



## Student-centred learning through a new investigative laboratory program in first year chemistry

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### Introduction

A new laboratory program in chemistry has been designed, with the aim of fostering student-centred learning, critical thinking and problem-solving skills. The pilot phase is being introduced in 2003, initially for a class of 175 first year students, who have a good chemistry background and who have already completed one session of chemistry. We set out to offer our entry-level students the opportunity to appreciate that there are important unanswered questions in chemistry, to begin to ask their own scientific questions, to design and carry out experiments and to evaluate their results, in a problem-solving or research context. Group work was introduced both to foster a student-centred culture in the labs and to enable more significant experimental work to be undertaken. This initiative coincided with a university-wide first year experience project at UNSW in the development of graduate attributes, which is providing support for the project. This paper will report on the program design, assessment issues and initial evaluation of effects on student learning and motivation. The results of this project will eventually be used to extend the approach to much larger first year courses.

### The laboratory program

The laboratory program begins with an introduction to group work, including both non-chemistry and chemistry-related team-building exercises. There are two open-ended laboratory components in the sequence, along with a similar number of more traditional skills-building experiments. The final four-week sequence involves more extended project work supported by a series of tutorials, in which students propose and test hypotheses within one of four project areas on offer. Each project area is built on a real research question (i.e. one which is represented in the current literature). Criteria for selection of open experiments and project topics are that: (a) they must have intrinsic scientific interest and a genuine investigative component; (b) they must be accessible to first year students having a range of backgrounds and interests; (c) the experiments involved and sufficient associated theory must be able to be tackled by first year students and to be implemented in large classes; and (d) recent research literature should be available to provide the context and motivation for the work.

Assessment is based on a mixture of individual and group work. Student input into assessment criteria for the project work is being sought. Feedback sheets have been designed for marking of open-ended reports, to enable demonstrators to provide clear and consistent feedback and guidance to students. Final group projects will be assessed on the basis of a results summary and a poster presentation, to be made at an Undergraduate Poster Day at the end of session.

### The tutorials

The tutorial component of the course is being redesigned in parallel with the laboratory program. Tutorial problems are now presented under three headings: (1) Concepts; (2) Skills; and (3) Open Questions. Open questions are those where one or more of the following applies: (i) the question itself may not be fully defined; (ii) not all of the required information may be given; (iii) not all of the required information may be available (thus requiring a scientifically reasonable estimate or

assumption to be made); and (iv) there may not be a unique solution to the problem or a unique 'best answer' to the question. In developing concept and open questions we drew extensively on some excellent resources available in the chemistry education literature (references 1-6 for example) and also on ideas from research papers, news items and science magazines. Several tutorial sessions have also been set aside as laboratory planning sessions, to enable issues relating to open-ended laboratory work to be explored.

## Evaluation and future developments

Formative evaluation is by means of questionnaires and student interviews. A research assistant is observing both laboratory and tutorial classes and a series of debriefing sessions for laboratory teaching staff are planned. One early change in behaviour is that students are not only attending tutorials regularly, a number are attending a second tutorial each week.

In 2004, we plan to more fully implement the new approach in both sessions of our higher-level chemistry courses. We will also begin to introduce some of these ideas, particularly the open-ended laboratory and tutorial problems, into our other first year courses. This will require appropriate modifications to take into account the differing chemistry backgrounds and undergraduate ambitions of different student cohorts. The first year project will take another two years to implement. The implications for laboratory work in second year courses are the next challenge.

## Acknowledgements

We thank Dr. Julian Cox and Ms Brenda Tronson for their ongoing contributions to the project. This work is supported by the Faculty of Science, UNSW and the UNSW First Year Grants program. All students and staff of the 'new-look' CHEM1041 course are thanked for their input to the project.

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