at Deakin Melbourne

A full three year Chemistry course, as part of a BEd or BAppSci at Victoria College and its antecedent institutions, was taught for many years on the Rusden campus, located opposite Monash University. Following amalgamation to become part of Deakin University in 1992, second, third and Honours year Chemistry were gradually discontinued at Rusden, leaving first year Chemistry to be taught as a service subject. During the 1990s, the staff and students involved in health related courses moved to the Burwood campus. Many of these students require first year Chemistry as a core unit in their courses.

Videolinked lectures on the metropolitan campuses

Until 2003, Deakin University had three campuses in metropolitan Melbourne, and three in country Victoria. The Geelong campus, at Waurn Ponds, is where most of the staff in the School of Biological and Chemical Sciences are located. The postgraduate students and most of the second and third year undergraduate students in Chemistry study on the Geelong campus.

In the Melbourne metropolitan area, Chemistry was taught on the Rusden and Burwood campuses until the end of 2001, when the Faculty of Science and Technology moved to the Burwood campus, prior to the closure of the Rusden campus at the end of 2002. The two Chemistry staff members were based on the Rusden campus, but the majority of the first year students were studying on the Burwood campus.

In first semester 1997, the introductory first year unit *Foundations of Chemistry* needed to be delivered on both the Burwood and Rusden campuses, which are 10 kilometres apart. Students could not commute between campuses because of the timetable constraints of their other subjects. Deakin University's internal videoconferencing system lacked enough bandwidth to be used, so the Optus Education channel was used to deliver lectures in real time from the Rusden to the Burwood campus (Clift 1997). In the second semester of 1997, the Optus Education channel was used for transmission of lectures in *Chemistry B*, and in first semester 1998, *Chemistry A* was added.

At the end of 1998, advances in technology enabled Deakin University to adopt a better system consisting of two large videoconferencing screens in each venue. At about the same time, the Optus Education channel ceased operation. In 1999, 2000 and 2001, the first year units *Foundations of*

Chemistry, Chemistry A and *Chemistry B* were taught on the Burwood and Rusden campuses using Deakin University's videoconferencing system. In 2002, following the move from Rusden, these three units were taught 'face to face' on the Burwood campus.

Chemical demonstrations using electronic media

An important part of first year lectures, particularly those in *Foundations of Chemistry*, involve demonstrations of chemical phenomena. The lecturer explains what is happening, assisted by a *PowerPoint* presentation. Molecular models are displayed and manipulated using a document camera. Another camera is used to project the chemical demonstrations onto the large screen at the front of the lecture theatre. This avoids the use of large quantities of chemicals, with their attendant risks and costs.

The lecture theatre on the Rusden campus had a demonstration bench with sink, water and gas supplies. There was a mobile fume cupboard on one side of the lecture theatre at the front to contain any fumes from chemical reactions. A large lecture theatre on the Burwood campus was chosen as the most suitable to install the required equipment in time for the start of first semester 2002.

The system design was based on the experience gained videolinking lectures and chemical demonstrations from Rusden to other campuses. The lecture theatre was refurbished to include a demonstration bench equipped with a sink, cold running water, gas and electricity. A recessed polypropylene sink and demonstration bench was installed in the lecture theatre. For non-chemical lectures, four panels that are placed over it to form a conventional lecture theatre front bench.

The lectern previously used at Rusden, a computer, document camera and overhead projector were incorporated into the front bench. Touch screen switches on the lectern enable the lecturer to switch between computer bench camera, document camera, videorecorder and audiocassette recorder.

When in use, the bench camera is mounted at either end of the demonstration bench, and is swivelled to display the bench or the fume cupboard. The existing camera does not pan automatically, and has to be focussed and zoomed manually.

The computer is networked so that files can be transferred from the office computer. The *PowerPoint* presentation and any other images are transferred to the computer in the lecture theatre and are displayed by the data projector. This is much faster and more reliable than using the network.

Changes in first year chemistry on the Burwood campus

Prior to 2003, the following three units were presented, *Foundations of Chemistry*, *Chemistry A* and *Chemistry B*. *Foundations of Chemistry* was run in first semester for students who had not studied Chemistry previously, and *Chemistry A* was for students with year 12 Chemistry. *Chemistry B* was undertaken in second semester by both groups of students. These units were developed as part of the BSc (Chemical Sciences) and were designed to prepare students for advanced studies in chemistry that were no longer offered on the metropolitan campuses. For timetabling reasons, *Chemistry A* was repeated in the summer semester for students who required it as a prerequisite for second year units, meaning that one staff member had to effectively coordinate and teach four units between February and December each year.

These units are no longer the most appropriate for Melbourne students. The majority of the students taking first year Chemistry units on the Burwood campus are enrolled in the BSc (Biological Sciences) or Biomedical Science courses, or are students of the Faculty of Health and Behavioural Sciences, or the Faculty of Education. The BSc (Chemical Sciences) course is not taught on the Burwood campus. It was decided that the existing four first year Chemistry units be replaced with two units, *Principles of Chemistry* and *Applications of Chemistry*, and that extra tutorial help in first semester for those students who had not studied Chemistry at school would be provided.

Therefore approximately 100 of the 300 first year Chemistry students have no experience of Chemistry at school, whereas the other 200 students have had variable experiences. Both the inexperienced and the experienced students attend the same lectures, although each lecture has to be repeated because of the lecture theatre is too small. Many students attend both the original lecture and the repeat, which is usually held in the hour immediately following.

Engagement of different student cohorts

There are two major cohorts of students who require first year Chemistry in their courses. The original cohort following amalgamation were those who were undertaking a BSc within the School of Biological and Chemical Sciences. Originally, the majority of these students wished to major in biological and ecological areas, very few wished to study the molecular sciences, including Chemistry. Over the years this changed so that many students wished to enter the molecular biology and biotechnology fields. The BSc (Chemical Sciences) was phased out in Melbourne so that students wishing to major in Chemistry either transferred to Geelong, or studied complementary units at another university, usually Monash.

Many of these students have not studied Chemistry at school, and if their interest is in zoology, botany or ecology rather than molecular biology, they cannot see the relevance of studying first year Chemistry.

The other major cohort are students in the School of Health Sciences. These students are studying in the area of food science, many with a view to becoming dieticians. Some of these students are studying health promotion, but taking units related to nutrition, in the hope that they might transfer courses at the end of first year.

Many of these students also have no previous experience of Chemistry but can see the relevance of Chemistry in their chosen course. A significant proportion are mature age students who do not have the level of mathematics required for university entry these days.

Design of the first year chemistry syllabus

The principles applied (Crisp 2000) included a thorough organisation of material which was regarded as ‘essential’ in the courses being studied by the students. The goals of the two units were clearly identified and stated to the students, and links were constantly made between core chemical concepts and the material being discussed and the relevance to their other studies.

The face to face contact in each unit is a total of 39 hours of lectures, 24 hours of practical work, and 12 hours of tutorials. Only the 24 hours of practical work is compulsory. A comprehensive resource manual is provided, but there is no prescribed textbook. The resource manual includes a written lecture summary as distinct from *PowerPoint* slides, the laboratory manual, and problem sheets. Selected *PowerPoint* slides are occasionally posted on the Web after the completion of lectures on a topic. Solutions to the problem sheets are posted on the Web after the students have had an opportunity to attempt the questions and discuss them in tutorials.

It proved to be impossible to timetable extra tutorial help during first semester, so this help was provided in the laboratory. There are eight compulsory practical exercises, so the remaining five practical sessions in first semester were used to run a 30 minute ‘progressive assessment’ based on the previous three weeks’ lecture and tutorial material, followed by two hours of group work in the laboratory. The students who remained for this session worked through a series of non-assessable experiments which reinforced basic principles such as writing chemical equations. The demonstrator worked closely with the students to ensure that they had a good grasp of the fundamental concepts.

Lecture demonstrations

Demonstrations can be extremely effective at sparking student interest by showing teacher enthusiasm (Swanson 1999), and initiating student inquiry. However, a survey of the literature (Walton 2002) indicates that the demonstrations must be carefully planned and carried out, otherwise they will be seen as a time-consuming and being presented for entertainment rather than educational reasons.

Live demonstrations are a very effective teaching tool because they stimulate a number of senses, sight, hearing and smell (only non-toxic nice smells of course). Students have different ways of learning, and benefit from presentation of information that appeals to several senses. As a result more students in the class will learn from the demonstrations than from lectures alone.

Relevance

It is extremely important that the demonstrations be used to highlight a point or to illustrate a concept. Good demonstrations will help to teach principles but will also help to make chemistry less abstract. It is much more fun to see an experiment happening in real time than to read about it in a book, or even to watch a video clip. If the demonstration is not relevant to the lecture, but is merely being presented for entertainment, then it will only reinforce the 'mad scientist' view so often portrayed by the media.

Usually it is best to have only one or two demonstrations per lecture, but occasionally students appreciate having a whole series of related demonstrations during a lecture, as they feel that they are being given a rest!

Time commitment

Setting up and performing the demonstration, then packing up afterwards takes a considerable commitment from the lecturer and the laboratory technician. The demonstrations are rehearsed in the Chemistry preparation room, then packed onto a trolley for easy transport to the lecture theatre. Very often, the lecturer has to boot up the computer in the lecture theatre and start the audiovisual system as well as setting up the bench camera and the demonstration.

Appropriate demonstrations for the lecture being presented need to be found. This task has been made easier by the considerable number of demonstrations that have been collected over the years at Deakin, and by the advent of the World Wide Web. The best and most well known sources are the 4 volumes *Chemical Demonstrations: A Handbook for Teachers of Chemistry* by Shakashiri. Reviews (Walton 2002) of the literature on chemical demonstrations, list numbers of references and links to web sites.

Credibility

The lecturer needs to have confidence that the demonstration will work, and be sufficiently familiar with the subject matter to be able to show the students the relevance of the demonstration to the topic being discussed.

On the other hand, no matter how thorough the preparation, sometimes a demonstration will fail, and students can still gain a valuable experience from this. The lecturer has to be able to indicate possible reasons why the demonstration did not work, and this can lead to fruitful discussions.

Safety

No matter how relevant, spectacular and exciting a demonstration might be, it cannot be performed in front of an audience if there is likely to be a danger. Even seemingly innocuous demonstrations can have hazards, and it is useful to talk about these with the students before actually performing the demonstration.

This is where the experience gained from videolinked lectures has been very useful. Much smaller scale apparatus and smaller quantities of chemicals can be used, but the students will be able to see and hear what is going on by watching it on the big screen at the front of the lecture theatre. It is also possible to zoom in a particular aspect of the demonstration, while the members of the class can still see what is happening on the front bench. There are some very impressive demonstrations of reactions of gases using microscale syringes and a mini digital movie camera to project what is happening on the screen (Obendrauf 2000).

If the demonstration is likely to be noisy, the students are warned beforehand. Anything that is likely to emit fumes is performed in the fume cupboard, which although mobile, is left permanently at one side in the front of the lecture theatre.

Some small scale demonstrations, for instance reactions of solutions in petri dishes, can be performed using the document camera. The document camera is also very useful for assembling and manipulating molecular models.

Summary

Student participation in lectures was excellent, and verbal and written comments from students indicated that they had found Chemistry to be both understandable and enjoyable. There was a discernible air of disappointment if it was apparent that there would be no demonstrations in a particular lecture.

The results attained by the class in individual assessments were variable, but generally good, and the final results were excellent. Marking all assessments indicated where there were misconceptions in certain areas, and gave ideas as to how these could be fixed in the future. It was interesting to note that many students made reference to lecture demonstrations in their examination scripts.

This reinforced the belief that lecture demonstrations are valuable, not only because they can illustrate chemical concepts, but because they make Chemistry more exciting and memorable for the students.

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