Development of POGIL-style classroom activities for an introductory Chemistry course (Adelaide University)

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Introduction

Level I Foundations of Chemistry IA (semester 1) and IB (semester 2) courses at the University of Adelaide are undertaken by students pursuing a wide variety of degree programs, many of which require a year of Chemistry at first year level. As a consequence, many students who have never studied Chemistry in high school enrol in these courses, which can have up to 350 students enrolled each semester. Prior to 2012, neither Foundations of Chemistry IA nor Foundations of Chemistry IB had SACE Stage 2 (Year 12) Chemistry as a prerequisite, but assumed much of this knowledge, resulting in students who had never studied Chemistry before (i.e. no Year 11 or 12 knowledge) having to come to terms with this unfamiliar course content very quickly. Some students thrived in this situation but others found it more difficult. For the latter group of students, the study of Chemistry can be a roadblock preventing their progress through their chosen degree program.

The discipline of Chemistry recognised that in the years to come, more and more students who have not studied Chemistry at secondary school will be enrolling in degree programs that require a year of Chemistry study. The discipline wished to maximise learning opportunities for these students by revising not only the content of the Foundations of Chemistry courses, but also the way in which they are taught.

The combination of Foundations of Chemistry IA and IB will provide students with a good basis of Chemistry knowledge that will enable them to continue their studies in level II courses not offered by the Discipline of Chemistry, but which may have first year Chemistry as a prerequisite.

Course content for the new Foundations of Chemistry IA and IB now begins at an introductory level, rather than assuming any prior Chemistry knowledge. Each semester-long course consists of four modules, with group-based Process Oriented Guided Inquiry Learning (POGIL)-style activities used to deliver the majority of the course content. Regular assessment through online tasks and short in-class tests provides students with continual feedback to guide and monitor their progress. It was anticipated that these group learning sessions would give students more of an opportunity to actively engage with the course content than the previous format provided.

Course content needed to be significantly revised, and in most cases completely rewritten, to accommodate the restructure of these courses, including the incorporation of group-based learning activities.

A POGIL activity begins by providing students with some information, in the form of a paragraph or two of text, a diagram or a table, followed by guided inquiry questions that allow students to make their own connections and build understanding by doing.

The aim of this project was to develop POGIL-style activities in the area of introductory organic chemistry, with their construction guided by feedback from current Chemistry students. Very few POGIL activities exist for introductory organic chemistry (much of what is already available is for second year-level college courses in the US and as such is aimed at too high a level for this course), so we wished to develop activities to cover subtopics such as systematic nomenclature, physical properties of organic compounds and functional groups for use in the semester 2 Foundations of Chemistry course.

Approaches and analysis of results

Development of three organic chemistry POGIL-style activities began in late 2011, covering the topics of proteins, physical properties of alkanes and introduction to alkenes and alkynes. A small-scale trial with first year students who had just completed Foundations of Chemistry studies was conducted in November, 2011. Students were introduced to the activities and the rationale behind their introduction and implementation, and were then asked to complete the activities in the same way as a student in class would. At the end of the session, students were asked to complete a survey, featuring both Likert-style and open-ended questions, in order to give their feedback on the activities. The response to the activities even in this early iteration was extremely positive, with 100% broad agreement for all Likert questions asked:

- The activities stimulated my interest in organic chemistry
- It was clear to me what to do in the activities
- The activities helped me to develop my thinking skills (eg, problem-solving)
- I understand the concepts presented in these activities
- Completing these activities has given me more confidence in approaching assessment tasks in organic chemistry

Responses to the open-ended question “Overall, what was the best aspect of the activities and why?” included “You can share ideas and learn from each other”, “Student involvement and participation and engagement. Problem-solving skills” and “A student can read anything, but when it comes down to doing questions and testing that knowledge, as done in these worksheets, that’s where the real learning happens.”

Students in the November workshop also provided some constructive ideas on how to improve the activities, especially commenting on the need for the activities to be less text-focused. Based on this feedback, the activities were updated in early 2012

and then trialled again in April 2012 in a workshop session featuring a mixture of second year and postgraduate chemistry students. The structure of this workshop was the same as the one held in November, but in addition, a focus group was run following the workshop session to enable more time for conversation and general feedback. A paper survey similar to the one used in the November workshop was provided to participants, who were asked to complete it to give their feedback on the activities. Once again, the responses were extremely positive, with 100% broad agreement for all Likert questions asked, which included the first four questions used in the November survey, with two additional questions: "There was a strong inquiry focus to the activities" and "The activities helped me better understand chemistry". Responses to the open-ended question "Overall, what was the best aspect of the activities and why?" included "Interactive. Keeps students focused. Independent learning", "They weren't too long so I didn't feel overwhelmed. There was a logical progression between parts", "Learning by example/problem solving. Keeps you awake in lectures! Allows you to get a better grasp of the concepts by actually applying them."

Further feedback on the structure and content of the activities was provided by participants in the April workshop, which was used to further refine the activities in preparation for their implementation into the semester 2 Foundations of Chemistry course in July/August 2012.

Discussion and conclusion

The use of workshops and a focus group to trial the activities were extremely beneficial. The students who attended the workshop sessions provided valuable feedback that gave us an insight into their thoughts about inquiry-based learning and also greatly assisted with refining the activities before their implementation. This feedback was especially useful in the development of the proteins activity: initially, this activity featured a very text-heavy introduction, providing students with a large amount of information that needed to be read before they could even begin to work their way through the questions that followed. Attendees in the first workshop picked up on this, and suggested that the activity be made "less wordy". This advice was taken and the information at the start of the proteins activity was reduced from almost a full page of text to just under half a page. The other activities were also revised based on feedback from the first workshop, and were received favourably when trialled in their revised form in the second workshop.

The focus group held after the April workshop resulted in a wide-ranging discussion between participants. It was clear that these students wanted to use their perspective as senior Chemistry students to enhance the activities. The focus group participants all recognised the need to incorporate interactivity in lectures, and were extremely supportive of the introduction of this style of learning into the new Foundations of Chemistry courses, with one participant commenting "I wish my lectures were like that now". Additional comments during the focus group session further supported the use of inquiry-based learning: "It definitely helps you to develop skills more than traditional lectures" and "What really helps with learning is that you are doing it yourself rather than the traditional where someone is telling

you something and you take in one word out of every thirty."

The group agreed that it would be beneficial if inquiry-based learning was introduced into Science (not just Chemistry) courses at higher year levels; however, they stressed that beyond first year, it was important that inquiry-based learning be used to support traditional lectures (for example, in tutorials), rather than replace them entirely.

This project began with the relatively simple aim of obtaining students' feedback in order to improve the teaching materials that we were preparing. This aim was certainly achieved; however, an unexpected side benefit was seeing the thoughtful nature with which the student volunteers approached this task in providing us with their views and ideas regarding not just the technical aspects of activity structure and content, but also the deeper concepts of how they approach their own learning, and the ways in which inquiry-based learning would be beneficial to them and to future students taking the course.