MONASH University

**RACI Chemical Education Symposium**
**March 31st - April 1st, 2016.**
**Monash University, Melbourne.**

raci
Royal Australian Chemical Institute

This symposium has two aims: to showcase some of the innovative thinking around chemistry education in Australia, and to facilitate rich discussion across institutions. The second aim will be achieved by using an open program, spearheaded by four key themes, and an intensive workshop focusing on meaningful research in chemistry education.

As outlined on the following pages, theme leaders have been chosen to guide the discussions, alongside members of our community who have contributed abstracts aligning with one of themes. We hope to hear of some great innovative work, and elicit hearty discussions from the quorum.

| Day 1: Thursday March 31st | |
|---|---|
| 10:30 – 11:00 | Registration, Welcome & Coffee |
| 11:00 – 11:15 | Introduction from the Chair |
| 11:15 – 12:45 | Theme 1: Laboratory Learning (Theme Leader: Mauro Mocerino) |
| 12:45 – 1:30 | Lunch |
| 1:30 – 2:00 | Poster Mini-Orals |
| 2:00 – 3:00 | Workshop Part 1 Handling Quantitative Data in Chemistry Education Research, (Workshop Leader: Daniel Southam) |
| 3:00 – 3:30 | Afternoon tea |
| 3:30 – 4:30 | Workshop Part 2: Handling Qualitative Data in Chemistry Education Research, (Workshop Leader: Mahbub Sarkar) |
| 4:30 – 6:00 | Posters Session, Drinks and Nibbles |
| 6:00 – 6:30 | BREAK |
| 6:30 | Dinner |

| Day 2: Friday April 1st | |
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| 9:00 – 9:30 | Registration & Coffee |
| 9:30 – 11:00 | Theme 2: Individualised Learning, (Theme Leader: Adam Bridgeman) |
| 11:00 – 11:15 | Morning Tea |
| 11:15 – 12:30 | Theme 3: Reaching the Regions, led by Erica Smith |
| 12:30 – 1:15 | Lunch |
| 1:15 – 1:45 | Division Citations & Medal Presentation |
| 1:45 – 3:45 | Theme 4: Authentic Assessment, (Theme Leader: Glennys O'Brien) |
| 3:45 – 4:00 | Wrap-up |

**Theme Leaders**

**Assoc. Prof Mauro Mocerino: Curtin University**

Mauro is an organic chemist with a long standing dedication towards chemistry education. He currently holds an OLT Fellowship, *Enhancing learning in the laboratory: Identifying and promoting best practice in the professional development of demonstrators*, that is aimed at tackling the issue of professional development for laboratory demonstrators in his project.

**Prof Adam Bridgeman: The University of Sydney**

Adam currently holds an OLT Fellowship work on *Personalising learning using diagnostic and success data for large cohorts*, which is aiming to develop a transition framework that can coordinate and integrate support and ensure skill development in large and flexible programmes.

**Dr Erica Smith: The University of New England**

Erica has broad experience as a research chemist in both industry and academia around the world. She has been lecturing at The University of New England since 2010. Erica is also a member of the RACI Chemical Education Division Committee.

**Assoc. Prof Glennys O'Brien: The University of Wollongong**

Glennys has a background as an analytical and environmental chemist, but in more recent times made enormous contributions to the field of chemistry education. She is currently working on the OLT project *Assessing the assessments: evidencing and benchmarking student learning outcomes in chemistry*, and is Co-Director of the Chemistry Discipline network.

**Dr Daniel Southam: Curtin University**

Daniel has one of the strongest chemistry education profiles in the country, including a healthy sized group of postgraduate students and a track record of OLT and other externally funded projects. He is Chair-elect of the RACI Chemical Education Division, and Chair of the RACI Accreditation Committee.

**Dr Mahbub Sarkar: Monash University**

Mahbub has numerous publications in the field of science education, having worked with a number of prominent groups including Prof Deb Corrigan (Monash), Prof Russell Tytler (Deakin). He is now driving the GEMS (Graduate Employability in Monash Science) project with Prof Tina Overton and Dr Chris Thompson.

## Theme 1: Laboratory Learning

Mauro Mocerino

Curtin University

*Enhancing learning in the laboratory: Identifying and promoting best practice in the professional development of demonstrators.*

The laboratory class is a unique learning environment with the potential to achieve an enormous number of theoretical and practical objectives. Subsequently, the demands on students are also great. They must not only learn manipulative techniques, but also link theory to practice, problem-solve, interpret data, interact with staff and other students, and successfully navigate the lab itself. Learning in this situation can be greatly assisted by an educator who is able to guide students through this complex of practical, cognitive and affective issues. In response to concerns about the quality of instruction in laboratories, a Laboratory Demonstrators Professional Development Program (LDPDP) was developed to enhance the teaching skills of laboratory demonstrators. This formed the basis of an OLT National Teaching Fellowship program to develop, with input from national and international scholars in institutions that have established PD programs, a refined LDPDP. Progress towards this end will be discussed, along with strategies to increase the profile and benefits of quality laboratory teaching, via an evidence-based "Certificate of Laboratory Demonstrating."

Catherine Burgess

University of Newcastle

Engaging and motivating students as they embark on their chemistry courses at university must be the primary objective of an introductory laboratory course, particularly if those students have no background in the discipline and lack confidence in their ability to succeed in the subject. A cohort of 288 mature age students, aged from 20 to 40, part time and full time attendees who had just completed an introductory chemistry course, were given the opportunity to perform a series of chemical reactions and report their experience. These students had never been in a laboratory. This paper describes the analysis of the student laboratory learning experience using the ASELL* methodology. Focusing on linking the theoretical concepts with the practical application, a highly structured multi-task exercise was designed to engage and motivate students while simultaneously developing the skill of observing and describing reactions using chemical equations. The students were then required to communicate key observations and in discussions with demonstrators, reflect on the underlying chemistry as part of their assessment. Analysis of survey results indicated an increased level of confidence in laboratory skills along with a new awareness of the relevance of the practical aspects of chemistry. Over 90% of the participants rated the laboratory as excellent and indicated a high level of enjoyment. The results of this study have implications for successfully introducing the practical aspects of chemistry to students from a range of backgrounds as well as demonstrating how the design of the chemistry experience can integrate assessment which increases engagement and reflection on conceptual understanding.

*Advancing Science by Enhancing Learning in the Laboratory.

Dr Andrew Pearson

Griffith University

As student enrolments continue to expand in the undergraduate Health programs, there is increasing reliance on sessional tutors to engage, mentor and teach students which has a direct impact on the quality of student learning. The quality of teaching & learning skills of sessional staff is particularly important in large first year courses when students are at high risk of attrition. A high proportion of sessional tutors in most Health faculties are postgraduate students who have demonstrated mastery of the course content but have very little discipline specific training in teaching & learning. Sessional staff training frameworks have been developed and implemented with a university wide focus; however, frameworks for training sessional staff in specific disciplinary contexts are still lacking.

Our aim was to establish a professional development program specifically designed for sessional tutors in bioscience laboratories. We considered supported reflective practice and situated learning as important components of the program as it allowed the time-constrained tutors to learn while they were in the process of teaching. To satisfy these requirements we placed opportunities for peer observation as the central focus of the program.

In order to create a framework specifically tailored to assist the professional development of the laboratory tutor, we needed to highlight health & safety responsibilities and amalgamate these with relevant teaching & learning guidelines for creating an engaging learning environment. While the university provides a generic teaching & learning workshop centrally, we identified the need for a specifically tailored framework for training the laboratory tutors and this was the primary aim of this initiative.

Presented here is the framework and methodology for implementing this program which was piloted in 2014 and, due to its success, is now embedded in the department of Medical Science as a prescribed training program for novice laboratory tutors.

Jeff Hughes

RMIT

*Final year Chemistry Laboratory ... Taking a Different Approach.*

The conventional way of organising laboratory work is not a very realistic approach to laboratory organisation in the 'real' world. Thus, in our final year Chemistry laboratory at RMIT we have taken a different approach.

In the conventional set up, students commonly work in pairs or individually on set experiments. Grouping into pairs is not a common structural feature in industry, and generally when the students work in pairs they do so with a friend, so compatibility is less of an issue.

For our third-year laboratory the experiments are organised into 'themes'. Each theme is based on one area of chemistry and runs for four weeks. Students thus select three themes for a twelve-week semester. They are then organised into groups of 3-4 with a nominated leader. They work in a different group for each theme and get a chance to be a leader for one theme. The selection process allows them to focus on a favoured area of chemistry, but not to pick-and-choose who they have on their team. This process of not necessarily working with your 'mates', and having to coordinate a group, we feel is a more realistic preparation for the work place.

Assessment and the nature of the reports also varies from the traditional lab report. The report format for the first round of themes is a poster (as would be presented at a conference), the second round is a 15-minute seminar, and the third round a traditional written report. The reports are group reports, but the assessment also includes individual contribution in the lab and compiling the reports.

This course is a capstone course for the Bachelor of Science degree and importantly maps into a significant number of the Program Learning Outcomes.

Angela Ziebell, Tina Overton, Chris Thompson

Monash University

*Transforming Laboratory Learning through Inquiry and Work Integrated Learning*

Undergraduate chemistry laboratory activities are traditionally prescriptive and expository during which students follow a 'recipe' to complete a routine exercise. These activities equip students with manipulative skills and enable them to interrogate the data that they collect. However, these activities do not mimic real problem solving in chemistry or the research process. By adopting an inquiry-based approach to laboratories students are able to learn how to plan investigations, solve real problems, communicate effectively, present data and findings in varied ways and develop an appreciation of the research method and how science works.

Work integrated learning is currently high on the agenda in Australia. Most models of work integrated learning involve undergraduates spending time with an employer. This is unarguably beneficial for the undergraduates but is not likely to be sufficiently scalable to enable all to engage with the experience. An alternative approach is to bring industry and an employment context into the teaching to enable undergraduates to develop a better understanding of how industry and commerce works and, in our discipline, what chemists do in industry.

Our approach is to redesign all years of our laboratory program to bring together inquiry-based learning with work integrated learning to produce an engaging learning experience that develops the skills and attitudes required for employment.

Dr Simon B Bedford

University of Wollongong

*Maximising the teaching and learning opportunities for higher education students – A learning analytics Chemistry Case Study*

AIMS

The primary aim was the deployment of information technologies and associated analytics that provide learning insights on students enrolled in large chemistry first year subjects. These data contain valuable learning progression and experience information for academics, part-time teaching staff and professional staff regarding students engagement, motivation and progression in near real time so as to maximise the teaching and learning opportunities for the students and to provide suitable interventions for those at risk of failing subjects.

DESIGN AND METHODS

Learning analytics (LA) is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs. No new data has been captured to get learning analytics started at UOW – existing information is being utilised from transaction processing information systems (PASS, Library and student management systems) and the Moodle grade book on the subject sites. As students make use of the subject Moodle sites, information is automatically gathered about learning resource use, time on task, assessment item activities and student involvement in online forums. Each student leaves 'electronic breadcrumbs' within these systems as they go about their student journey and these are consolidated in the learning analytics data warehouse. Learning Analytics then aims to draw data from these diverse systems to provide actionable intelligence visualisation for staff to make decisions on. A comprehensive privacy framework supports the operation of learning analytics at UOW and aspects of this are included in this Chemistry case study.

DISCUSSION OF RESULTS

The learning analytics have been deployed in four first year Chemistry subjects, which have a combined cohort of some 700 students and contain some 50 activities, assessments and resources to monitor. The study concluded in November 2015 covering some 26 weeks of teaching and with 10 visualisation reports having been created. The full analysis of data will have been completed by the time of the RACI presentation,

Key findings so far are:

• Bringing together information from multiple data sources to provide a more holistic picture of student engagement and activity within a subject is useful in broad terms but caution is required when interpreting data to avoid making assumptions, and drawing false conclusions. A mutual understanding from both learning analytics staff and academic staff is required in the decision making process.

• Analytical insights can inform more tailored and focused student interventions that bring about a positive change in student resource utilisation and performance on assessment tasks and developing a culture that uses data in making instructional curriculum design changes.

• The study so far has shown that learning analytics has been able identify a group of students early on in the semester at risk of failing, that interventions have been successful in preventing this, but that data noise is an issue that can obscure others whose performance drops off towards the end of the semester.

Danny R. Bedgood, Jr, Yann Guisard, Julia Howitt, Paul Prenzler, Danielle Ryan, Celia Barril

Charles Sturt University

*Rasch Analysis to Examine and Validate first year Chemistry Exams, and Provide Individualised Feedback to Students on Their Subject Mastery*

Abstract

Do you use Multiple Choice tests? How do you know if the test is a balance between difficulty and coverage of material? Do male students perform better than their female counterparts? Is the exam valid for DE and Internal students? Should the same exam be provided to any course cohort?

This presentation reports of a Rasch analysis (Rasch, 1960) performed on two final exams for first year, service taught, chemistry subjects. These subjects targeted students of vastly different educational

backgrounds, but the exams were designed and proofed by the same team of academics.

Using this approach, we were able to assess the performance of students as well as that of the exam questions (Bond and Fox, 2007). We identified mis-fitting of students and question in both exams.

We were able to ascertain that one of the exams would benefit from removing several question and that the other would benefit from integrating one or several “harder” questions. Similarly, we were able to review the performance of students in view of their gender, compare students from different courses, and in one subject, their mode and location of study. The information will be presented in a graphical and non-mathematical manner.

Importantly, we were pleased that for both exams, the performance of students correlated well with their grades. We observed however evidence of “guessing” in these exams.

We suggest that the use of Rasch analyses yield important information with regards to the performance of exams and students. From a student’s perspective, we argue that these analyses can provide student specific feedback. For academics, we propose that this method can contribute towards banking validated exam questions for the purpose of randomly populated online exams. We suggest however that these data be used in combination with other data analytics such as CSU Interact reports to enrich the nature of the subject coordinator’s reflections. This is because statistical analyses only describe the “performance” of students, and the Learning Environment data provides “behavioural” and therefore valuable complementary information.

Bond, T. G. and C. M. Fox (2007). Applying the Rasch Model. Fundamental Measurements in the Human Sciences. Mahwah, New Jersey, Routledge.

Rasch, G. (1960). Probabilistic models for some intelligence and attainment tests. Copenhagen, Danmarks Paedagogiske Institut.

# Theme 3: Reaching the Regions

Trevor Brown

University of New England

"Remote chemistry laboratory to enhance science learning and access"

Brown, TC, Wallace, A,

Chemistry, School of Science and Technology, University of New England, Armidale, NSW 2351

Experiments are crucial for science students to understand and apply concepts, to develop self-efficacy and tactile skills, and to allow the development of scientific thinking. At UNE the majority of students study externally and experimental learning outcomes are achieved during residential intensive schools. Online experiments will facilitate the engagement of external students, particularly from rural, regional, remote and international locations in science and allow them to achieve learning outcomes and complete their degrees with less frequent attendance at intensive schools. This would reduce the financial burden and other barriers to enrolling or completing their programs.

Remote laboratories are actual experiments using instruments and equipment that are controlled by a student from their computer via the Internet. Webcams allow the student to observe each experiment in real time. By integrating laboratory-based activities with online delivery, scientific learning can be enhanced. Tangible advantages of remote labs are that delivery is flexible: there are no time restrictions, the experiment can be repeated many times at the time of the students choosing and can be closely aligned to lecture content.

At UNE we have recently integrated remote chemistry experiments into a course unit. In one of these experiments, students are able to remotely control and measure the temperature and pressure of phenol in order to calculate the enthalpy of vaporization. The paper will describe the technical and educational aspects of this and other remote experiments that we have developed.

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Michael Moylan

University of Melbourne

Starting in 2016, the curriculum for Victorian Year 11 students will include instrumental analysis, focusing on investigation of water quality by HPLC, AAS and UV-vis spectroscopy.

The University of Melbourne's Chemistry Outreach Program has developed workshops and teaching materials that allow school students and teachers the opportunity to complete comprehensive preparation in their classrooms and/or at home before either:
- attending workshops on our campus, or
- completing these workshops with materials and equipment that are posted to schools for a small fee

This presentation will cover the way these on- and off-campus practical sessions run and the way these workshops could translate to laboratory learning at university level.

Mick Moylan is Chemistry Outreach Fellow at the University of Melbourne and Project Officer for the Chemistry Education Association. Around 3500 school students and 400 teachers participate in our outreach activities each year.

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Barbie Panther

Federation Uni

"What do our online students say?

This presentation will summarise online student feedback gathered over a number of years of teaching chemistry in a flexible delivery mode at Federation University Australia. The objective of this study was to find via surveys and interviews about about students' perceptions and use of the resources provided via the learning management system, in particular their perceptions of video resources including recorded lectures. Online students had diverse preferences with regard to resources, with some students primarily using video resources, while others preferred the ability to print materials for use off-line. Overall, online students were looking for greater interaction with their teachers and peers in the online environment and clear organisation of the materials in the course was important. Online students reported a perception of inequality between online and on-campus students, which is an important consideration for those designing blended learning environments. "

## Theme 4: Authentic Assessment

Elizabeth Yuriev

Monash University

The current consensus in the education research literature is that collaborative learning is effective in leading to increased motivation and academic achievement. Sufficient evidence also exists for the structured approach to the organisation of collaborative learning. For example, the process component of POGIL ("Process-Oriented Guided-Inquiry Learning"), is based on allocation of specific team roles (manager, presenter, timekeeper, scribe, and reflector). Rotation of these roles is designed to provide a group structure with specific goals and expectations and, therefore, to scaffold opportunities for the development of collaborative learning skills. Furthermore, the development of collaborative learning skills is a continuous process rather than a result of a single learning activity and as such should be designed over an extended period of study to allow learner sufficient time to reach appropriate levels of mastery. Finally, this process faces/may face certain barriers, not common in other learning domains. Specifically it may be affected by learners' initial pre-conceived attitudes to group work – often, negative – and by personality traits, such as shyness and introversion, on one hand, and domineering and extraversion, on the other. Research shows that these barriers could be successfully overcome by a positive, productive and enjoyable group-work experience. However, there remains a lack of clarity about what type of group-work experience is perceived by students as positive and productive and how the structured approaches are used to modulate such perceptions and to enhance learning. In this presentation, I will describe a structured group-work approach we implemented for both the skill development and the achievement of learning objectives. We have investigated factors, which influence student perceptions of collaborative learning, and the effects of these factors on student buy-in into the collaborative mindset as well as on their academic performance. The data from student surveys and reflections will be presented.

Gwen Lawrie

The University of Queensland

Collaborative group work offers a rich learning environment for students where they can work collectively, to demonstrate communication skills and create a consensus solution to a problem. Indeed, this type of assessment task enables students to demonstrate multiple learning outcomes including: communicating scientific results, information, or arguments, to a range of audiences, for a range of purposes and using a variety of modes (TLO4.1); being accountable for their own learning and scientific work by being independent and self-directed learners (TLO5.1); and working effectively, responsibly and safely in an individual or team context (TLO5.2).

Despite these affordances, many academics will avoid implementation of collaborative small group work because they perceive that managing group dynamics and the assessment of individual learning outcomes has a high workload. There are however strategies available that can lower these barriers when supported by learning technologies. We have developed an effective model for managing and assessing collaborative, independent group work that has been demonstrated for small groups of 3-4 students within both large (over 1400 students) and medium (approx 250 students) classes since 2009. This model comprises 4 critical elements to ensure student engagement in the tasks and constructive collaboration, these are:

- An open problem to solve where students have a degree of autonomy in choosing their context and setting the boundaries to create an evidenced solution.
- Positive inter-dependency between group members so that students perceive that cannot complete the task without the contribution of their peers.
- Scaffolded communication skills.
- Peer assessment and peer review to develop professional appraisal and reflective skills.

In this presentation, the role of each of these elements will be shared through exemplars of the implementation of our model. The assessment and learning outcomes of different group products (written reports, quantitative problem solving and videos) will be shared along with moderation strategies.

Kieran F Lim

Deakin University

*Working towards TLO 4.1: presenting information in a variety of modes*

Although graduates are expected to be able to communicate by “presenting information, articulating arguments and conclusions, in a variety of modes, to diverse audiences, and for a range of purposes”, students and assessment tasks tend to focus only on a few types of communication modes. This paper will report on an assessment task in which students practised communication by “creating a document or work” by using “a medium of [their] choice”.

Kieran F Lim

Deakin University

*Working towards TLO 5.1: metacognition and self-directed learning*

Self-judgement is an important skill. When we cook a meal, we should have some idea of whether the product satisfies implicit edibility criteria before we eat it. Is it suitable to be served as a meal? The same skill is desirable in the context of teaching and learning. When students prepare pieces of work for assessment, it is desirable that they have some idea of whether the products satisfy assessment criteria before they submit the work. Are those items suitable to be submitted?

This paper describes a series of tasks that require the students to self-evaluate their own work. In this study, students tended to be over-optimistic in their self-evaluations. Over the course of a single unit, there were modest improvements in the ability to critically and objectively self-evaluate assessment tasks.

Siegbert (Siggi) Schmid

The University of Sydney

*Assessing the assessments: Evidencing and benchmarking student learning outcomes in Chemistry*

Higher Education in Australia is in a phase of rapid change due to a number of regulatory changes. Over the past five years the Australian Chemistry community has agreed on a list of Chemistry Threshold Learning Outcomes (CTLOs) that every student graduating from an Australian University will have attained. In addition, the Royal Australian Chemical Institute (RACI) has changed its accreditation process for Chemistry degrees and now uses these CTLOs as the basis for accreditation.

Therefore, it is now paramount to ensure that our assessment items allow students to demonstrate attainment of the CTLOs during a degree [1]. The “Assessing the Assessments” project, funded by the Australian Government’s Office for Learning and Teaching (OLT ID14-3562) is developing a framework designed to help academics at tertiary institutions to determine the alignment of their assessment items with the CTLOs. The project is also collating a database of standards-based assessment items.

The project team has developed an online pro-forma, allowing self-assessment and submission of assessment items. Through workshops, colleagues are guided through the evaluation of assessment items to determine how they meet or fall short of attainment of specific CTLOs. These workshops are designed to support evaluation of assessment items to ensure that they are CTLO compliant.

We will reflect on the first year of this large project and seek suggestions and feedback from the audience.

[1] M. Elmgren, F. Ho, E. Åkesson, S. Schmid & M. Towns, J. Chem. Educ. 92, 427- 432 (2015). Comparison and evaluation of learning outcomes from an international perspective: Development of a best-practice process.

Alexandra Yeung

Curtin University

*Using teacher prompts to develop group communication in an active learning environment*

Active learning has shown to improve student learning and engagement (Cole, Becker, & Stanford, 2014). Curtin University uses an active learning framework in its first year chemistry units to help students engage better with content, compared with traditional didactic lectures. It is also intended that students develop other skills such as communication. However, these skills are not always explicitly taught and we assume students are proficient communicators when they enter the classroom.

This study aimed to create activities targeting development of group communication. An examination of how students communicate with each other within their group as they complete their learning activities was conducted. The Talk Science Primer was used as a framework for the learning design of the activities where students work through four goals to develop communication skills (TERC, 2012).

Students (n=452) enrolled in an introductory level chemistry unit who had very little chemistry background were divided into two groups – intervention and non-intervention. The interventions were activities conducted in class in throughout the semester. The impact of the interventions was measured using a communication survey (frequencies students used communication prompts in groups) and achievement in a concept inventory relating to chemical bonding and representations.

This presentation will showcase the interventions developed, discuss the student perceptions of the interventions and the impact of the interventions on the use of communication prompts and development of content knowledge.

References

Cole, R. S., Becker, N., & Stanford, C. (2014). Discourse Analysis as a Tool to Examine Teaching and Learning in the Classroom. In Tools of Chemistry Education Research (Vol. 1, pp. 61–81). http://doi.org/10.1021/bk-2014-1166.ch004

TERC. (2012). Talk Science Primer. Cambrige, MA: TERC.