Online Preparation for Laboratory Work

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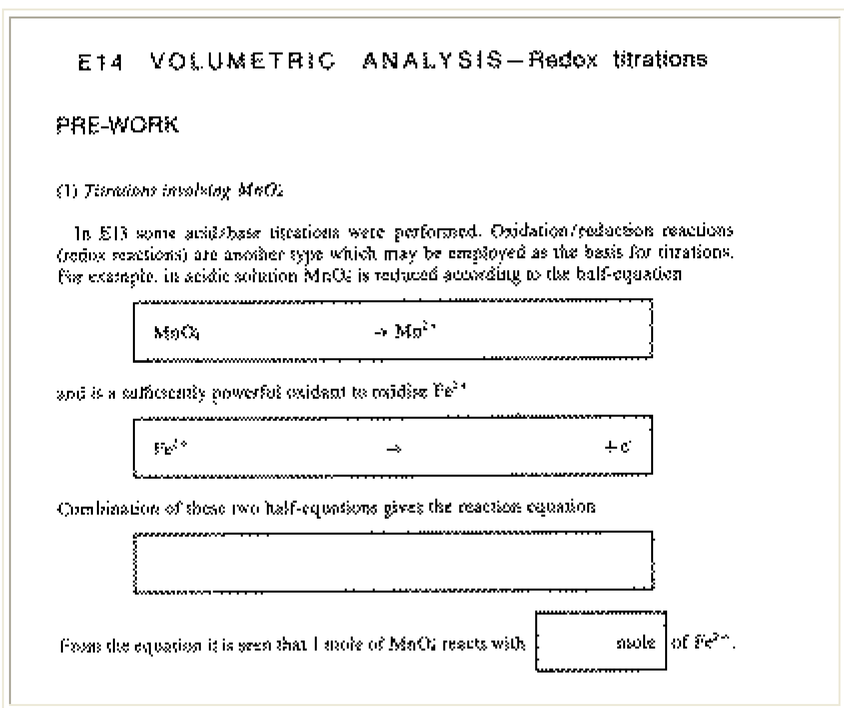
Course structure

Approximately 1800 students study Chemistry in the first year of their degree at The University of Sydney. The course consists of lectures, tutorials and a laboratory component, all of which contribute to the assessment of the student. Chemistry is taught as a practical based discipline and students spend three hours each week in the laboratory. This is half the face-to-face teaching time they spend in First Year Chemistry.

The laboratory component of the course is structured in three parts: the pre-laboratory work, a series of laboratory exercises and the post-laboratory work, Figure 1.

- The students conduct the pre-laboratory work in their own time, prior to their scheduled laboratory class. The purpose is to provide background and theoretical backup to the experiment that will be conducted that week. The information is supported by a number of questions designed to test the comprehension of the student.
- The practical work is conducted in a three-hour block in the laboratory and introduces the students to important practical techniques as well as providing some experience of the concepts taught during lectures.
- The post-laboratory work is brief and usually consists of an analysis of the results obtained in the laboratory or a supporting problem. This is conducted in the student's own time.


E14 VOLUMETRIC ANALYSIS—Redox titrations

PRE-WORK

(1) *Titrations involving MnO_4^-*

In E13 some acid/base titrations were performed. Oxidation/reduction reactions (redox reactions) are another type which may be employed as the basis for titrations. For example, in acidic solution MnO_4^- is reduced according to the half-equation

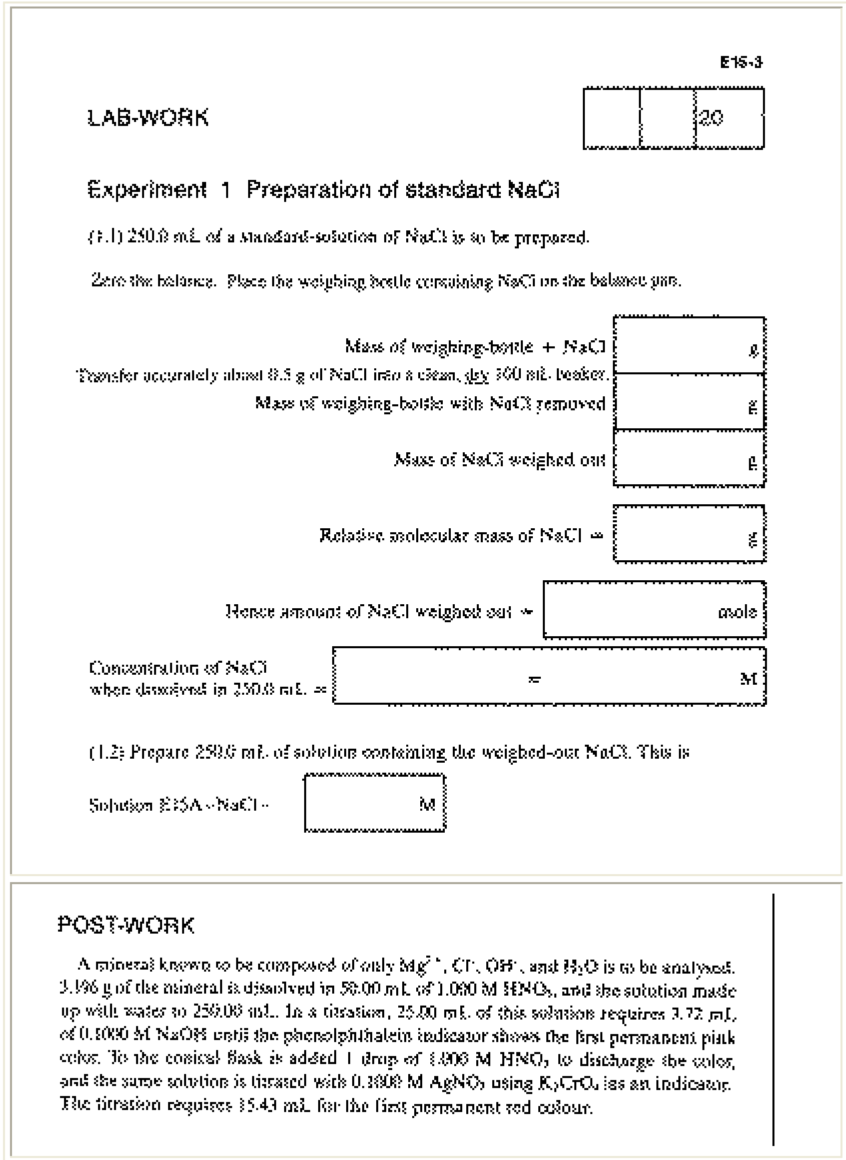
MnO_4^- → Mn^{2+}

and is a sufficiently powerful oxidant to oxidise Fe^{2+}

Fe^{2+} → + e^-

Combination of these two half-equations gives the reaction equation

From the equation it is seen that 1 mole of MnO_4^- reacts with mole of Fe^{2+}.



E15-3

LAB-WORK

20

Experiment 1 Preparation of standard NaCl

(1.1) 250.0 mL of a standard-solution of NaCl is to be prepared.

Zero the balance. Place the weighing bottle containing NaCl on the balance pan.

Mass of weighing-bottle + NaCl ____ g

Transfer accurately about 8.5 g of NaCl into a clean, dry 300 mL beaker.

Mass of weighing-bottle with NaCl removed ____ g

Mass of NaCl weighed out ____ g

Relative molecular mass of NaCl = ____ g

Hence amount of NaCl weighed out = ____ mole

Concentration of NaCl when dissolved in 250.0 mL = ____ = ____ M

(1.2) Prepare 250.0 mL of solution containing the weighed-out NaCl. This is

Solution E15A - NaCl - ____ M

POST-WORK

A mineral known to be composed of only Mg^{2+}, Cl^-, OH^-, and H_2O is to be analysed. 3.196 g of the mineral is dissolved in 50.00 mL of 1.000 M HNO_3, and the solution made up with water to 250.00 mL. In a titration, 25.00 mL of this solution requires 3.72 mL of 0.1000 M NaOH until the phenolphthalein indicator shows the first permanent pink color. To the conical flask is added 1 drop of 1.000 M HNO_3 to discharge the color, and the same solution is titrated with 0.1000 M $AgNO_3$ using K_2CrO_4 as an indicator. The titration requires 15.43 mL for the first permanent red colour.

Figure 1. An example of the print based resources used in 2000

There are up to 300 students in the First Year laboratories at one time under the supervision of a laboratory director and with a number of tutors, each responsible for a group of around 18 students.

Design of application

When all of the pre-laboratory work was print based, the laboratory tutors checked the work of each student at the start of the laboratory class. This took considerable time and detracted from the time available to conduct experimental work. We set out to design a means of hosting the pre-laboratory work online. This would be coupled with a formative quiz, which could give feedback to the students at the time they were thinking about the material and alert tutors to individuals that might be having difficulties with a particular area. All of the time in the laboratory would then be available for practical work with the tutors able to focus on teaching practical skills.

In designing the online pre-laboratory work application we wanted to:

- provide students with an individual logon and a moderate level of security;
- create a site that was easy to navigate around and did not require prior computing skills;
- construct a 'nested' arrangement of content pages so students seeking more information on a concept could access it via a hyperlink while confident students could quickly move on;
- provide a colour, pictorial introduction to some of the equipment and techniques to be used in the forthcoming laboratory;
- couple information on the background to the experiments to a formative quiz that would test the students' understanding of the material and provide hints and feedback at the time the student was thinking about it;
- ensure the students received consistent, high quality feedback to their quiz responses;
- enable students to track their performance in the quizzes and assess how they are performing relative to the class average;
- obtain congruence between the online pre-laboratory work and the laboratory manual, which contains the experimental procedure, so that students would not have to print out material from the web site;
- possess an online evaluation module to allow students to give feedback on the technical and educational aspects of the application;
- allow tutors to access marks and quiz question responses of the students for whom they have responsibility;
- have an easy to use section for administrators to create course schedules and quizzes; track student marks and responses to quiz questions; send announcements to individuals or specific groups and analyse evaluation data; and
- create a robust system that would run reliably with minimal maintenance for periods of at least one semester.

How it works

Access to the site is on three levels: student, tutor and administrator, Figure 2.

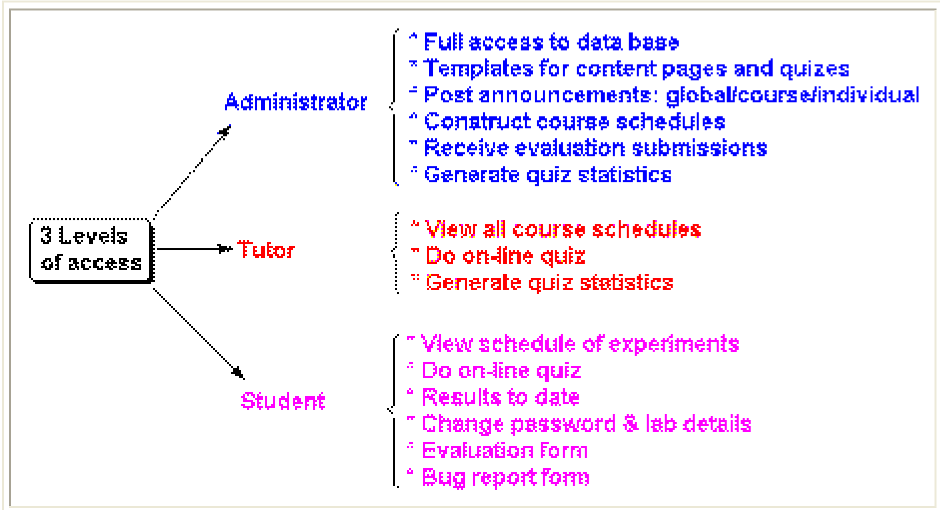


Figure 2. Summary of structure of pre-laboratory work application

For students, the welcome page requires entry of a name, The University of Sydney student identification number (9 digits) and a password, chosen by the individual. When students first enter the site they register some personal details (name, student identification number, password of their choosing, email address), the course they are enrolled in and where they work in the laboratory. Subsequent entry into the site takes the student to their personalised laboratory schedule from which they access the text associated with the pre-laboratory work and the quiz, Figure 3. Students also have the opportunity to view their results of previous quizzes, complete an online evaluation, send a bug-report or change their personal details.

We require the students to complete the pre-laboratory work before coming into the laboratory and compliance with this is taken as submission of the quiz associated with each practical exercise. A 'due by' date is associated with each quiz, to coincide with the date of the laboratory class. A student may complete the quiz after the 'due by' date but the marks are not recorded. Similarly a student may return to any quiz for 'refresh' or revision purposes and their marks are not recorded. The quiz contains between 3 and 10 questions and it is intended to be formative in nature while still providing the student with an incentive to attempt each question. If the student scores above 20% on the quiz they are given full marks for completing the pre-laboratory work. If a student scores less than 20% (likely if they randomly select each answer) they are credited with the quiz mark they obtained for completing the pre-laboratory work. The students see the mark they scored at the end of the online quiz and can compare it with the class average and the top mark, which are calculated at the time. Feedback on the quiz answers is designed to reinforce understanding of the pre-laboratory work text.

In this manner, students come into the laboratory prepared for the experiment. The entire laboratory time is now available for experimental work resulting in a greater flexibility in number and range of experiments achieved.

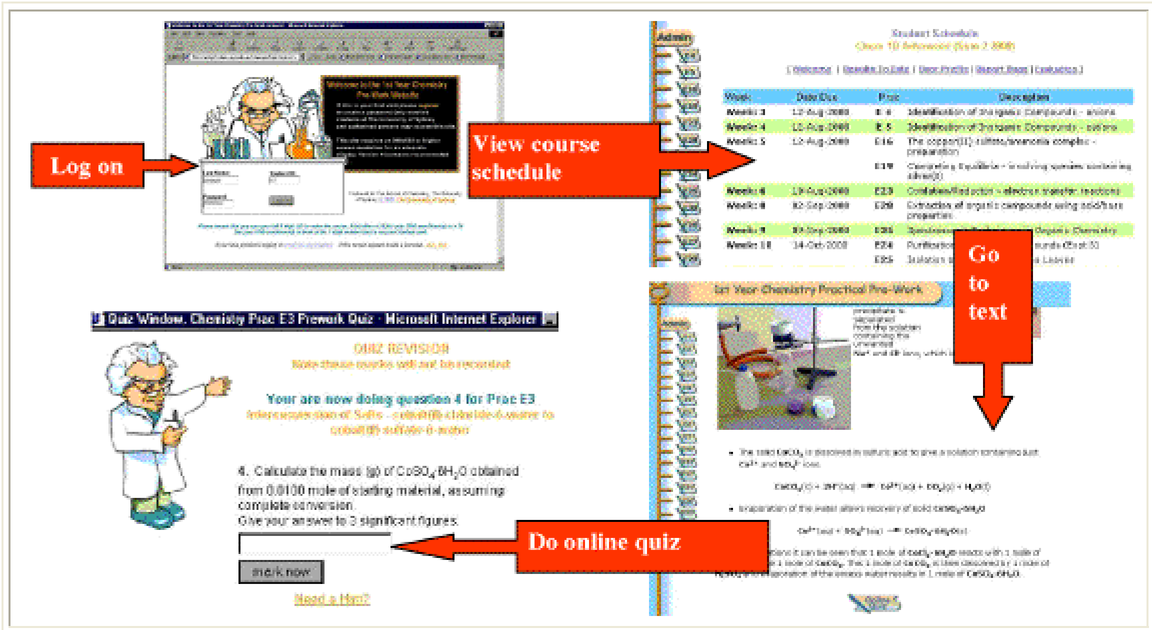


Figure 3. Example of sequence of pages used in the online pre-laboratory work

The tutors can access the pre-laboratory work quiz marks and question responses made by the students under their supervision. The tutors can then focus on those that had difficulty with the material and clear up any misconceptions at the start of the laboratory session. Thus the individual attention given to those students most in need is increased.

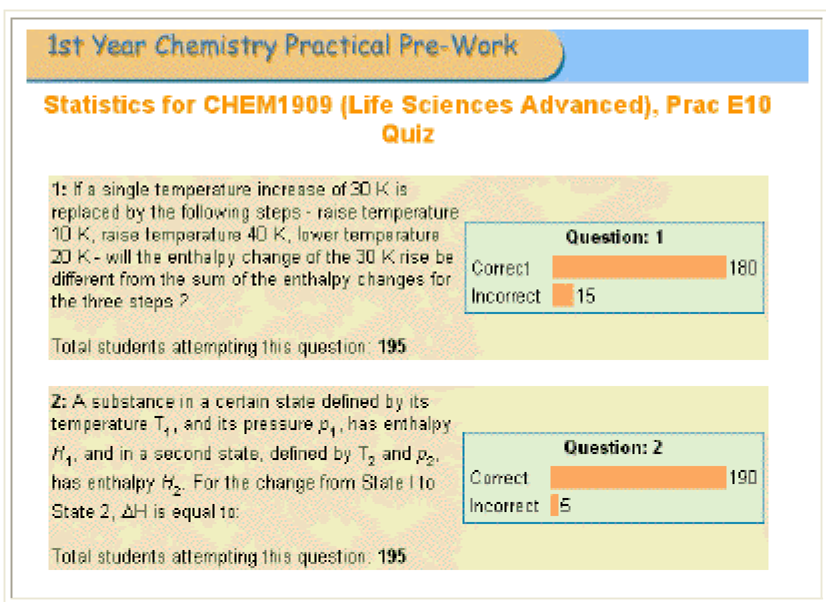


Figure 4. Example of question statistics

Statistical data is compiled on the quiz responses at the time of the laboratory session that may be used by the laboratory director to address any widely experienced difficulties or to highlight problems with particular questions, Figure 4.

The administrator has access to all the data enabling rapid compilation of marks at the end of each teaching semester. Technical information, for example, web browser types used, time and place of login is also available for review to allow optimisation of the application to best suit our students' needs.

Student evaluation

Evaluation is, of course, an integral part of any development. The alpha test was conducted on a group of approximately 1000 students before we launched the application to the entire First Year Chemistry cohort. One of our initial concerns was related to the equity issues surrounding access to computers. Although there was anecdotal evidence that many students had access to the Internet via a home computer we needed to ensure there were adequate opportunities for those without personal computers to have free access to the site while at University. A computer laboratory of 30 machines was established in the School of Chemistry allowing access to the pre-laboratory work application (and a few limited Internet sites).

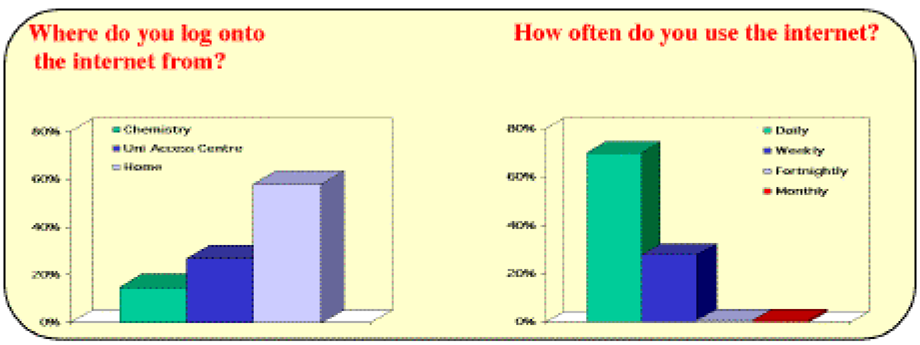


Figure 5. Student use of the Internet (N=271)

An evaluation module was built into the application to request information of a technical and of an educational nature. During first semester of 2001, 271 students completed the online evaluation, the vast majority (75%) indicating they accessed the Internet daily and that this was done from their home, Figure 5.

Students were asked a range of evaluation questions relating to the content of the pre-laboratory work. This feedback allows continued optomisation of the online resource. Examples are given in Figure 6.

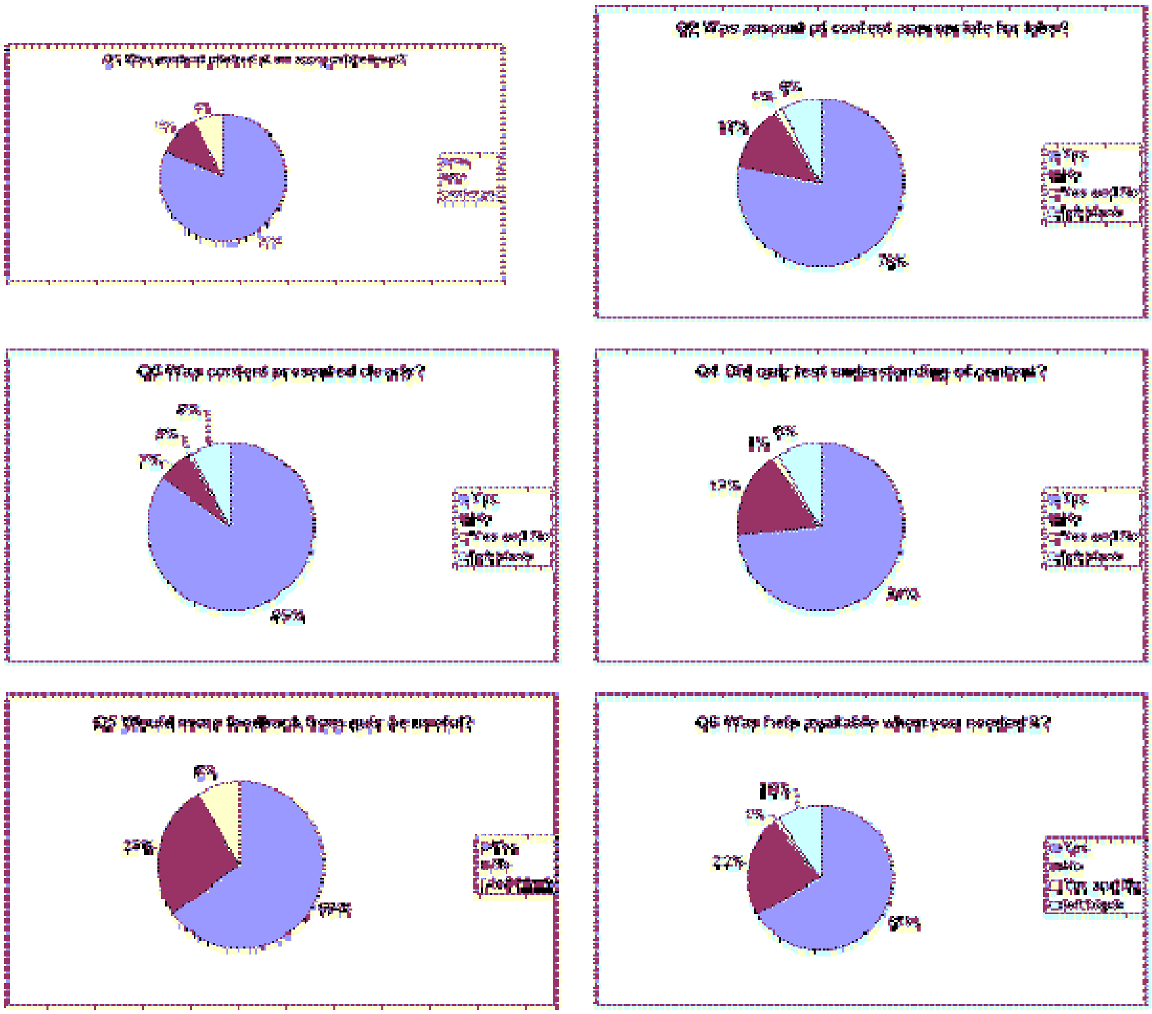


Figure 6. Examples of the questions asked in the evaluation of the pre-laboratory work (N=271)

In addition, the online evaluation provided the opportunity for students to write free form comments. Though these are always difficult to quantify, they can provide some of the most useful feedback. There is also much anecdotal evidence collected from the students, tutors and laboratory director during the practical sessions.

While the overall evaluation is very positive, it also indicates where we should direct our focus to improve the online pre-laboratory work - there is a need for more feedback to the quiz questions for example.

Our perspective

The alpha test in 2000 enabled a number of features to be optimised, particularly associated with the initial registration of students. It highlighted a few bugs in the program and gave us insight into student response to this form of pre-laboratory work. All the students were informed of the development nature of the online application and appeared willing to offer helpful comments and feedback.

When we launched the online pre-laboratory work to all of our First Year Chemistry students in 2001, we were confident that the hardware, software and computing facilities available were adequate to meet the need of our students. From our perspective there has been a big gain in the useful laboratory time available to the students now that the tutors do not mark pre-laboratory work at the start of each session. Feedback from the tutors has been very positive and centred on the finding that students coming into the laboratory appear much better prepared than was previously the case.

We are still experiencing some problems with the students incorrectly entering their identification number or laboratory details but these are generally easily sorted out. This online approach means that it is not possible for students to complete the pre-laboratory work while on the train travelling to their laboratory class however the requirement of a static environment is probably more conducive to learning!

Summary

This has been a major project in First Year Chemistry and is associate with 'obvious' costs for purchase of the web server ($12 000) and programming ($50 000) as well as many hours of work by several members of staff of the School of Chemistry. We believe it is a success and represents a significant improvement to the education of our students.

Acknowledgements

The financial support of the School of Chemistry, The University of Sydney and IT Committee of The University of Sydney is gratefully acknowledged as an essential part of this project. Moreover the success of a project such as this is due, in large part, to the dedication, willing hard work and good humour of a team of people. Particular mention should be made of Jason Bayly and Lisa Hodgson for writing the software, Craig Barnes for compiling the text and Don Radford for writing the quiz questions, all of whom played a major role in the project.

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