Chapter 4: Chemistry delivering to Agriculture students

Background
There are four undergraduate Agriculture degree programs that require students to take chemistry in the first year of study, as illustrated in the table below.

<table>
<thead>
<tr>
<th>Degree Program</th>
<th>Chemistry options</th>
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<tbody>
<tr>
<td>Bachelor of Horticultural Science</td>
<td>CHEM1001 <em>Fundamentals of Chemistry 1A</em> and CHEM1002 <em>Fundamentals of Chemistry 1B</em> or CHEM1901 <em>Chemistry 1A (Advanced)</em> and CHEM1902 <em>Chemistry 1B (Advanced)</em></td>
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<tr>
<td>Bachelor of Land and Water Science</td>
<td>CHEM1001 <em>Fundamentals of Chemistry 1A</em> and CHEM1002 <em>Fundamentals of Chemistry 1B</em> or CHEM1101 <em>Chemistry 1A</em> and CHEM1102 <em>Chemistry 1B</em> or CHEM1901 <em>Chemistry 1A (Advanced)</em> and CHEM1902 <em>Chemistry 1B (Advanced)</em></td>
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<tr>
<td>Bachelor of Resource Economics</td>
<td>CHEM1001 <em>Fundamentals of Chemistry 1A</em> and CHEM1002 <em>Fundamentals of Chemistry 1B</em> or CHEM1101 <em>Chemistry 1A</em> and CHEM1102 <em>Chemistry 1B</em> or CHEM1901 <em>Chemistry 1A (Advanced)</em> and CHEM1902 <em>Chemistry 1B (Advanced)</em></td>
</tr>
<tr>
<td>Bachelor of Science in Agriculture</td>
<td>CHEM1001 <em>Fundamentals of Chemistry 1A</em> and CHEM1002 <em>Fundamentals of Chemistry 1B</em> or CHEM1901 <em>Chemistry 1A (Advanced)</em> and CHEM1902 <em>Chemistry 1B (Advanced)</em></td>
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</table>

However, the Agriculture students are advised to take CHEM1001 *Fundamentals of Chemistry 1A* and CHEM1002 *Fundamentals of Chemistry 1B*. Additional support material for students enrolled in the Fundamentals of Chemistry units of study is offered, including a suite of modules that were developed at The University of Melbourne and bought under licence and extensively modified by the School of Chemistry for use at the University of Sydney. These are known collectively as *ChemCAL* and each module used at the University of Sydney is licensed separately.

*ChemCAL* provides a self-paced learning environment with feedback in the form of formative quizzes to enable the student to test his/her understanding of the topic. Each module consists of a series of screens that typically start with a brief explanation of a concept, often accompanied by animations, followed by interactive questions on that concept. Each question provides a hint if required and after an answer has been entered and checked, an explanation is also available. A wide range of question types is used. The modules were originally provided as ‘stand-alone’ and this limited access to them to the School of Chemistry’s computer laboratory. During the last few years the School of Chemistry at The University of Sydney has collaborated with The University of Melbourne in modifying the *ChemCAL* modules to improve their content, to convert them to web delivered format, and to align them more closely with first year chemistry units of study at The University of Sydney.

Within the cohort of students taking the Fundamentals of Chemistry units of study there were 86% of the first year Agriculture students in 2001.
Development proposal
The School of Chemistry proposed to:
• buy more ChemCAL module licences;
• tailor the ChemCAL modules to better suit the targeted units of study and the School of Chemistry’s teaching philosophy, thus making the content more relevant to the students’ learning; and
• convert ChemCAL modules to an online format so that they can be accessed and used by students any time, any place, thus making the modules more available to students.

Summary of development
Existing modules were to be modified to provide support for all the first year chemistry units. Whilst the modules were originally intended for students with little or no chemistry background, it is now recognized that the modules are of value to all first year chemistry students in enhancing their learning. In addition to supporting the learning of first year students, the modules may also be used for revision and review purposes by students engaged in intermediate and senior units of study in chemistry, and possibly for revision in Chemical Engineering units of study.

The University of Melbourne developed the ChemCAL modules, of which 27 were supplied under licence to The University of Sydney. The School of Chemistry at The University of Sydney, in collaboration with The University of Melbourne, modified the modules to improve their content, align them with The University of Sydney’s units of study and converted them to web-based delivery. Note that a number of the computer-based modules had been modified previously to suit The University of Sydney’s units of study.

The evaluation of the modules included student evaluations of use and perceptions of usefulness, and evaluation of the transfer of basic chemistry knowledge from first year to second year agricultural chemistry.

Detail of development and evaluation

Timeline
Semester 1, 2001 Convert ChemCAL modules to online format and implement as they become available.
Semester 2, 2001 Continue to convert ChemCAL modules to online format and implement as they become available. Evaluate participant reaction, students and staff. Modify modules, if necessary.
Semester 1, 2002 Evaluate transfer of knowledge and understanding from first year to second year. Simplify student WebCT access to the online modules. Investigate ways to reinforce the relevance of these support modules for the Agriculture students.
Semester 2, 2002 Carry out in-depth evaluation. Identify and document other teaching programs where the modules might be used, either for revision, just-in-time learning, or core topics.
**Online implementation**

Currently a total of 27 *ChemCAL* modules have been modified and converted for online delivery. As well as two introductory modules, these modules include:

<table>
<thead>
<tr>
<th>General Chemistry</th>
<th>Properties of Atoms</th>
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<tr>
<td>Stoichiometry</td>
<td>Atomic and Nuclear Structure</td>
</tr>
<tr>
<td>Behaviour of gases</td>
<td>Atoms, Electrons and Orbitals</td>
</tr>
<tr>
<td>States of matter</td>
<td>Atomic Properties</td>
</tr>
<tr>
<td>Electrochemistry</td>
<td>Quantum Numbers and Atomic Orbitals</td>
</tr>
<tr>
<td>Chemical energy and calorimetry</td>
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</tr>
<tr>
<td><strong>Properties of Molecules</strong></td>
<td><strong>Equilibria</strong></td>
</tr>
<tr>
<td>Covalent Bonding</td>
<td>Chemical equilibria</td>
</tr>
<tr>
<td>Molecular Shape and Structure</td>
<td>Solubility equilibria</td>
</tr>
<tr>
<td>Molecular Shape and Bonding</td>
<td></td>
</tr>
<tr>
<td><strong>Acid/Base</strong></td>
<td><strong>Kinetics</strong></td>
</tr>
<tr>
<td>Acids and bases</td>
<td>Reaction rates and Chemical Kinetics I</td>
</tr>
<tr>
<td>Weak acids and bases</td>
<td>Reaction rates and Chemical Kinetics II</td>
</tr>
<tr>
<td>Calculations with weak acids and bases</td>
<td>Thermal Energy, Collisions and Reactions</td>
</tr>
<tr>
<td>Acid/base titrations</td>
<td>Reaction Mechanisms</td>
</tr>
<tr>
<td><strong>Organic Chemistry</strong></td>
<td></td>
</tr>
<tr>
<td>Structure and Bonding in Alkanes</td>
<td></td>
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<tr>
<td>Conformers, stereochemistry and cycloalkanes</td>
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<tr>
<td>Alkenes, Benzene and Alkynes</td>
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<tr>
<td>Organic functional groups</td>
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</table>

**Access of modules**

In 2001 the Fundamentals of Chemistry students could access the online modules through their WebCT site (or from the School of Chemistry web site). As this was simply a link to the *ChemCAL* site where the student then had to login again, it was decided that this link would be streamlined from 2002.

The School of Chemistry is indebted to The University of Melbourne for the collaboration that has enabled the former to tailor, extend and convert materials developed by The University of Melbourne.

**Revision of online implementation**

Information obtained through the evaluation process was used to:

- guide modification and enhancement of the teaching materials;
- guide changes aimed at improving the student learning experiences within the targeted first year unit of study; and
- assist in evaluation of the underlying model for teaching reform.
Evaluations
There were four relevant evaluations done during the online implementation of the ChemCAL modules:
• the first was an evaluation of the unit with particular emphasis on student use of and their perceptions’ of the purpose and usefulness of the modules;
• the second was usage data collected for the modules;
• the third was an investigation of the amount of transfer of knowledge and understanding that took place between the junior unit of study and the intermediate unit of study; and
• the fourth was a measure of the perception of the teaching staff with respect to their involvement in the planning and implementation of the teaching innovation.

1. Student evaluation of CHEM1002 Fundamentals of Chemistry 1B
This survey was carried out at the end of Semester 2, 2001 and sought information on student expectations of IT skills, on collaboration with other students to support chemistry learning, and on the types of resources they had used for supporting their learning. In particular, the survey used open-ended question methodology to find out about students use and perceptions of the ChemCAL modules. The survey instrument is presented in Appendix 1A and the full analysis of the survey is in Appendix 1B. A summary of the analysis is presented here.

• Demographics
Of the 160 students taking the unit 77% responded to the survey of which 61% were female (39% male), 98% were full-time students and 77% are either direct school leavers or at least not long out of school, 96% were used to using the Internet with 91% using email. Figures for the Agriculture subset varied slightly with 58% female, 100% full-time students, 83% either direct school leavers or at least not long out of school, and 94% using email.

A lower percentage of Agriculture students (65%) accessed the Internet at home compared to the cohort as a whole (74%). A minority of students (12% of Agriculture and 15% overall) report difficulties accessing the ChemCAL modules. It should be noted that most of these difficulties were to do with plug-ins, browsers, the network, etc. rather than ChemCAL itself.

• Information technology skills
A majority of students felt they would need to use computers in general and the Internet for this Chemistry unit of study, although a small majority felt they would not need email, database, word processing and electronic discussion groups. There was a high non-response rate of 7-8% for database, word processing and electronic discussion groups overall. This may reflect the fact that there was no unsure/don’t know category, or perhaps some of the students were unsure of the nature of these things.

Most Agriculture students felt they would be using email for the unit of study, though the students overall felt this would not be needed. Agriculture students also ranked higher on their expectations of using word processing, with half the group agreeing with this proposition.

In fact the students do need to be able to use computers and the Internet in order to access the full range of unit of study resources – in particular, the ChemCAL modules.
Word processing and database skills are not necessary, as the practical write-ups are done by hand, as are the quizzes. Electronic discussion groups are not utilised in this unit of study. Thus the expectations of the majority of students proved true.

- **Collaborative study**
  Informal assistance between Fundamentals of Chemistry students is common, with three-quarters of students (75%) discussing aspects of the course with their peers or sharing notes to help their fellows. A large minority of students overall (41%) and a majority of the Agriculture students (52%) have met with other students for the purposes of collaborative study, but meeting regularly with peers for study is undertaken by only about 15% of the cohort overall. However, students indicated that they mostly preferred to study alone (65% for cohort and 67% for Agriculture subset). Only 18% of students for the cohort preferred to always study alone (15% for the Agriculture subset) and there were no respondents that preferred to always study collaboratively.

A slightly higher percentage of Agriculture students display interactive study behaviours with respect to chemistry. Helping behaviour with peers, for example sharing notes, is far more common among the Agriculture students. This group seems to be more cohesive and supportive of one another as a whole, or miss more lectures!

- **Resources used for study**
  The majority of students (around 65%) prefer the combination of textbook, lecture notes and web-based material for their study. A significant proportion of Agriculture students (31%) prefer to study just using the textbook and lecture notes. Note that for some sections of the unit of study the academics supplied photocopied lecture notes whereas for others the lecture notes were available online.

- **Use of resources for learning**
  The traditional course components of lectures, tutorials and quizzes have a high use and usefulness ranking, with 86-95% of students (92-100% for Agriculture) finding these useful or extremely useful in their studies. The laboratory classes are not as highly rated with 70% (75% for Agriculture) finding these useful or extremely useful and 63% (69% for Agriculture) finding the laboratory manual useful or extremely useful.

  The ChemCAL modules were found to be useful or extremely useful by almost all who used them. However, there was a sizable minority (17% or 29% for Agriculture) of students who did not access them. This is to be addressed in 2003 by further integrating the resource into weekly assignments.

  The textbook has not received a high acceptance rate with students. Just over half of the cohort found it useful or extremely useful. Approximately 40% of students either did not use the textbook or did not find it useful. This is to be addressed in 2003 with the introduction of a new textbook. The library was a much underutilized resource, with only 24% of students finding it useful or extremely useful. More than half the students did not use the library.

  The duty tutor was used by a far higher percentage of Agriculture students than the group overall. The duty tutor usage rate is low – around 40% – lowest of all resources except the library. Around 15% of students do not find the duty tutor useful. This may depend on how close the examinations are. However, it should be noted that the
purpose of the duty tutor is to support the weaker students only, and so, many students may not have felt the need to use the service.

- **Evaluation of use and perceived usefulness of online ChemCAL**
  
  Within Fundamentals of Chemistry 1 there is a set of ChemCAL modules. What do you think was the purpose of these modules? Why do you think the unit coordinator arranged for these modules to be included? How did you use these modules to support your learning?

  The ChemCAL modules were perceived to be of use in helping students understand concepts or help with calculations (50% of responses) and in assisting with revision and testing, especially prior to the quizzes (22%).

  The reasons for including the modules were seen as providing animated explanations and visual aids (13% of responses), interactive learning (6%), practice (6%) and to encourage students to do additional work (6%).

  In addition, 17% of students used the modules for consolidating, summarising and practising material learnt in lectures and practical class.

  Each ChemCAL module includes some learning materials and associated self-test revision questions with feedback. Overall, in what way(s) were these modules useful to you? Which aspect of the modules did you find most useful? How did this aspect of the ChemCAL modules help you in understanding and learning Chemistry?

  Students indicated that the most useful aspects were the practice questions, in particular the feedback, the diagrams, illustrations and 3D animated graphics and the provision of an overview of the scope and depth of work to be covered.

- **Summary**
  
  It was surprising how homogeneous the group was, i.e. how closely the responses from the Agriculture students reflected the total group responses. The feedback obtained through this evaluation was used by the unit coordinator to make appropriate changes to the online implementation and delivery of the ChemCAL modules for 2002.

  **2. Usage data for the online ChemCAL modules**

  During Semester 1, 2002, the School of Chemistry collected data relating to the usage of the ChemCAL modules by first year students. The method of collection was to log the number of hits on each module across time. CHEM1001 Fundamentals of Chemistry 1A students (which includes 86% of the Agriculture students) were the most prolific users. This is not surprising as ChemCAL has been more strongly integrated with that unit of study. The full analysis is in Appendix 2.

  Weekly usage data showed, that as different topics were covered in class, usage of the relevant modules increased. For example, stoichiometry was the most popular module until May when calorimetry, molecular shape and organic chemistry modules became popular. Later in the semester, modules on acid/base, equilibrium and kinetics were favoured. Particularly heavy usage was seen in the period before the examinations – it would appear that the students found the online ChemCAL modules valuable for revision.
With respect to those units of study taken by Agriculture students, the stoichiometry module was by far the most used with 1027 hits. The popularity of this module probably reflects the fact that even well grounded students find stoichiometric calculations difficult. The next most popular module over the semester was the basic *Atomic and Nuclear Structure* module which was used on 555 occasions, followed by *Chemical Energy & Calorimetry* (392), *Behaviour of Gases* (385), *Chemical Equilibria* (334), *Covalent Bonding* (332) and *Kinetics 1* (330). The organic chemistry modules are only relevant to the Life Science and Veterinary Science units of study. Other modules that were not heavily used tend to relate to topics covered in Semester 2.

Students are given the option to comment on each module as they log out. Two questions are posed “How much did this module help in your learning in this topic?” and “How well did this module run?” While the great majority of students chose not to give any feedback, some did offer useful feedback and most of the feedback is of a positive nature. From the data collected it seems that the modules typically run well and are found to be very useful as a learning tool. Where students have problems with the operation it is usually due to not loading the *Shockwave* plug-in successfully.

The feedback obtained through this evaluation was used to:
- guide modification of and enhancement to the teaching materials;
- guide changes aimed at improving the student learning experiences within the targeted first year units of study; and
- assist in evaluation of the underlying model for teaching reform.

### 3. Transfer of knowledge

The Agriculture students who completed the first year Chemistry units of study in 2001 went on to take AGCH2002 *Agricultural Chemistry 2* in 2002. They were surveyed towards the end of Semester 1 in 2002 and their responses were correlated to their performance in AGCH2002 *Agricultural Chemistry 2*. There were 27 responses to the short survey which asked two questions about their perceptions of the reasons for including the chemistry units of study in the degree program. The survey instrument is in Appendix 3A and the full analysis is in Appendix 3B.

The implementation of the survey complied with The University of Sydney’s Ethics Committee Guidelines for research with humans. A copy of the approval document is in Appendix 3C. The approval enabled us to seek permission from the students to correlate their performance with their perceptions of the reasons for including the first year unit of study in their degree program.

There was a 44% response rate to the survey, which was done in class time. The gender balance was 72% female and 28% male; with all except one student studying full-time; and most students in the school leaver category (82%). Whilst the majority of students had taken the Fundamentals of Chemistry units of study in first year (82%), 11% had done the more challenging standard first year units of study, 4% (one student) had completed the advanced units of study, and one student had entered without the prerequisite chemistry units of study.

**Question 1** Why do you think that the program coordinator required you to do a chemistry unit of study before going on to take the unit of study AGCH2002 *Agricultural Chemistry 2*?
The majority of students (78%) felt that first year chemistry had knowledge and skills that were assumed in AGCH2002 Agricultural Chemistry 2. Stoichiometric calculation in particular, often felt to be a difficult section of the course, was believed to be an essential skill introduced and practiced in first year chemistry. Another challenging topic was organic chemistry and reaction mechanisms. Some students felt that without the first year basics, they would have had a difficult time in AGCH2002 Agricultural Chemistry 2.

A sizable percentage of students (22%) mentioned practical work learnt in first year chemistry being of particular help in tackling the second year subject.

**Question 2** As you studied AGCH2002 how did you use your understanding from first year chemistry? Why did you use the knowledge from first year chemistry in the ways you did?

The responses echoed the answers to question 1, with two-thirds (67%) of students finding that the first year chemistry is basic and necessary to understanding the second year material. Again, organic chemistry and stoichiometry received special mention, but so did titration, atomic orbitals and biochemistry.

Again, practical work gained a special mention in 22% of the responses.

Some students (11%) did not feel there was much overlap, transfer or continuity from first to second year chemistry.

Pearson’s correlation was used to look for significant linkages between previous study, perceptions of transfer, gender, age and final performance in the second year unit of study. There was a significant positive correlation between gender and age, with the older students tending to be male. There was a significant positive correlation between the two open-ended question responses so that those students who recognised the necessity for doing the junior year chemistry also saw significant content or skills links between the junior and intermediate units, although this did not necessarily translate into better marks.

4. **Teaching staff involvement**

The staff closely associated with the chemistry first year units of study and the agriculture second year unit of study were interviewed and asked about their involvement in the development process and how well they perceived it was carried out. The questions used for this purpose are in Appendix 4. From the chemistry point of view, the project progressed at a satisfactory pace with the revisions of the modules being suggested by a Sydney chemist and the staff in Melbourne revising their existing modules to suit Sydney. In addition the chemistry units of study were put into the WebCT framework and the ChemCAL modules linked from each WebCT site.
Summary
The model took the approach of the development of small online teaching and learning modules to be used within a number of units of study across various degree programs. This involved the acquisition of appropriate base modules from the University of Melbourne, modifications to better fit The University of Sydney’s teaching program, and adaptation to online delivery. The ChemCAL modules have been tailored to meet the needs of first year chemistry students, in particular those enrolled in CHEM1001 Fundamentals of Chemistry 1A and CHEM1002 Fundamentals of Chemistry 1B. While the vast majority of the Agriculture students are enrolled in CHEM1001 Fundamentals of Chemistry 1A and CHEM1002 Fundamentals of Chemistry 1B and hence catered for by the innovation there was no attempt to single out the Agriculture students and bring the ChemCAL modules to their attention or to integrate their use into the Agriculture professional degree program. A suggestion was made that a brochure/flier might be included in the Agriculture student’s information kit at the beginning of Semester 1 but this has not been actioned.

In 2002 the use of ChemCAL was introduced as an online resource in all Chemistry 1 units of study. The monitoring of student use of each module showed that usage mirrored that of the Agriculture students in CHEM1001 Fundamentals of Chemistry 1A and CHEM1002 Fundamentals of Chemistry 1B. That is, students used the relevant module as a resource at the time the material was being covered in lectures and again for revision purposes towards the end of each semester. Once again, written feedback comments by the students using the online evaluation form were extremely positive.

With the aid of a Faculty of Science Teaching Development Grant the integration of ChemCAL will be further extended in 2003. Students will be encouraged to access the system by embedding its use at strategic points in the weekly assignments of all units.

Student expectations of the amount of material available for their use online are increasing. Moreover, an increasing level of sophistication is expected. ChemCAL combines ‘easy to understand’ text with interactive tasks, animations and supportive questions to enhance student learning. Student feedback to the survey conducted by the School of Chemistry (Appendix 2) was positive. The online mode allows self-paced learning appropriate to the individual and asynchronous delivery. Surveys conducted by The University of Melbourne (Charlesworth et al. 2002) and the School of Chemistry, indicate that it is an excellent learning tool for the majority of Chemistry 1 students. However, it is not pitched at a level to extend students in the Advanced stream of Chemistry 1 who should use other resources. While a resource such as ChemCAL can engage students in active learning, it must be remembered it has physical constraints (the need to access the Internet) and so cannot be used while the student is commuting on the train! The School of Chemistry is currently actively seeking funds to write and purchase licences for more modules on organic chemistry. This will enable ChemCAL to support all parts of the Chemistry 1 curriculum.

The very nature that ChemCAL is being actively used by at least two large universities is an indication of its portability.

Reference

31