ChemCAL Prelabs Online

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Introduction

The teaching of science in the Australian university system is challenging. Complex key concepts must be developed in the context of increasing class sizes and a diversity of interest and ability in the student body. Student expectations about university study are changing, with signs of what McInnis (2001) terms 'disengagement' from university study. There is an expectation that university will fit in with students' lives, rather than the other way around. With a significant increase in the proportion of students working and in the number of hours of part-time work they undertake (McInnis, James and Hartley, 2001), students are increasingly seeking access to forms of learning they can use off-campus and at times convenient to them. James (2000) has found that students simply expect technologies to be part of their study and learning experience at university.

The University of Melbourne has included a computer aided learning component in its first year chemistry courses for around 10 years (McTigue et al., 1995). Our current suite of web-deliverable interactive multimedia tutorials, *ChemCAL Online* (Coller and Tregloan, 2001), was developed during 1999-2001 and covers a full range of topics typical in a first year chemistry syllabus. Chemistry 610141 and 610142 are each one semester subjects, with enrolments of around 1000; 610141 is a prerequisite subject for 610142. Each subject includes 12 topic modules, representing a total of around 10% of the workload of the course. Each module is designed to take a student 30-40 minutes of study time. Students are encouraged to make their own decisions about how to use the modules in their study program, but are advised to pace themselves at about one module per week.

The interactive animations in *ChemCAL Online* have been developed to provide students with engaging ways to review and explore central ideas in chemistry and to help them to make connections between those ideas. Where possible, a concept is presented in a way that must be explored actively. Integration of the resources into the course is important and our lecturers link specific pages in *ChemCAL Online* to their *PowerPoint* presentations in lectures, to encourage students to try the interactivity out for themselves in their own time. The module structure is flexible enough that we can easily reorganise the content from year to year or to complement a specific course.

In 2001, the *ChemCAL Online* program was developed further, with the addition of the Online Prelab resources – 8 modules of questions and animations to be designed for each of 610141 and 610142, which students must complete before undertaking each laboratory class. The objective was not to replace direct laboratory time or experience for students, but to increase the effectiveness of this aspect of our undergraduate teaching program. This paper outlines the development and current versions of *ChemCAL Online* and *Prelabs Online* in use at The University of Melbourne. Student patterns of use of the resources are summarized and students' experience of the products examined.

Prelabs Online

Laboratory based teaching is at the heart of an experimental subject like chemistry and the aim of the *Prelabs Online* project was to use our experience in multimedia development to enhance the

effectiveness of our major first year laboratory courses. The conventional preparation for laboratory work is a brief written 'prelab' exercise, handed in to a group demonstrator before a class.

Beginning with a pilot project in 2001 and a full set of prelab modules on-stream for the Semester 2, 2001 course, *Prelabs Online*, set out to:

- replace each written prelab with a multimedia module to be undertaken shortly before the class. The intention was to require participation and individual responsibility for these tasks in a way that the written prelabs need not do.
- use the techniques available to us through our ChemCAL Online system to present and review the context of a particular experiment together with various aspects of the laboratory procedure, using animations, videos and interactive questions. Some examples are given in Figures 1 and 2.
- provide demonstrators with access to the prelab files before a class, so that they could confirm successful completion of the module – a requirement for a student to begin the class.
- use the multimedia modules to link the laboratory aspects of the course more specifically to the lectures and other aspects of the course – addressing a commonly expressed difficulty for students – while also emphasizing the aspects of the laboratory experience which focus on manipulative or measurement skills and experience in the handling of materials.

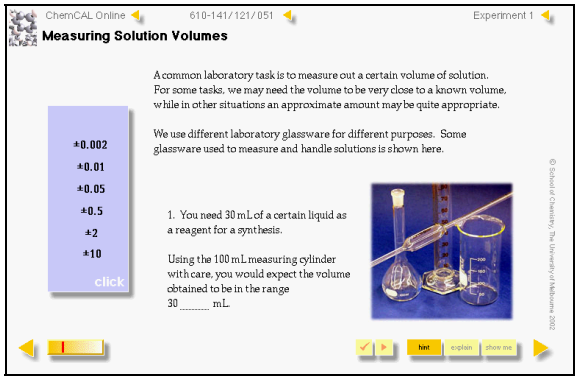

Figure 1. Measuring Solution Volumes

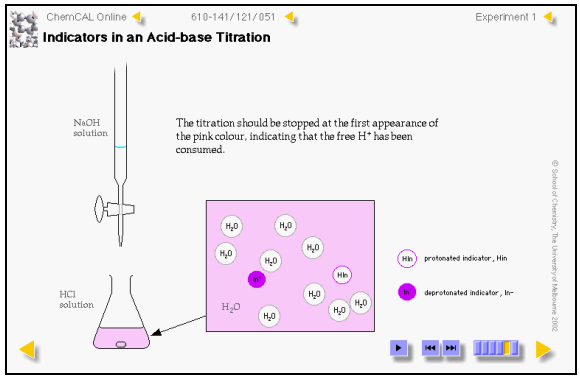

Figure 2. Acid-base Indicators

Our objective is to make time spent in laboratory classes more effective – not to replace, but to significantly improve and enrich the practical laboratory experience for our students. The intended learning outcomes are an improved understanding of experimental chemistry and an increased level of laboratory skill in our graduates. The pre-laboratory modules in this project must not be a major additional study burden and were designed for 15-30 minutes of student time before each experiment. The nett change in the required student workload was expected to be minimal. Once implemented, the impact on staff workload was also expected to be minimal. Laboratory demonstrators have been relieved of hand-marking a total of over 20,000 written prelabs a year. Many routine and repetitive questions to demonstrators and tutors are now handled through the online resources both prior to and during laboratory classes. Demonstrators can use their skills and knowledge to work with individual students on more sophisticated and detailed problems associated with laboratory work.

Patterns of use

ChemCAL Online and the *Prelabs Online* resources now form an integral part of our first year courses and the system delivers over 600,000 pages of information, interactive questions and animations to students in our first year classes each year. Server log information and data returned by the *ChemCAL Online Shockwave* objects, provides us with pattern of use and performance data.

For Chemistry 610142 in Semester 2, 2001, we found that the use of Prelabs was largely constant across the semester as expected for a compulsory component of the practical program (Figure 3). The peaks in use correspond to the commencement of practical work (in Week 2 of the semester) and to new modules coming online for the first time. Weeks 38 and 39 relate to a mid-semester break.

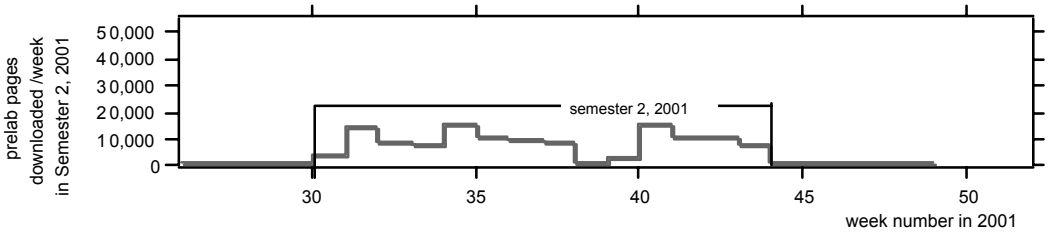

Figure 3. Prelab pages/week during Semester 2, 2001

The *ChemCAL Online Prelabs* were designed to take about 20-25 minutes to complete. This objective has been realised as illustrated by the example below showing a distribution of student session times for Experiment 5 (Figure 4), though it is also important to note the wide range of times individual students choose to spend on the tasks required. The typically high average mark for the prelabs (Figure 5) suggests that students have a good understanding of the concepts presented. This conclusion was also borne out in the results of the focus group interviews.

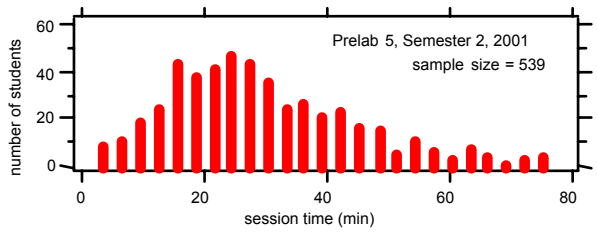

Figure 4. Sample distribution of session times for a prelab module

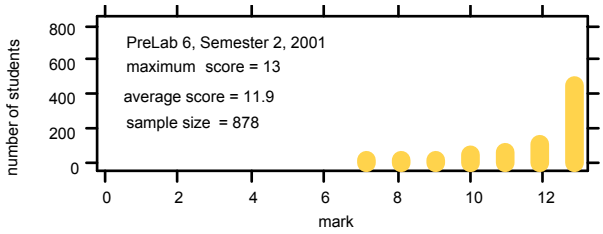

Figure 5. Sample distribution of marks for a particular module

For all first year General Chemistry subjects, the 'non compulsory' *ChemCAL Online* modules are used consistently across the semester with dramatically increasing use towards the end of semester (Figures 6 and 7). This pattern is consistent with students using the modules to assist their learning across the semester, with intense use to aid their revision and examination preparation. The sharp decline at the end of week 45 marked the conclusion of the examination in Chemistry 610142, the largest of the Semester 2 chemistry subjects. By comparison, once practical work was completed few students felt the need to access the Online Prelab modules (Figure 3).

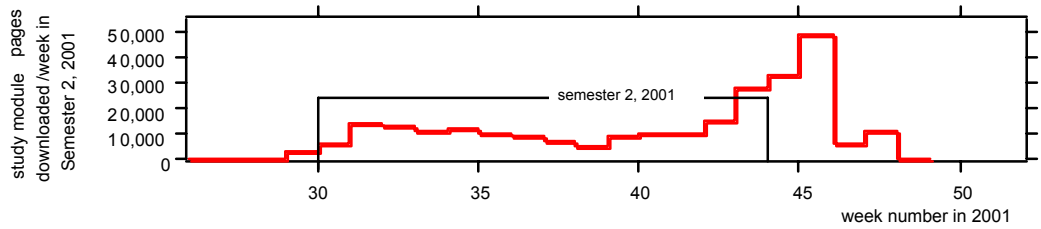

Figure 6. Study module pages/week during Semester 2, 2001

The total of Online session times for students varied widely, although the 'average' student appears to spend between 5-10 hours per semester using *ChemCAL Online* (Figure 8).

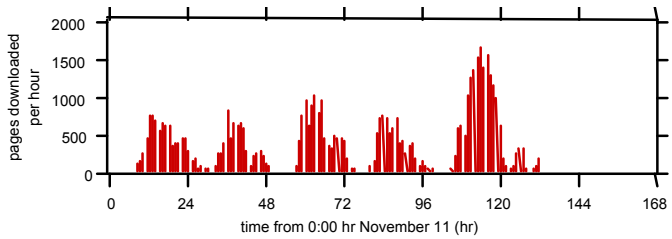

Figure 7. Hourly deliveries in week 45, 2001

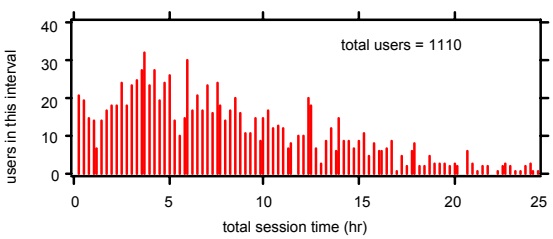

Figure 8. Total Semester 2, 2001, session times

Students' experience

Our evaluation during 2001 of *ChemCAL Online* and *Prelabs Online* incorporates observations of patterns of use, pre-use and post-use questionnaires and focus group interviews with students. Questionnaire and interview data relevant to *ChemCAL Online* and interview data about the Prelabs are reported here. Interview data indicated that students found *ChemCAL Online* useful for their learning and in reinforcing chemistry concepts learned through other mediums. In the post-use questionnaire, there were four items that related to student perceptions of the value of *ChemCAL Online*. These responses to these are summarized in Table 1.

Thinking of using *ChemCAL* at university so far…	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	Mean
ChemCAL has given me valuable opportunities for online learning at my own pace	1	4	9	60	26	**4.1**
The step-by-step approach used to explain concepts in *ChemCAL* is an advantage over textbooks	0	3	12	59	26	**4.1**
ChemCAL helps to break up the monotony of reading lecture notes and textbooks in examination revision	1	1	11	58	29	**4.1**
If I miss important information in *ChemCAL*, the choice to go back over it is valuable	1	2	6	57	34	**4.2**

Table 1. Student perceptions of the value of *ChemCAL Online*

Of particular value, according to the data from the post-use questionnaire, was the option for students to test themselves on practice problems. They also found personal feedback on their attempts at the incorporated problems to be very beneficial. A summary of student responses to the two items in the post-use questionnaire that related to feedback appears in Table 2.

Thinking of using *ChemCAL* at university so far…	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	Mean
The individual feedback provided by *ChemCAL* has improved my learning	1	14	32	41	12	**3.5**
ChemCAL provides me with useful feedback on my understanding of Chemistry	1	7	24	58	10	**3.7**

Table 2. Student perceptions of feedback received through *ChemCAL*

This data also indicates that students' expectations, gathered in the pre-use questionnaire, that educational technology would provide them with helpful feedback on their progress, had been met.

The timeliness of feedback was also experienced through the ability to check understanding. As one student put it, 'You can be tested straight away'. Most students also appreciated being able to go back and retry after an incorrect answer rather than just being told it was incorrect.

In data from the second focus group interview, students agreed that *ChemCAL* allowed interactive exploration and manipulation of material in ways not possible with traditional media and that this was of particular benefit. A number of students mentioned that they found it difficult to visualise three-dimensional models adequately when using textbooks with two-dimensional representations. The majority of the group agreed that the ability to rotate three-dimensional objects in *ChemCAL* allowed for a better understanding of the models.

Most of the interviewees agreed that *ChemCAL* allowed interactive exploration and manipulation of material in ways not possible with traditional means. When asked about the ability to explore

material in ways not possible with other learning mediums, most students stated their learning had benefited from *ChemCAL*'s interactive format; the ability to manipulate variables and revisit steps.

The responses to the post-use questionnaire items related to graphics and interactive features of *ChemCAL Online* are summarized in Table 3.

Thinking of using *ChemCAL* at university so far…	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	Mean
Using *ChemCAL* means I can manipulate material to help my learning in a way not possible with other means	1	6	27	52	14	**3.7**
The interactivity of *ChemCAL* helps me focus on understanding Chemistry	2	6	16	60	16	**3.8**
The ability to rotate three-dimensional objects in *ChemCAL* allows for better understanding than just using two-dimensional images from classes and textbooks	1	1	7	52	39	**4.3**

Table 3. Student perceptions of *ChemCAL* graphics and interactive features

In terms of possible enhancements, students suggested that example problems should have increasing levels of difficulty (e.g. 'easy', to 'medium', to 'hard'). Some students suggested that the descriptions contained in *ChemCAL* could be too lengthy at times. A dot-point option was suggested.

Students' overall attitude to *Prelabs Online* was overwhelmingly positive. It was unanimously agreed by those interviewed in the focus group that *Prelabs Online* were 'much better' than the paper-based version. They were perceived to be more efficient and as facilitating better quality and more focused learning outcomes than the paper-based predecessor. In particular, students felt that *Prelabs Online* led to a clearer understanding of the concepts associated with laboratory work, prepared them better for the practical aspects of laboratory sessions and gave better feedback. Student comments included:

With the Prelabs that related to experiments, you learn more and you know what you're doing when you get there.
The Prelab tell you what to expect.
Visualisation is easier – you couldn't do that last semester.
Last semester, you'd do it and forget, now Prelabs explains the question, fits everything together, you understand and don't forget.
I used to do them at lunch time just before the lab with little care – now I do it properly.
This way you know ahead of time what will happen – the labs are clearer.
I enjoy the labs more now because I know what is going on.
I recognised a reaction!
When you actually do the prac in the lab, you remember it from the prelab.
I knew what a piece of measuring equipment was called *and* how to use it.
We used to get to labs [in first semester] and go 'What's going on?' and no-one would know.
There's less stress now because we are more familiar with everything before the lab.
Now if something goes wrong in the lab, we're more likely to understand *why* and not be upset or confused.
We used to just get a tick or a cross with no explanation.
Prelabs include explanation and feedback.
You know straight away whether you understand or not and you can go over things if you don't quite understand.

Students thought the compulsory nature of *Prelabs Online* was good as it meant they were forced to prepare for the laboratories and that this was useful for the reasons outlined above.

Summary

Flexible access and use of high quality learning resources are important criteria for current university students and *ChemCAL Prelabs Online* meets these criteria. However, this analysis of the student experience of using *ChemCAL Prelabs Online* also demonstrates clearly that the product is much more than a convenient, attractive information resource for university learners. Our students expect

educational technology to provide them with feedback and these online resources meet these expectations. Further, these students are interested in and enthusiastic about the material and their learning. Their interactive use of this product is contributing to this engagement with their study of chemistry.

Acknowledgements

Matt Coller, with Peter Tregloan, created the *ChemCAL Online* system and programmed many of the interactive resources in the *Online Prelab* materials. Alison Funston and Bob Craig implemented many of the operating screens in the current suite of Prelab modules. Carol Johnston made available the evaluation tools developed for her 2000 survey of students in Economics and Commerce at The University of Melbourne. Richard Scott-Young carried out the statistical analysis of the two student surveys reported in this work. The *ChemCAL Online* and the *Online Prelab* projects were made possible by project grants from The University of Melbourne, Teaching and Learning (Multimedia and Educational Technology) Committee.

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