

Development and evaluation of inquiry based laboratory experiences for students in the capstone Instrumental Analysis subject, CHM320, (CSU)

Charles Sturt University Chemistry Teaching Team.

Introduction

Our involvement in the project has been the introduction of inquiry based laboratory experiences for students in our third year analytical chemistry subjects as part of their Bachelor of Science (Analytical Chemistry) degree. Historically these subjects have run as a single one year subject; however, 2012 is the first year the subject is being offered in a new sequence of two single semester subjects – CHM323 (Instrumental Analysis 1) and CHM324 (Instrumental Analysis 2). The changes and rewrites of the subject topics for this new two subject format provided a perfect opportunity to make substantive changes in the format for the laboratory experience. Students in these subjects study by distance, and complete their practical experiences at intensive four day residential schools.

Our aim was to give students a better understanding of analytical instrumentation and what is required for their optimisation along with a taste of instrument trouble shooting. More broadly we hoped to develop students' skills in problem solving and analytical thinking using inquiry based approaches.

Approaches and analysis of results

We have trialled the activities on CHM323 and CHM324 students only. The expectation is that as we instructors become more experienced and comfortable with such laboratory methods we will expand such inquiry methods into the laboratory experiences for our other chemistry subjects.

In our application we indicated we would introduce inquiry laboratory experiences into our second semester Instrumental Analysis 2 subject (CHM324). In fact we moved such changes forward into CHM323 in the first semester as a trail experience for both the students and the instructors.

The CHM323 students had a 'traditional' prac experience as we have done in the past for about $\frac{1}{4}$ of the four day residential school. The instructors for the subject, Dr. Howitt and Dr. Doran, have, through conversations with Drs. Ryan, Prenzler, and Bedgood have changed the remainder of the pracs to inquiry based labs. As an example, there is an experiment analysing caffeine in beverages that compares liquid chromatography techniques with derivative UV-Vis techniques. In the past students have been told what to do and asked to compare their results from the different techniques. This year students were referred to a scientific paper and asked to make decisions about which analysis technique to use for their samples. Essentially students needed to do the legwork to decide what and how to conduct

their experiments.

Assessment methods for the introduction of inquiry based pracs involved student questionnaires/evaluations, and instructor personal reflections. Student responses to evaluations for CHM323 can be surmised as follows:

- self directed pracs are more challenging but 50% of students preferred this style of prac compared to a more traditional approach
- time was highlighted as an issue
- students requested more initial direction in preparing for an inquiry based prac and also assistance in how to interpret and report their results since the report writing style for an inquiry prac differs to the standard lab report to which they are more accustomed.
- students enjoyed working in pairs on the inquiry based prac and enjoyed the flexibility in determining their laboratory and instrumental approach; “self directed pracs help me to learn better as I know why I’m doing things”

Instructors for CHM323 also reflected that time was an issue; students required significant time in order to decide their approach. It was also necessary for the Instructor to ask a series of leading questions to ensure students considered issues such as replication, solvent blanks, safety requirements etc. One Instructor noted that “there is a fine line between guiding and directing” and both instructors agreed that that students were much more comfortable with the “usual style” of prac whereby a clear set of instructions are provided. On the whole, the reports for this exercise were not as well done as for the other practical where their instructions were more clearly laid out. The comparative part of the activity was not well done and no student commented on changes they might have made to the sample preparation method. One Instructor noted that “if the students were more familiar with this style of activity from classes in earlier years they would have handled the reports better, but the level of complexity in the analysis combined with being unfamiliar with inquiry style practicals resulted in them taking a superficial or incomplete approach to reporting their experiments.”

Lessons learnt in our trials in CHM323 were carefully considered for the incorporation of inquiry based pracs in CHM324. In this subject Dr Prenzler, in consultation with Dr. Bedgood, has revised the chromatography experiment to put the onus on students to think carefully about what instrument conditions and parameters are appropriate for reasonable results (please see attached information provided to students *before* res school as an advance organiser.)

Based on feedback from CHM323, students were given more direction to prepare for the inquiry based prac in CHM324, namely “Optimisation of a Chromatographic Method for the Analysis of Phenolic Antioxidants in Red Wine”. Students were given information regarding the material provided to them in the lab, and a starting point (eg isocratic elution using a specified mobile phase) from which they could plan their optimisation experiments. Students were given a pre-lab exercise to document their

optimisation plan and assessment points were allocated to this task. The students were required to submit their written plan to Dr Prenzler prior to the commencement of the residential school and were advised that their report for the inquiry based prac would be marked differently compared to the traditional directed prac.

Student feedback for this experiment was positive and, as expected, was more successfully received than the first implementation of an inquiry based prac in CHM323; most likely this is attributed to student experience and students commented that this style of prac should be introduced in second year rather than being “thrown in at the deep end in third year”. Students felt they had adequate time and enjoyed discussing their optimisation strategies with the Instructor. Students enjoyed optimising and troubleshooting the instrument; “the ability to fault find and experiment on the (instrument) rather than just performing an experiment” was highlighted as something that worked well for the inquiry based prac. This was precisely our goal in that we wanted students to develop a deeper fundamental understanding of instrument functions and processes (moving away from the instrument as a magic black box).

The Instructor for the optimisation prac was a casual employee with expertise in chromatography. He noted that students found the pre-lab plan challenging since they have had no previous experience in instrumental optimisation and recommended that a few more hints could be given to students to assist them. He thought the instrument (liquid chromatograph) could be broken down into component sections (eg instrument injector; column/separation; detector) to encourage students to consider the breadth of optimisation options and better understand the functioning of the instrument.

Reflections and conclusion

Student feedback indicates that despite students finding inquiry based pracs to be more challenging, they are clearly of great learning value. As a direct result the Chemistry Teaching Team needs to continue to refine our approach to implementing inquiry based pracs and introduce students to this style of prac as early as possible; in their first year would be wonderful however this is challenging due to large student numbers and limited Instructor support. At this point we are focusing on our second and third year subjects and one of our team members has plans to change the laboratory experience in her second year organic chemistry subject to incorporate inquiry based pracs as a result of this project. The pracs in our second year analytical chemistry subject, which are part inquiry based, will also be reviewed in light of this project.

Working collegially towards student centred learning has been of significant value to both students and instructors alike. The Chemistry Teaching Team will continue to work together to ensure the best possible learning outcomes for our students; we have no doubt that inquiry based approaches will feature heavily in our future learning and teaching strategies.