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Final report

Developing leaders of change in the teaching of large university chemistry classes



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Executive summary

This project aims to establish a new direction in first year chemistry teaching – away from didactic teaching methods in large lecture style teaching to more active, student centred learning experiences. Initially six universities have been involved in practice-based innovation: Charles Sturt University (NSW), The University of Sydney (NSW), Curtin University of Technology (WA), The University of Adelaide (SA), Deakin University (Vic), University of Tasmania (Tas).

Three domains have been identified as the architecture upon which sustainable L&T innovation will be built. These domains include Learning and Teaching innovation in project leaders' and colleagues' classrooms, development of project leaders as *Science Learning Leaders*, and creation of a Science Learning Hub to serve as a locus and catalyst for the development of a science teaching community of practice.

Progress against specified outcomes and deliverables

Learning and Teaching Innovation

The purpose of this domain is to improve student learning, engagement, retention and performance in large chemistry classes through increased use of student-centred teaching practice.

- The Project is named: ALIUS (Active Learning in University Science) - Leading Change in Australian Science Teaching
- All six ALIUS universities have now implemented Teaching Innovation into ALIUS team member classrooms
- Chemistry colleagues at three ALIUS universities have now implemented Teaching Innovation into their classrooms
- The ALIUS member in physics has implemented Teaching Innovations into his classrooms
- Chemistry colleagues at three ALIUS institutions have tried some Teaching Innovations in their classrooms
- Non-chemistry colleagues at four ALIUS institutions have tried, or expressed an interest in trying, Teaching Innovations in their classrooms
- The POGIL method has proved to be a useful model for Teaching Innovation in the classroom
- Many classroom resources have been developed and used at several ALIUS institutions; some of these have been submitted to the ALIUS database for public access. The remainder will continue to be submitted
- Two seminars about Teaching Innovation have been developed, critiqued, revised, and presented at five ALIUS universities and three non-ALIUS universities
- Particular issues associated with implementing Teaching Innovations in Australian classrooms have been identified and possible solutions developed
- ALIUS members have worked with Learning and Teaching Centres at their universities to share methods.

Developing Science Learning Leaders

The purpose of this domain is to develop leadership capacity in the project leaders to equip them with skills to lead change first at their institutions, followed by developing leaders and leading change at other local institutions



- ALIUS members participated in Leadership Professional Development sessions with Craig McInnis and Colin Mason; both these sessions were found to be valuable and provide context and direction for the members and the ALIUS team
- The passion of an 'early adopter' was found to be a significant element in each node of the distributed framework
- Members developed an awareness of the necessity to build both the 'sense of urgency' and the 'guiding coalition' at each node
- ALIUS found the success of the distributed framework is strongly influenced by the relational aspects of the team.

Create a Science Learning Hub

The online Hub serves as a local and national clearinghouse for development of institutional Learning Leaders and dissemination of L&T innovation.

- The ALIUS website is now active and being populated with resources
- The sharing resource database structure is finalised and being populated with contributed materials.

Lessons Learnt

In order to bring about change in teaching practice it is necessary to:

- demonstrate a convincing benefit to student learning
- show that beyond an initial input of effort classroom innovations will not take more time than what is now done
- maintain a prominent exposure among colleagues - repeatedly give seminars, workshops, and everyday conversations; talk about teaching innovation; talk about easy tools to use; invite people to your classroom; engage colleagues in regular peer review of classroom practice
- have support from people already present in leadership roles to lead change in teaching practice
- have a project leader, someone for whom the project is paramount and will push it forward
- find a project manager, even with money budgeted
- meet face-to-face.

Dissemination

- Seminars presented 19 times including over 400 individuals and more than 24 Australian universities
- Workshops presented 25 times, over 80 participants at 11 Australian and two New Zealand Universities
- Two articles published in Chemistry in Australia, the Australian Chemistry Industry Journal of the Royal Australian Chemical Institute
- One refereed paper published in the Journal of Learning Design.



Abbreviations and Acronyms

ACDS	The Australian Council of Deans of Science
ACS	The American Chemical Society is the professional organisation for chemists in the United States
ALIUS	Active Learning in University Science. ALTC funded project about which this report is written. Note in the context of this report ALIUS is used as a noun to refer to the project itself, and as an adjective to describe people, institutions or activities associated with the project. Further information can be found at the dedicated website, http://www.alius.edu.au
ASELL	The Advancing Science by Enhancing Learning in the Laboratory project is an ALTC-funded project, focusing on learning in science laboratories and the professional development of university science teaching staff
AUTC	Australian Universities Teaching Committee. An Australian Commonwealth agency to promote quality and excellence in university teaching (2000-2004)
ARC	Australian Research Council. An Australian Commonwealth agency that delivers policy and programs that advance Australian research and innovation
CAUT	Committee for the Advancement of University Teaching. (Australia) An Australian Commonwealth agency to promote quality and excellence in university teaching (1992-1996)
CUTSD	Committee for University Teaching and Staff Development. An Australian Commonwealth agency to promote quality and excellence in university teaching (1997-1999)HERDSA The Higher Education Research and Development Society of Australasia
L&T	Learning and teaching
NSF	National Science Foundation – the major research funding agency in the United States of America
PD	Professional development
POGIL	Process Oriented Guided Inquiry Learning, United States National Science Foundation funded series of research projects. Also used as an adjective to describe people, activities, and resources associated with the POGIL project (for more information see: http://www.pogil.org)
RACI	Royal Australian Chemical Institute



Chapter 1 About This Project

Nomenclature

The name for this project is ALIUS – Active Learning in University Science: Leading Change in Australian Science Teaching. For the purposes of this report ALIUS will serve as a name for project activities, members, and artefacts.

Introduction

Many first year science programs in Australian Universities are characterised by large enrolments, sometimes well over 1,000 students per subject. Current teaching strategies tend to combine administrative ‘coping’, such as dividing cohorts into large, sequential and repeated lectures of sometimes 500 students with didactic teaching that is teacher-centred and based on uni-directional, transmission modes of learning. While such methods are widespread in university chemistry classes, research shows that student-centred teaching methods lead to improved student outcomes. Within the academic science teaching community a will exists to innovate and shift from highly teacher-centred practice. Ad hoc examples exist whereby individual science lecturers experiment and achieve change, for example in establishing student-directed learning in the context of large lectures, or in exploring the affordances of blended learning. However, without a coordinated effort, it remains unclear how to distil and translate local pedagogical experimentation into useful knowledge that might broadly influence Australian Higher Education Science L&T. *Learning leadership* is needed, yet it remains unclear how leadership might form the basis for systemic change that ‘takes hold sustainably and consistently in daily practice’. (Scott et al 2008)

This project aims to establish *Science Learning Leadership* and to systematise through a *Science Learning Hub* the collaborative development of L&T innovation. Both leadership and classroom innovation strategies have been identified as critical to the success of change, because, as Scott, Coates and Anderson point out, “Change does not just happen – it must be led, and led deftly”. This project aims to lead deftly a qualitative shift away from mono-cultural and unidirectional didactic teaching methods in science lecturing in Australian universities towards teaching methods that are diverse, multi-directional and that foster student-directed learning and enquiry.

Need

A number of noted international groups L&T have stressed the need for more student-centred teaching in university chemistry. In particular, over the last five years statements have been issued by:

- The American Chemical Society Committee on Professional Training in their 2003 report ‘Undergraduate professional education in chemistry; Guidelines and evaluation procedures’ (ACS 2003)
- The European Commission Directorate General for Research (2007)
- The International Council of Associations for Science Education, together with the Australian Science Teachers Association (2010).

Why are international groups pushing for a change to more student-centred teaching? Evidence from the literature indicates a number of improved learning outcomes, among them (Johnson and Johnson 1989):

- higher achievement and increased retention
- more frequent higher-level reasoning, deeper-level understanding and critical thinking



- more time on task and less disruptive behaviour
- greater achievement motivation and intrinsic motivation to learn
- greater ability to view situations from others' perspectives
- greater social support
- more positive attitudes toward subject areas, learning, and school
- more positive self-esteem based on basic self-acceptance
- greater social competencies.

Students too indicate a value in more student-centred learning. Feedback from commencing science students at The University of Adelaide (2007 First Year Expectation survey) indicate that 83% of respondents (n=378) agreed or strongly agreed that working with other students in class time would be important to their learning. At Charles Sturt University (2007 and 2008) 78% of first year Veterinary students (n= 42) agreed/strongly agreed that student-centred class activities encouraged them to study more. These are examples of the strong support students have for learning in a social environment.

Despite the fact these learning techniques have been well known and documented for decades, they rarely appear in chemistry classes. A survey conducted in March 2008 by Bedgood asked every university chemistry instructor in Australia (over 400 individuals) about their satisfaction with their teaching style and other aspects of their teaching practice; 45 individuals responded (11%) from 29 different universities. Responses from the survey include:

TABLE 1: Teaching Survey responses of Australian University Chemistry Instructors

Question	to a lesser or small extent
I am satisfied with my teaching style	43%
I am familiar with cooperative or collaborative learning methods	73%
My students are engaged during class	66%
I am satisfied with student achievement in class	69%
There is often discussion among student during my class	83%
I think students learn well in a lecture format	91%

Bearing in mind the low response rate, these data suggest a significant proportion of Australian University chemistry instructors are less than satisfied with their teaching style; they are unfamiliar with student-centred, cooperative or collaborative teaching methods; they report low student engagement; and are less than satisfied with student achievement in their classes. Data above indicates that less than 10% of respondents think students learn well in a lecture format. It is surprising though, that in a separate question - 81% of respondents indicated they *spend more than 75% of class time lecturing*. **This survey suggests that among university chemistry instructors there is a perceived need for a change in teaching practice.**

The RACI *Future of Chemistry Report* (2005) indicates a considerable shortage of university trained chemists in Australia, as well as shortage of students studying chemistry and science in general. By examining the benefits of student-centred teaching methods in order to improve classroom teaching it may be possible to not only impact *chemistry* student retention and graduation rates, but have application across all science disciplines. In this way the dire shortage of students studying chemistry, and science in general, in high school and university might be improved. This project will provide information to support the changing of teaching methods in other science disciplines suffering from the same shortages of interested students and competent employees; many other science disciplines



have very large student numbers in their first year subjects as well.

Thus the literature and international industry/academic/government groups indicate a need for more student-centred teaching practice, university instructors believe a change in teaching practice could improve student learning, and students themselves indicate they believe team learning with fellow students will be important to their learning. Support for this project includes not only the six participating intuitions, but also the Royal Australian Chemical Institute, the Australian Council of Deans of Science, and the National Science Foundation (NSF) sponsored POGIL project described below.

People

Project Leaders came from six Australian Universities, distributed geographically around Australia – Sydney, Melbourne, Wagga Wagga, Hobart, Adelaide and Perth. All project leaders are chemists by discipline, except for Marjan Zadnik (physicist), and Gayle Morris (educational designer).

Senior Lecturer **Dan Bedgood** has received several teaching awards at universities in the USA and Australia; he leads the Chemistry Teaching Team (CTT) at Charles Sturt University, which has earned university as well as Carrick awards for teaching excellence (2007). He is Chair of the Division of Chemical Education of the Royal Australian Chemical Institute. Dan also mentors new colleagues in their teaching and is a regular presenter and mentor at the Charles Sturt University Foundation of Learning and Teaching program for new instructors.

Associate Professor **Adam Bridgeman** is the Director of First Year Studies and a Senior Lecturer in the School of Chemistry and the eLearning Coordinator for the Faculty of Science at The University of Sydney. He has published over 60 peer-reviewed articles. He was awarded the 2005 RSC Higher Education Teaching Award in the United Kingdom (UK) for his work on using the internet to enhance and support student learning. He received both a Faculty of Science Citation for Teaching Excellence and the Vice Chancellors Award for Support of the Student Experience in both 2008 and 2010.

He is part of the project team for the current Carrick funded project 'A cross-disciplinary approach to language support for first year students in the science disciplines'. He is presently focusing on developing personalized feedback for large classes and effective electronic resources in the School of Chemistry and the development of graduate attributes across first year science units in the Faculty of Science.

Professor **Mark Buntine** is a Founder and Director of the Advancing Science by Enhancing Learning in the Laboratory (ASELL) project, and has been awarded a Carrick Citation and a Carrick Program Award for his work in this area (2007). He has received several teaching awards, including The University of Adelaide's Stephen Cole the Elder Prize for Excellence in Teaching (2000) and the Royal Australian Chemical Institute's D R Stranks Medal for Excellence in Chemistry Education (2004) and Centenary of Federation Award for Excellence in Teaching (2004). In 2007 Mark completed a Graduate Certificate in Education (Higher Education) and is a finalist for the 2008 South Australian Science Educator of the Year award. He has extensive experience in curriculum design and implementation at the tertiary level. Since 2005 Mark has served on the Chemistry Subject Advisory Committee of the Senior Secondary Assessment Board of South Australia where he provides advice on the Year 12 chemistry curriculum. As Head of Chemistry at The University of Adelaide (2003 - 2008) and Head of the Department of Chemistry at Curtin University of Technology (2009 -) Mark has led by example in terms of bringing an evidence-based approach to curriculum design



and teaching practice.

Associate Professor **Kieran Lim** was a chief investigator in a CUTSD project on the use of videoconferencing in chemical education (1997) and a Director of the ALTC-funded Advancing Science by Enhancing Learning in the Laboratory (ASELL) project. He is the author of over 22 refereed papers in the areas of educational research and science education and is a regular presenter at teaching and learning conferences. He has won two teaching awards at Deakin University, a national RACI Division of Chemical Education Citation (2002), the RACI Division of Chemical Education Medal (2008) and an ALTC Citation for Outstanding Contribution to Student Learning (2010). His teaching practices have been used as exemplars of good teaching by the Deakin University Institute of Teaching and Learning and in the Graduate Certificate of Higher Education. Kieran is a past Chair of the RACI Division of Chemical Education and worked on the P-12 National Curriculum as a member of the Science Advisory Panel for the Australian Curriculum, Assessment and Reporting Agency.

Associate Professor **Mauro Mocerino** is the Director of Undergraduate Studies in the Department of Chemistry at Curtin University of Technology. He obtained his BSc(Hons), DipEd and PhD from the University of Western Australia and has had post-doctoral appointments at the Victorian College of Pharmacy and at The University of Western Australia. He is a co-editor of the Australian Journal of Education in Chemistry, is a past Chair of the Division of Chemical Education of the Royal Australian Chemical Institute, and the first year chemistry coordinator at Curtin University of Technology. He has a particular interest in improving the understanding of how students learn chemistry and what can be done to improve their learning. He also has over 20 years experience in organic chemistry. He has received numerous awards for teaching, including the Inaugural Premier's Prize for Excellence in Science Teaching: Tertiary (2003) and an ALTC Citation for Outstanding Contribution to Student Learning (2010). Recent Projects include an ARC Discovery (2006-2008) with D Treagust (Using explanatory frameworks to enhance students' metacognitive capabilities in science) and a Carrick Institute Competitive Grants Program (June 2008-June 2010) with C Howitt et al (Science for early childhood teacher education students (ECTES): Collaboration between teacher educators, scientists and engineers).

Gayle Morris is an educational designer based in the Faculty of Science and Technology, Deakin University. Specifically relevant to this project is Gayle's work with science-based educators where she supports academics in enhancing the student experience through curriculum design and innovative learning strategies. Gayle holds a PhD in Adult Learning and has twenty years experience teaching and supporting teaching in post-compulsory environments.

Associate Professor **Simon Pyke** currently holds the position of Associate Dean (Learning and Quality) in the Faculty of Sciences at the University of Adelaide. He has received several teaching awards within The University of Adelaide, including the Stephen Cole the Elder Prize for Excellence in Teaching (2001), as well as the Royal Australian Chemical Institute's D R Stranks Medal for Excellence in Chemistry Education (2007). He has been recognised for his contributions to student-centred learning by an ALTC Citation. Simon has had significant influence on curriculum design, development and assessment in Stage 2 Chemistry for the South Australian Certificate of Education over a period of more than 10 years. He is strongly positioned to mentor and lead scrutiny of chemistry teaching at The University of Adelaide.

Associate Professor **Marjan Zadnik** from the Department of Imaging and Applied Physics at Curtin University of Technology has worked for many years to improve science students' learning, and colleagues' teaching, through research and



application of innovative science education ideas. He was the inaugural Dean of Teaching and Learning in the Faculty of Science and Engineering at Curtin University of Technology (2003-2007), and has won a number of honours and awards for teaching excellence, including a CAUT National Fellowship in 1996, the Australian Institute of Physics Medal for Excellence in Physics Education in 2005, and an ALTC Citation in 2008. He published over 140 papers and conference abstracts, has received many invitations to speak and run workshops nationally and internationally on improving science teaching, and with co-investigators, has won over 50 competitive R&D grants, including three ARC Discovery and Linkage grants, and eight CAUT/CUTSD/AUTC/Carrick and ALTC grants.

Daniel Southam is Lecturer and Director of First Year Studies in the Department of Chemistry at Curtin University of Technology. He obtained his PhD at the University of Tasmania. A passionate advocate for active learning, his teaching practices at first and second year inorganic chemistry are now predominantly in the active learning mode, with the broad aim to improve retention of knowledge, teamwork, problem solving skills and metacognition in large first year chemistry classes at Curtin. He has a particular interest in measuring effectiveness of teaching innovation.

Professor **Brian Yates** is a National Carrick Teaching Award Winner (Physical Sciences). He has also been awarded a University of Tasmania Teaching Excellence Award and the national RACI Chemical Education Medal (2007). He is a regular presenter at teaching and learning conferences and has published three papers relating to teaching practice and student engagement. As Head of School he can provide leadership in implementing change in teaching practice among his colleagues. Current grant : 2007 \$121,992 'A cross-disciplinary approach to language support for first year students in the science disciplines' (F Zhang, B Lidbury, J Schulte, A Bridgeman, J Rodgers, B Yates), Carrick Program Grant.

Project Visitors are people invited to build capacity among the project leaders in Leadership, and Teaching Innovation. The project visitors have included:

Associate Professor **Suzanne Ruder** teaches second year organic chemistry at Virginia Commonwealth University. Suzanne has used POGIL style active learning methods in her large organic classes for several years, and is an experienced facilitator of POGIL workshops. Suzanne lead two days of Learning and Teaching Innovation PD with the ALIUS team during meeting 1.

Craig McInnis is a Director of PhillipsKPA. He is an internationally recognised expert in strategic policy development and implementation with almost 20 years experience in higher education research and consultancy involving a wide range of issues. He has led numerous high profile national and institutional policy projects and initiatives, including establishing the national agenda to improve student engagement, developing key survey instruments to assess the quality of the student experience, and advising on quality assurance, academic standards and accreditation processes. He has conducted organisational and program reviews in almost every major field of study, and across a wide range of university contexts in Australia and overseas.

Prior to joining PhillipsKPA in 2005, Craig was Professorial Fellow at The University of Melbourne, and Professor and Director of the Centre for the Study of Higher Education (CSHE).

Hayden Thomas was director of the Charles Sturt University Project Management section and came to speak with the ALIUS team about project management, project scope, stakeholders, and planning during meeting 1.



Professor **Rick Moog** is the project leader for the POGIL project and the joint developer of the POGIL approach to active learning with Nick Farrell at Franklin and Marshall College, Pennsylvania, USA. Rick ran workshops and consulted with ALIUS project leaders at meetings four and five, as well as workshops at The University of Adelaide, Flinders University and The University of Sydney.

Associate Professor **Jennifer Lewis** received her BS in Chemistry in 1992 from North Dakota State University. She went on to receive her PhD in physical chemistry from the Pennsylvania State University in 1998. While pursuing her graduate research on supercritical fluids, she participated in a curricular reform project aimed at improving retention in general chemistry and sat in on one too many courses (some would say) in the College of Education. From 1998 to 2000 she was a post-doctoral associate at Beloit College, then the headquarters of the NSF-sponsored ChemLinks Systemic Change Initiative, where she taught with ChemConnections modules and participated in dissemination efforts, leading workshops on student-centered active learning. She is currently an Assistant Professor of Chemistry and Secondary Education at the University of South Florida. Her research has focused on the evaluation of the effectiveness of reform practices and the dissemination of those practices, and she has been an evaluator for several different NSF-sponsored projects in addition to implementing and investigating curricular reforms at her own institution. She is quite active in the ACS Division of Chemical Education, serving as the Chair of the New Members Committee, Alternate Councilor, and as a member of the Program Committee.

Professor **Colin Mason** Colin describes himself as '... a highly motivated, energetic, flexible and creative person who is committed to the enhancement of tertiary level learning, including personal and professional development, whether for students or staff'. He was appointed as the Director of the Institute of Teaching and Learning at Deakin University in January 2009. Previously he was the Dean, Teaching and Learning at Unitec New Zealand, where he had a strategic senior executive position and responsibility for developing a distinctive approach to teaching-led, research-informed education which has a strong focus on practice. That promotion built upon his most immediate previous appointments in staff and educational development at the University of St Andrews, UK from 1996-2007 where he devised major programmes for staff development in learning and teaching, delivering these through workshops, seminars and both departmental and individual consultancy. Previously, he was a senior lecturer, specialising in haematology, with interests in innovation and curriculum design in teaching of biology as well as staff and student development at the University of Bradford, UK.

He has been an external examiner on three accredited Postgraduate Certificate in Higher Education programs in Scotland, UK, and has had a wide range of other external examining experience (Masters to PhD). He has extensive experience of securing funding for, directing (or co-directing) and managing research and development projects in teaching, learning and assessment. He contributed extensively to the distinctive Scottish QAA Enhancement theme management, steering and consultation groups from 2003-2007. He acted as one of eight Workshop directors for the Assessment theme, 'Assessing personal transferable skills', and together with Professor David Lines at Robert Gordon University, Aberdeen, co-edited 'Enhancing practice: Assessment', a summary paper of the main outcomes of all eight workshops. Together with colleagues at St Andrews and other educational developers at 16 Scottish institutions of higher education he successfully piloted a Scottish, QAA-funded project to explore a model of shared ownership and delivery of academic resources, SHEDLOADS.



Professor **Renee Cole** received a BA in Chemistry in 1992 from Hendrix College and a PhD in Physical Chemistry from the University of Oklahoma in 1998. She then went to the University of Wisconsin-Madison to work as a post-doctoral fellow with John W Moore. While at Wisconsin, she focused on chemical education research projects, studying the impact of computer-based homework and tutorials on student achievement and attitudes. She was also actively involved with the New Traditions project. She is currently a Professor of Chemistry at the University of Central Missouri. She has been actively involved with the physical chemistry on-line (PCOL) consortium and involved with the physical chemistry guided inquiry materials. Her research focuses on the impact of innovative materials on student learning and attitudes. She is co-PI with Juliette Lantz on a recently funded NSF grant to develop POGIL materials for analytical chemistry. She is a PI on a collaborative grant using Toulmin Analysis to study how students develop understanding of physical chemistry concepts in a POGIL classroom.

Dr. Cole's primary research is in the area of chemical education. She is interested in issues related to how students learn chemistry and how that guides the design of instructional materials and teaching strategies. Much of her research focuses on the impact of novel teaching strategies on student learning and attitudes. She is co-PI with Juliette Lantz on a National Science Foundation (NSF) grant to develop POGIL materials for analytical chemistry and assess their impact on student learning and attitudes. She is a PI on a collaborative grant using Toulmin Analysis to study how students develop understanding of physical chemistry concepts in a POGIL classroom.

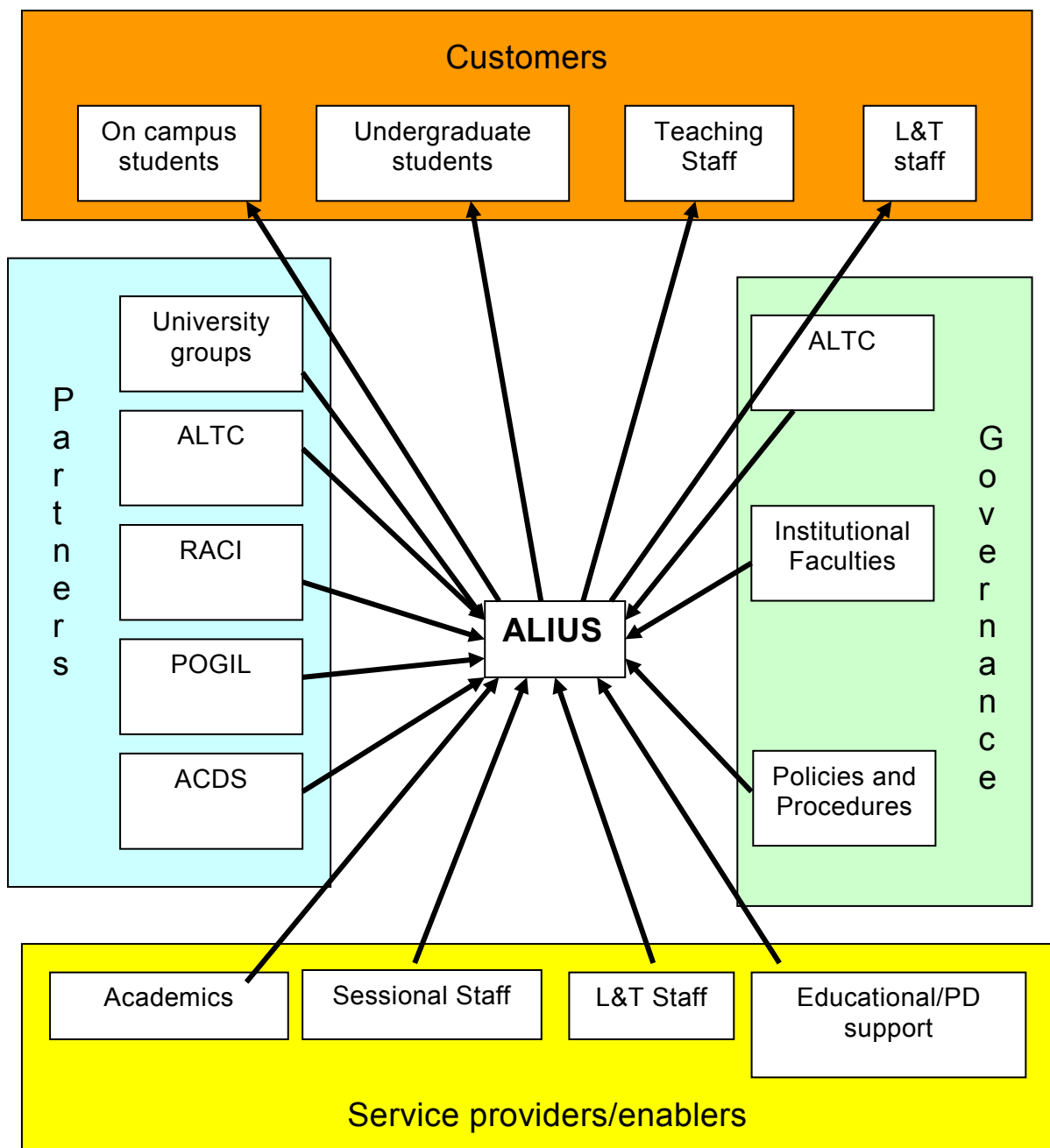
Professor **Vicky Minderhout** is Professor of Chemistry at Seattle University, and a respected researcher in biochemical education. She is a coauthor of materials developed for guided inquiry and problem solving in a year-long biochemistry sequence for majors, and a member of the departmental team implementing similar activities in general chemistry. She has published papers on classroom activities and implementing active learning in college classrooms, including creating a facilitation plan for active learning.



Stakeholders

A diagram of the stakeholders in this project could be represented as illustrated as below:

Figure 1: Stakeholders in the ALIUS project.



Chapter 2 Project Goals

The Three Domains

This project aims to establish a new direction in first year chemistry teaching (in large lecture style teaching and didactic teaching methods). Initially six universities have been involved in practice-based innovation: Charles Sturt University (NSW), The University of Sydney (NSW), Curtin University of Technology (WA), The University of Adelaide (SA), Deakin University (Vic), University of Tasmania (Tas).

Three domains have been identified as the architecture upon which sustainable L&T innovation will be built. These domains are described in the table, below.

TABLE 2: Domains comprising the architecture of this project

Domains	Development Strategy	Purpose
Learning Leaders	Learning Leaders will be developed in the following programs 1. Leadership Development Program 2. Practice Based Innovation Training	Develop leadership capacity in the project leaders to equip them with skills to lead change first at their institutions, followed by developing leaders and leading change at other local institutions
Practice-Based L&T Innovation	Learning Leaders at each of the collaborating universities will develop practice-based innovation in L&T	Improve student learning, engagement, retention and performance in large chemistry classes through increased use of student-centred teaching practice
Learning Hub	The Learning Hub will provide a virtual space within which the developing community of Science Learning Leaders will engage with each other, share innovative strategies, mentor each other, and create a materials archive	Serve as local and national clearinghouse for development of institutional Learning Leaders and dissemination of L&T innovation

The outcomes for this project lie within these three domains.

Project Goals by Domain

Learning and Teaching Innovation

- Provide a catalyst for change in the teaching of the chemistry discipline
- Present to chemistry academics a model for student-centred teaching practice
- Provide resources, workshops and practice for chemistry instructors to easily implement student-centred teaching methods in large university classrooms
- Produce exemplars to direct systemic change through learning innovation such as Learning Development Action Plans for individual universities
- Produce model classroom materials for use in Australian chemistry classrooms
- devise and test strategies to incorporate teaching and learning innovation in large classrooms
- Liaise with L&T Centres at participating universities to share exemplars developed and enhance systemic L&T innovation across disciplines.



Developing Science Learning Leaders

- Provide leadership development, initially for the eight project leaders
- Provide leadership development for educators at neighbouring institutions
- Produce a leadership development model for creating *Learning Leaders* that can promote change in teaching practice by using project investigator's development as Learning Leaders as a case study
- Develop PD materials using this model that will promote change in teaching practice among colleagues and lead to systemic change to all Australian universities
- Liaise with L&T Centres at participating universities to share exemplars developed to enhance systemic leadership development.

Creating a Science Learning Hub

- Develop a virtual *Science Learning Hub* where collaborators from the six participating universities will develop communities of support and practice to encourage, sustain, and foster each collaborator's teaching practice at the local level through shared teaching materials, web blogs, implementation plans and classroom experiences
- Provide a public space where a wider community of science educators and university L&T Centres can gain access to debates, materials, classroom experiences, and exemplars to assist them to innovate when teaching large science classrooms in other disciplines.

These goals fulfil the ALTC objectives by promoting and supporting *strategic change* to enhance the learning experience of university chemistry students; the *Science Learning Hub* will foster development of a nationwide community of practice in teaching excellence, illumine recognition of the importance of teaching, and serve as an exemplar for fostering of teaching excellence.



Chapter 3 Project Methodology

This Chapter describes the general approach taken by the ALIUS project. Specific details, discussion and outcomes for the three project domains can be found in Chapters Four to Six.

Developing New Capabilities

The project leaders at the six universities met in Melbourne, Sydney, Perth and Adelaide approximately every six months. At these meetings Learning Leadership Training and Practice-Based Innovation Training occurred, as described below. A model **Learning Leadership Action Plan** was developed to assist each Learning Leader in building practice-based innovation at each of the six university sites, where those plans were initiated within local chemistry classes. Ethics approval was obtained (Charles Sturt University Protocol 2008/150) from the lead university to meet requirements at all participating institutions.

Developing Learning Leadership at Six Universities

Evidence from the literature (Diamond, RM (2006), Stigler, JW and Hiebert, J (2004), McManus, D (2002)) indicates that initiating change in teaching practice is extremely difficult. It is difficult to change one's own practice, but very difficult to extrinsically motivate change in teaching practices of others. The *Science Learning Leaders* used a method of appreciative inquiry (Cooperrider, D & Srivasta, S (1987)) to examine their own teaching practice, reasons that have motivated them to change their practice, fears and concerns about implementing changes in their teaching practice, and barriers to implementing the changes they desire. The outcomes of this exercise led the *Learning Leaders* to develop materials and resources to use as exemplars to lead change in teaching practice among colleagues. These discussions were approached "as a social encounter in which knowledge is collaboratively constructed, not just a means of mining the existing knowledge of the respondents" (Holstein, JF & Gubrium, JA (1999), Fontana, A & Frey, J (2000)). Discussions were designed to be a "site for transformation of lecturer perceptions, and hence teaching practice" (Adlong, W, Bedgood, D et al. (2006)).

The 10 *Science Learning Leaders* developed in two stages. Stage One involved PD in leadership development in addition to PD to develop new skills in student-centred teaching. During this stage, the learning leaders developed *Learning Leadership Action Plans* for their institution.

The leadership development PD occurred through workshops and seminars provided by university PD, in consultation with the project leaders to focus on development of *Leaders of Change* in L&T. This PD was a collaborative exploration between the PD provider and the ALIUS participants. As the *Learning Leaders* progress in their experience and development, there were additional leadership development workshops to build participants' leadership skills. This process of developing Learning Leaders will be evaluated through discussions using action research (Kemmis, S & McTaggart, R (2000)) and appreciative enquiry methods to devise a PD program which can be shared with colleagues at other universities, and disseminated by university L&T centres.

Stage Two provided advanced training in student-centred teaching methods and an opportunity to refine and re-develop *Learning Leadership Action Plans*.



Developing Learning and Teaching Innovation

The PD in L&T Innovation - student-centred instruction – was provided by facilitators not only experienced in both student-centred teaching practice in their own **chemistry** classes, but also experience in facilitating workshops modelling student-centred teaching practices for university chemistry instructors. The framework used in this project is POGIL - Process Oriented Guided Inquiry Learning - an NSF funded project attracting well over US\$3 million since 2001 (NSF). The POGIL project has funded the development of student-centred activities and materials for high school and first through fourth year University chemistry classes in the USA. In addition to development and assessment of learning materials for student-centred teaching, another vital component of the POGIL project is dissemination of student-centred teaching methods through nationwide (US) introductory and advanced workshops; these workshops involve experienced chemistry instructor/facilitators leading discussions of and modelling student-centred instruction methods. POGIL facilitators create a student-centred learning environment to model practice in the classroom, allowing academic participants to experience the approach from a student's perspective; participants are introduced to various instructional techniques that support a student-centred learning environment. Workshops were tailored to the interests and needs of the attendees – like implementing such methods in large classrooms. It is these experienced POGIL facilitators who led the PD in L&T Innovation.

In a POGIL classroom the academic acts a facilitator of student learning. Students purchase a book of activities or worksheets which have been carefully prepared and vetted by the POGIL project researchers. The development and publication of these activities is a vital component of the POGIL project, as it alleviates the extraordinary time requirements necessary for a chemistry academic to devise their own activities. The students may do an activity each class session, or only one or two per week, removing the pages from the book and working in teams through the worksheet. In small classrooms a single academic can provide the support and facilitation for the students. In classes larger than about 40 students though – 10-13 teams – a single academic cannot provide the guidance necessary; larger classes utilise post-graduate students to help in facilitating the student teams. Such post-graduate students are typically on a stipend and freely available to help with teaching subjects as necessary.

While there are many ways of implementing student-centred learning, the POGIL facilitation has been chosen for this project because of strong positive feedback from Australian and New Zealand chemistry instructors who attended a POGIL workshop at the RACI Chemical Education Conference in 2007. In survey responses these chemistry instructors were overwhelmingly positive about the POGIL model as a method to improve teaching in their classes. University participants were surveyed about the workshop by Bedgood: *all* participants either strongly agreed or agreed they: ‘.. would like to use POGIL type methods in my classes’; and ‘based on the POGIL workshop, I think the POGIL method of teaching would improve student learning in my class’. All participants strongly agreed ‘POGIL materials would help me more easily adopt student-centred teaching methods in my classes.’ Based upon the feedback of these Australian and New Zealand participants, the POGIL teaching method appears to serve as a concrete example of a student-centred teaching method. Every participant commented on the desire for more training and supervised practice to implement the teaching method. It is because of the overwhelmingly positive feedback from Australian university chemistry instructors, the practiced experience in using student-centred teaching methods in their classes and their experience in facilitating workshops disseminating such teaching methods, that ALIUS used POGIL workshops for the PD for L&T innovation.



Developing Practice-Based Innovation at Six Universities

Practice-based innovation trials were conducted at six institutions, using approaches developed through discussion and reflection at the ALIUS meetings. The trials were developed systematically during semester 1, 2009 and refined through reflective discussions at our meeting April 2009; these trials were evaluated and reported in order to promote research-informed practice. The trials were run by ALIUS members at their own institutions, supported by the ALIUS team.

Expanded trials of innovative teaching practice took place during the following three semesters (Spring 2009, Autumn and Spring 2010) within the faculties within which the Learning Leaders do their teaching. All institutions involved in this project have established Science Learning Leaders at each institution and have implemented trial innovation in science L&T in large first year lectures. Specific details of the implementation for each institution are described in Chapter Four.

Dissemination of project resources and methods occurred during the last year of the project through Learning Leader's activities with colleagues in their own and neighbouring universities. This dissemination occurred through seminars and workshops presented at each institution, neighbouring institutions and at conference presentations and workshops (such as the RACI Chemical Education Conference December 2008; HERDSA July 2010; Connect 2010, the RACI National Convention in July 2010 and the International Conference on Chemical Education in August 2010) and culminated towards the last year of the project through workshops and peer modelling of student-centred teaching by project leaders with colleagues at neighbouring universities. These seminars and workshops were led by ALIUS members as well as POGIL facilitators brought from the US. Specific details of dissemination activities and analysis of effectiveness can be found in Chapter Four.

Creating the Science Learning Hub

The Science Learning Hub was designed by the ALIUS leaders and created by a website developer in consultation with the project leaders, project manager and interested colleagues. A menu of anticipated needs and functionalities were developed and implemented. This site is freely open and available at www.alius.edu.au.

Specific details of the Science Learning Hub design and analysis of effectiveness can be found in Chapter Six.

Meetings

Team leaders met approximately every six months during the project (see table at right). Meetings were typically for three days.

Meeting One included a Leadership PD day with Craig McInnis, and two days of L&T PD with Suzanne Ruder

Meeting	Location	date
1	Melbourne	10/08
2	Perth	12/08
3	Melbourne	4/09
4	Sydney	9/09
5	Adelaide	4/10
6	Melbourne	5/10

Meeting Two was a joint meeting with the RACI National Chemical Education Conference. This meeting was a planning meeting for activities for 2009.

Meeting Three was a meeting reflecting on active learning experiences for the ongoing semester



Meeting Four was a joint meeting with the UniServe conference. Rick Moog consulted with the ALIUS team, discussed implementation issues, and contributed to discussions about leading change. Rick ran workshops at the conference.

Meeting Five followed jointly with the ASELL lab workshops, and included visits with Colin Mason, Rick Moog and Jennifer Lewis. Colin Mason led discussions of leadership and innovative assessment practices. Rick and Jennifer discussed implementation of active learning methods and classroom facilitation skills; Jennifer discussed chemical education research and publication.

Meeting Six was a brief meeting during which Bedgood, Morris and Pyke discussed leadership models and the learning hub.



Chapter 4 Outcomes - Developing Learning Leaders

The project team set out to achieve transformation of teaching practice in large first year chemistry classes from traditional teacher-centred or didactic teaching methods towards methods that foster student-directed learning, enquiry and engagement. It was identified that pedagogical shift within the discipline would need to be underpinned by the development of academic leadership capabilities of the project team through targeted professional learning.

Two aspects of leadership needed to be considered in this context – leadership of the project itself (the ‘hub’) and leadership of change by project team members within their home institutional context (the ‘spokes’).

The ‘Hub’ – Characteristics of Distributed Leadership

Distributed leadership may be thought of as a different way of thinking about and representing (in discourse) the phenomenon of leadership (Gronn 2006). Two major conceptual discussions of distributed leadership by Spillane et al. (2001) and Gronn (2002) form the substantive backdrop to a review of distributed leadership by Bennett et al. (2003). In this review, Bennett et al. proposed that distributed leadership has three principle characteristics:

- Distributed leadership highlights leadership as an *emergent property of a group or network of interacting individuals*. This contrasts with leadership as a phenomenon which arises from the individual. A key distinctive feature of distributed leadership is identified by Gronn (2002) as *concertive action*. That is, where people work together in such a way that they pool their initiative and expertise, the outcome is a product or energy which is greater than the sum of their individual actions.
- Distributed leadership suggests *openness of the boundaries of leadership*. This means that this approach is likely to widen the conventional net of leaders, which in turn raises the question of which individuals and groups are to be brought into leadership or seen as contributors to it.
- Distributed leadership imposes the view that *varieties of expertise are distributed across the many, not the few*. Related to openness of the boundaries of leadership is the idea that a range of perspectives and capabilities can be found in individuals spread through the group or organisation. If these are brought together it is possible to forge a concertive dynamic which represents more than the sum of the individual contributors. Initiatives may be commenced by those with relevant skills in a particular context, but others will then adopt, adapt and improve them within a mutually trusting and supportive culture.

Against this conceptual framework of distributed leadership was the project team; a network of interested academics in changing chemistry teaching, but disparate in experience and familiarity with student-centered learning. Picking up the characteristics articulated above, the project team consisted of a diverse group of academics, united in their desire to improve student learning in large entry level classes (Characteristic #1). For some members of the team, this was their first formal exposure to a leadership role in their academic career (Characteristic #2). The variety of background expertise of the team prior to commencement of the project was a reflection of the experiential differences of the team together with the range of their academic responsibilities in their home institutions (Characteristic #3).



The model adopted by the ALIUS project team is illustrative of distributed leadership in practice, that is, we worked in ways that connected each of the project team members, but independently on initiating change in our individual classrooms and in leading our colleagues to change *their* teaching practice in local contexts. In the latter respect, the leadership and trajectory of our individual change was intrinsically constructed. It was this aspect of leadership that the project team chose to explore through targeted professional learning.

The 'Spokes' – Leadership by the team in their own institutional contexts

Professional leadership development with Craig McInnis (Principal Consultant, PhillipsKPA) early in the life of the project introduced two key elements for consideration:

- identifying and understanding the key points of resistance to change
- identifying the attitudes and skills required to lead colleagues to change their approaches to teaching.

In order to accommodate the first point, the team were introduced to the “7 unchangeable rules of change” (Robbins and Finley 1998):

1. People do what they perceive is in their best interest, thinking as rationally as circumstances allow them to think
2. People are not inherently anti-change. Most will, in fact, embrace initiatives *provided* the change has positive meaning for them
3. People thrive under creative challenge, but wilt under negative stress
4. People are different. No single ‘elegant solution’ will address the breadth of these differences
5. People believe what they see. Actions do speak louder than words
6. The way to make effective long-term change is to first visualize what you want to accomplish, and then inhabit this vision until it comes true
7. Change is an act of the imagination. Until the imagination is engaged, no important change can occur.

Of these seven ‘rules’, Number One, Number Two, Number Four and Number Five had significant resonance with the team. These elements subsequently framed much of the practice of team members in their individual contexts. Reflection and discussion on these ‘unchangeable rules’ served as an introduction to the complexities of leading change and to a range of leadership models and strategies (Bass and Bass 2008, Fullan 2001, Goleman 2000, Greenfield 2007, Hargreaves and Fink 2006, Harris and Lambert 2003, Hung et al. 2005) taking into account the context of the high level of individual autonomy found in the academic workplace (McInnis and Anderson 2005). The discussion then moved to ‘rule’ Number Six where it was identified that a significant gap existed between the *visualisation* of change and the actual *enactment* of that change. The project team turned to the work of Kotter, specifically his model for change leadership (Kotter 1996) as an explanatory framework that could be applied to this visualisation/enactment gap. Kotter identifies the eight stages of change as follows:

1. Establish a sense of urgency
2. Create and develop the “Guiding Coalition”
3. Develop a change vision



4. Communicate the change vision
5. Empower broad-based action
6. Generate short-term wins
7. Don't let up
8. Make change stick

Influenced by our reading of Kotter, much of the activity of both the project team as a whole and each of the team members in their home institutions then focused on development and delivery of the key message '*Why should I change the way I teach?*'. This effectively addressed stages Number One, Number Three and Number Four of the Kotter process. Each team member also engaged in stage Number Two in their local context. Given that enactment of long-term change takes time, most team members are yet to reach stage Number Eight.

As the project progressed, it became apparent that a number of significant barriers existed to the successful implementation of the desired pedagogical changes. The team clearly had a good pedagogical model (with extensive published validation) yet a critical question remained as to why our colleagues were not rushing to adopt it? Apart from recognizing that it was unrealistic to expect that every colleague would identify with the need for change ('rule' Number One of Robbins and Finley above), the team also engaged with the concepts of diffusion research (Rogers 2003) and in particular the 'adoption chasm' (Moore 2002) between innovators/early adopters (the project team) and the majority of adopters. The 'adoption chasm' phenomenon has been widely recognized, most recently in Towns (Towns 2010) who draws from chemistry education to analyze and explain the barriers to adoption of audience response systems.

While there is clearly scope for development of a model that combines the Kotter process with the insights gained from consideration of diffusion research and the 'adoption chasm' phenomenon, this work has not been completed at this stage but will form a forthcoming publication led by Pyke and Morris.

Learning Leaders

As noted previously, a key aspect of the project was developing the project participants' sense of themselves as learning 'leaders'; specifically, the project aimed to enhance the capacity of each project member to bring about pedagogical change at the local level. It should be noted that for many, leadership development is inextricably interconnected with development in active learning pedagogies; this is a point that we will return to below. To that end participants' engaged in a number of professional learning activities throughout the life of the project. Each of the activities was designed to contribute to conceptual understandings of leadership, of change leadership within higher education and to expose participants to new ways of teaching chemistry. The activities ranged from the explicit, for example, exposure to leadership thinking by experts such as Professor Craig McInnes, teaching and modelling of POGIL (Professor Rick Moog) and active learning strategies (Professor Colin Mason) to those that might collectively be deemed to be more experiential, for example, integrating active or POGIL-type learning activities in the teaching program, facilitating or co-facilitating professional development events for colleagues and documenting/disseminating experiences through internal faculty news and conference presentations. Specific details of each of the key explicit professional learning activities and reflections are detailed below.



Initial leadership professional development

Craig McInnis was recruited to provide a full day workshop on leadership specifically targeted towards changing academic teaching practice. The workshop was uniformly viewed as valuable, and gave the team insight and direction in developing the ALIUS leadership vision, and ideas about how to lead change. While not exhaustive of Craig McInnis' input the following were seen as critical contributions to the team's endeavours: the relationship between job and action motivation of university academics; the importance of individual participant's personal theories of leadership and change; and the concept of 'elevator talk' where participant's develop a conversation that can be used to engage administration and key senior individuals in the important issues of the project that is clear and efficient.

Creating space for conversations about leading change became a regular inclusion in project team meetings. For example, in meeting four in September 2009 we discussed the early stages in leading change; this conversation was enriched by the contributions of Simon Pyke who developed considerable interest in both developing and leading change and is working with Gayle Morris to lead our discussions and reflection. There was agreement that the project team required more focused professional development on the early phases of **change management**, particularly in influencing the **need** for change. Critical to the project's success in bringing about pedagogical change was the need to learn how to move the 'middle third' of our colleagues to change (one third of our colleagues will recognise the need for and be interested in change; one third will be ambivalent (the middle); one third will be immovable).

An important aspect of the project was ascertaining the extent to which each participant's capacity to lead pedagogical change increased over the lifespan of the project. It is important to note that each participant reflected a different starting point and trajectory in leadership and pedagogy development. For example, the project team included academics that occupied a formal leadership role within their institution to those that did not; it included academics comfortable and well practiced in alternative learning paradigms to absolute novices in terms of student-centered and active learning. The project team approached the gathering of this information in two critical ways. First by developing a map of influence to track incidences where project members engaged in the following kinds of activities: incorporating active learning within individual teaching program or at a course level, sharing new understanding of active learning with colleagues either formally or informally, facilitating POGIL workshops either within home institution or neighboring, being invited to facilitate professional development on POGIL or more broadly active learning strategies. These activities while not definitive provide 'evidence' of enhanced capacity and are indicative of a growing individual and collective capacity. Participation in a comprehensive range of professional learning activities would suggest that each participant had an opportunity to grow but that each embarked on a very individual change trajectory; changes in identity, behaviors and confidence.

Second, qualitative data was gathered toward the latter part of the project when the project team met in Adelaide, April 2010 in order to develop a more comprehensive picture of some of the changes undertaken. To that end interviews were held with six of the project team in attendance at that particular team meeting. The interviews, conducted by Dr Morris were semi-structured lasting approximately 30 - 45 minutes and were designed to elicit a personal



perspective on the following three broad areas:

- progress in achieving the project goals of developing leadership capacity in the 3 domains as articulated in original project brief
- the extent that individual capacity to lead change has been enhanced through engagement with this project and indicators of areas that still require work
- future needs in relation to the project team's capacity to bring about change.

The interviews were recorded and transcribed with the data being analysed for patterns of responses against each of the three areas. The project team recognises that the sample size is very small and does not represent the full project team compliment, however the findings do provide an insight into how participants are working to bring about change and in what is important in terms of developing and enacting leadership. It is beyond the scope of this report to provide the full analysis; work is currently underway by Associate Professor Pyke and Dr Morris to fully integrate the findings with the proposed leadership model and to offer the analysis and findings for publication. We do offer the following preliminary findings and analysis.

Taken as a whole, the cohort strongly reflect three critical aspects in terms of their capacity to bring about change, first the **importance of relationships** in broadening out **sphere of influence**, second, **working within** that sphere of influence, and third in the **ability of showing others within discipline contexts examples of leadership**.

The following comment is fairly typical where individual relationships, in local contexts, are critical to the initial process of influencing change. This participant summarizes it as follows:

I think we're lucky in our department that people are seeing and can see there's a change in student's perspective of the lecturer, and they can see there's a measure of improvement to the student's performance. I think that leading by example is really beneficial. We have lots of young academic staff in our department; all of us are quite close friends as well as colleagues and that helps because they are seeing in cases where they're teaching in the same unit. I'm doing the active learning type strategies and they're doing the didactic style and they are starting to see a shift where the students are starting to say 'look we really like what X's doing or 'we really like his perspectives' They might not be taking up POGIL as an idea but they're looking at new ways of assessment, new ways of measuring the performance and not necessarily stuck in the same format that they perhaps inherited when they took on the unit. (Number One)

Intimately connected to the importance placed in relationships and context is the importance placed on others being able to **see** the changes that are being implemented. There is a sense that this imposes immediacy to the change, where colleagues are exposed to tangible evidence of the effect on students, on student learning and on teaching methodology. There is anecdotal evidence to suggest that this is a far more powerful enabler to change than, for example, abstracted exposure to new pedagogies through presentations or generic workshops.

In this quote similar themes emerge, but this academic stresses the importance of developing confidence in self-promotion in terms of exposing his colleagues to changes in his practice that are reaping benefits:



I think I'm very lousy at self-promotion but to lead change you need to do a lot more of that, 'look what I've done' and 'look this works and you should try it'. It's hard to lead change if you're not leading and showing that you're doing it. I really need to learn to stand on my soapbox a bit more often not saying I'm wonderful but 'hey this is good, I'm doing this and it really work'.. (Number Six)

The importance of exposure, or seeing in terms of bringing about change in colleague's teaching practice was also an important element in terms of personal growth in leadership for one of the participants. In his situation, development in leadership came in part from being exposed to other models of being an academic. For example one of the other participant's in a similar discipline has a senior leadership role in teaching and learning, this appeared to open up new possibilities in terms of being an academic.

I hear someone like 'Y' talking who obviously does that sort of thing [leadership in TL], but I guess it has influenced me that I could do that or should do that. I mean that was just an example, an academic, a chemist who's taking a faculty interest in teaching matters ... (Number Three)

All the same, the same participant (three) was quite comfortable in exploiting his sphere of influence in quite a single-minded way:

Ultimately I'm in charge of setting the work for those tutorials, so any week we might have 70 tutorials going on and I provide the students the worksheets, so I just decided and I've got the power to do that, to change the way that we structured the tutorials. So there's a bit of work that they do beforehand, and a bit of a POGIL type work that they do in their class and then I run workshops for the tutors to help them do that. (Number Three)

While not conclusive these preliminary insights into the project participant's leadership development do provide the foundations of an evidence-base into the emergent capacity of each participant in leading pedagogical change. The scope of this project, particularly given the time bound nature of the project means that to gain a more robust picture of each of the participant's contributions and capacity would require an ongoing and more robust approach to their 'measurement'. Taken as a whole the following learning can be reflected:

- the passion of an 'early adopter' is a significant element in each node of the distributed framework
- awareness of the necessity to build both the 'sense of urgency' and the 'guiding coalition' at each node
- success of the distributed framework is strongly influenced by the relational aspects of the team
- in the distributed framework, different people with different starting points, trajectories and personal spheres of influence almost guarantee that outcomes will not be the same in each node.



Chapter 5 Outcomes - Building Teaching Innovation

There are a number of sections to this chapter:

- Summary of Outcomes
- Teaching Innovations – a variety of active learning approaches
- Implementation of Teaching Innovations
- Institution Specific Implementations
- Dissemination to ALIUS and other Institutions
- Dissemination to Chemistry Professional Bodies
- Dissemination to Colleagues in Other Disciplines
- Artifacts Produced
- Observations regarding Learning and Teaching Innovation
- Workshop Evaluation and Comments

Summary of Outcomes

- All six ALIUS universities have implemented Teaching Innovation into ALIUS team classrooms
- Specific implementation of these innovations vary from institution to institution; details can be found below
- Chemistry colleagues (not ALIUS) at two ALIUS universities (Charles Sturt University, Curtin University of Technology) have now implemented Teaching Innovation into their classrooms
- The ALIUS member in physics has implemented Teaching Innovations into his classrooms
- Chemistry colleagues (not ALIUS) at three ALIUS institutions (Charles Sturt University, Curtin University of Technology, The University of Adelaide) have tried some Teaching Innovations in their classrooms
- Non-chemistry colleagues at four ALIUS institutions (Charles Sturt University, Curtin University of Technology, The University of Adelaide, Deakin University) have tried, or expressed an interest in trying, Teaching Innovations in their classrooms
- The POGIL method has proved to be a useful model for Teaching Innovation in the classroom – not just for chemistry instructors but other disciplines
- Classroom resources have been developed and used at several ALIUS institutions
- Two seminars about Teaching Innovation have been developed, critiqued, revised, and presented at five ALIUS Universities and six non-ALIUS universities
- As a result of workshops and seminars provided, feedback from workshop/seminar participants indicate they have tried ALIUS teaching innovations in their classrooms (James Cook University, Murdoch University, Monash University, Flinders University, Macquarie University)
- Particular issues associated with implementing Teaching Innovations in Australian classrooms have been identified, and possible solutions suggested
- ALIUS members have worked with L&T Centres at their universities to share methods and develop PD experiences

Teaching Innovations – a variety of active learning approaches

ALIUS members have found different methods to engage their students. While details of the specific implementations at each institution follow, a summary of methods adopted are found in Table 3:



TABLE 3: Descriptions of Active Teaching Methods Employed

method	Description
POGIL – type activities	Students work in teams on prepared activities (worksheets) carefully constructed to help students work through models and facts to build understanding of a particular concept. These activities often use much of a single class period, and may include assigned team roles, reflection, and reporting to develop process skills described in graduate attributes
Clickers - also called audience response units; these are devices that allow students to 'vote' for answers to questions posed in class.	Graphical summaries of class responses are produced, which fosters class discussions. Questions are often multiple choice, but with different types of clickers can be more sophisticated allowing for ranking multiple selections from a list. Students can work individually or in teams. Clickers can be used to push students through classroom activities to help keep a class of teams together while working on activities. More information can be found at the ALIUS website, www.alius.edu.au
Shorter activities	Academics employ questions or problems as they have used in the past in class, but instead of working out the problem for the students as an example, the presentation is changed and the onus put upon the students to work through as teams
POGIL – type activities in tutorial	Instead of implementing in the classroom with very large student numbers, some implementations used POGIL type activities in tutorials, where students worked in groups in a tutorial with smaller numbers that are more easily facilitated. This also helps address issues of trying to bring on board multiple academics teaching lecture at different parts of the semester
Demonstrations	Many chemistry instructors use demonstrations in class; instead of a show-and-tell experience, students can be asked to write down predictions with teams (or just neighbours) about what will happen, reflect on their predictions after the demonstration, and make predictions about changes to the demonstration. In this way students are intimately engaged with the demonstrations, rather than passive observers
Stand alone approaches	These are specific actions or tools which may be used in class to engage students in short, specific study. They are easily inserted into a normal lecture, and can be used to break up lectures, check on students' understanding, or provide you and the students with feedback on their understanding. Examples of these are described at the ALIUS website.



Implementation of Teaching Innovations

ALIUS members at all six universities are now using student-centred activities in their chemistry classes (see detailed notes in Table 4 below). The NSF funded POGIL project has developed active learning classroom materials; these materials have been used as a model for integrating active learning into ALIUS classrooms. The POGIL model has proved to be a useful model for ALIUS members – both to begin change in their classrooms, and as a model for development of their own classroom activities. The fourth project meeting the end of September 2009 included presentation of activities developed by team members, and critique and discussion of those activities by the team.

We have found the semi-annual face to face meeting vital to working together as a team, and developing our community of practice. Such meetings permit the dedicated focus and supportive environment necessary to reflect and generate change in teaching practice.

Working with Learning and Teaching Centres

- Dan Bedgood at Charles Sturt University has been working closely with Learning and Teaching Committee staff and educational designers in developing and presenting seminars about student-centred teaching methods. Dan has also given seminars in other schools and been asked to present seminars at teaching workshops outside his school. Presentations showcasing the ALIUS project have been made at CSUEd conferences for two years. Bedgood is contributing a 'Teaching Tips' segment to monthly School and Faculty L&T newsletters; each 'Tip' promotes a particular teaching innovation tool for use in classrooms, with examples of how the tool might be used.
- Gayle Morris is an educational designer with CLT at Deakin University, and has enthusiastically joined the ALIUS project as a full member. Gayle keeps a close watch on ALIUS discussions and provides valuable input from a non-chemistry instructor perspective. Gayle is working at Deakin University to broaden the exposure of ALIUS aims among other science disciplines. This has included a presentation by Kieran Lim at the University Teaching and Learning Conference and an Institute of Teaching and Learning workshop.
- Brian Yates has included L&T people at University Of Tasmania in presentations by Rick Moog (leader of the US NSF sponsored POGIL project). Yates hopes to get someone from this L&T group on board interested in ALIUS methods and their use across the wider university.
- Simon Pyke (The University of Adelaide) is Associate Dean (Learning & Quality) in the Faculty of Sciences. He has been engaging with staff from other science disciplines and L&T staff in discussions around student-centred learning and the ALIUS aims in a number of science disciplines. He has given a presentation at the Education Research Group of The University of Adelaide conference on active learning methods and has been an advocate for methodological change in a variety of contexts at The University of Adelaide.
- Adam Bridgeman (University of Sydney) is a member of the Faculty of Science Learning and Teaching Committee and the Faculty eLearning Representative. He has been engaging with teaching coordinators across the faculty in discussions about the style of teaching tutorials and lectures and in implementing active learning strategies in tutor and new staff training. This includes the introduction of new professional practice initiatives in collaboration with the Institute of Teaching



and Learning.

Institution specific implementations

A narrative for experiences at each institution is included in the appendices at the end of this report. A brief summary of implementation at each institution follows:

TABLE 4. Institutions Specific Implementations

Charles Sturt University	<p>Extensive use of activity sheets and clickers in Veterinary chemistry (47 students) for three years; developed some new activities</p> <p>Trial use of activity sheets in CHM1B (180 students) for two years</p> <p>Enthusiastic uptake of some student-centred methods (clickers) by one chemistry colleague, with complete integration into CHM1B and CHM108 (120 students)</p> <p>Trial uptake by three chemistry colleagues</p> <p>Enthusiastic uptake by Statistics, Botany, Dentistry, Nutrition colleagues.</p> <p>Interest from colleagues in math, physics, agriculture</p> <p>10 iterations of seminars presented to three different schools across five campuses</p>
Deakin University	<p>Extensive use in Kieran Lim's SBC131 Principles of Chemistry in semester 1, 2009, to introduce each new topic. Student focus group interviews were conducted by Gayle Morris mid-way through the trimester. Interview comments reflected a positive change in students' experience of lecture; teaching innovations were perceived as useful particularly for students returning to chemistry or for those who completed Year 11. There were concerns raised on the pacing of activities, and in a preference for more complex packing of the problems. Kieran noted that it was difficult to move around the classroom, and that having only one facilitator raised particular challenges. Planned use in SBC152 Chemistry of Life in semester 2 did not occur as Lim had additional administrative responsibilities that were unforeseen at the start of the project. Implementation will continue to expand next year</p>
The University of Sydney	<p>Adam Bridgeman has introduced active methods into first year tutorials across all streams and units in 2010 (approximately 80 tutorials per week). He also introduced and facilitated the use of POGIL approaches in large classes across a number of the first year lecture classes. He now personally uses a roughly 50:50 split of POGIL: didactic teaching in his own lectures in first, second and third year. CHEM1101 using worksheets and MCQ 'tests' in several lectures with around half the lecture given over to group work on the worksheets. On student evaluations, some students commented that they liked this 'tutorial style lecture' with its immediate feedback. After the exam, Adam was contacted by a couple who said that they hadn't liked it during the semester, as they wanted lectures to just be the lecturer talking, but after, when revising, they realized that this had been done to help them prepare for the exam.</p> <p>In the second semester, Fundamentals of Chemistry course CHEM1002, Adam is using a combined lecture, demonstration and worksheet approach. This approach has brought a large</p>



	<p>improvement in student attendance at lectures and participation by the students in the material. Although the combination of this approach and the large size of this class initially led to some problems with noise levels in 2009, the course ran much more smoothly in 2010.</p> <p>In the CHEM2915 workshops and CHEM2401 lectures (second year), Adam used worksheets and group work in every class with about half the time given over to this. The students said that they found the material (quantum mechanics and spectroscopy) very hard but had enjoyed working and talking it out.</p> <p>Worksheets are being used in every CHEM3114 class (third year) with again half lectures being given over on a regular basis to group work on the sheets. This has gone down very well – partly because these students don't get any tutorial support – and the small class works well.</p> <p>Adam used worksheets in every CHEM2402 class but didn't have time to devote more than 10 minutes in lectures to group work on these. The tutorials for this class are also large so Adam used these for group work on worksheets, and old exam questions. This approach has since been extended to other second year courses, by other lecturers, with a noticeable increase in student attendance and participation.</p> <p>The other lecturers and tutors involved in these courses have all reported that their teaching has been more effective and more enjoyable for both themselves and for the students as a result of these interventions.</p>
The University of Adelaide	<p>Collaborative problem solving methods used in both entry level and upper level classes. There has been interest from colleagues in a range of other disciplines including biology, agriculture, and computer science. The main emphasis, though, has been in engaging senior management (DVC, PVC, Deans and Associate Deans) in dialogue about 'learning leadership'.</p>
University of Tasmania	<p>Michael Gardiner joined the ALIUS team to work with Brian Yates very early on. They now use clicker activities in lectures. These have worked OK for a first attempt and Gardiner/Yates want to use them again next year. In terms of encouraging active learning, the secret is to allow enough time for students to interact with each other and respond. Michael and Brian found this was difficult for the first time through, but could see that students did enjoy the activity and even looked forward to it as part of the lecture. Both feel a need to work hard to build in more flexibility in lectures.</p> <p>Following a POGIL workshop by Rick Moog at University of Tasmania there was more implementation of POGIL-style activities in classes in 2010</p>
Curtin University of Technology	<p>ALIUS members at Curtin University of Technology include chemists and a physicist (Marjan Zadnik).</p> <p>For ASTRO 101 (about 50 to 70 students), Marjan and a colleague used clickers with typically 6 to 8 questions with multiple choices in a 2 hour interactive lecture. For Physics 101 (for majors and double degree students etc about 80 students) Marjan did not use clickers, but did use conceptual questions (some multi choice, others not) in the style of Paul Hewitt and Eric</p>



	<p>Mazur.</p> <p>Active learning activities have been used extensively in three large first year units; Chemistry 101 and 102 (380 students, two campuses) and Introduction to Pharm Chem 121 (160 students). They have also been implemented in two second year classes; Inorganic Chem 202 (45 students) and Chemical Structure and Spectroscopy 201 (65 students). Many of these activities have been developed in-house, while others were adaptations of those developed by the POGIL project. Clicker questions are used extensively in lectures for feedback and revision. Colleagues in chemistry are now using some of the activities developed by the team in their tutorial classes.</p> <p>Further details are provided in Appendix 1.</p>
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Teaching innovations as described in Table 4. include POGIL type activities, clickers, think-pair-share, minute papers, and other student-centred teaching methods.

Dissemination to ALIUS and Other Institutions

A summary of the dissemination activities in L&T is found below. A detailed list of the dissemination activities in L&T Innovation can be found in the Appendices.

TABLE 5: Summary of Dissemination Activities

Type of activity	Number of presentations	Total attendees	Australian and international institutions represented
L&T seminar	19	> 610	> 35
L&T Workshop	25	> 260	> 24
Publishing L&T seminar	1	8	1
ALIUS information Seminar	3	120	8+
ALIUS information Poster	2	80	Many

Seminars indicated above are two seminars that were developed, presented, revised and critiqued by the ALIUS team for presentation at each institution and at other institutions to disseminate change. These powerpoint presentations can be found in resources at the ALIUS website, and the ALTC site.

Workshops are POGIL workshops, or adaptations of POGIL workshops.

Notes on major workshops

Uniserve 2009

POGIL resources were provided to participants at a POGIL workshop at the UniServe conference given by Rick Moog, director of the POGIL project in the USA. The workshop covered three important aspects of the POGIL approach –



active engagement in a carefully designed activity; modelling and discussion of the importance of group roles in developing students' process skills; and an activity which explored the structure and design of a POGIL activity. 35 people attended this workshop from several science disciplines; 16 Australian Universities were represented, and two New Zealand universities. Several ALIUS members attended this workshop as well. Questionnaires indicate that the workshop was extremely valuable, and informal feedback was overwhelmingly positive. This workshop led to an invitation for Bedgood to speak at the Tertiary Chemistry Education Symposium in Wellington, New Zealand and at LaTrobe University.



Copyright Deakin University 2010

RACI Connect 2010

A POGIL workshop as described above was presented by Vicki Minderhout and Renee Cole. This workshop included 25 attendees, all chemists from more than six institutions.

HERDSA 2010

A presentation on the leadership development aspects of the project was given by Simon Pyke at HERDSA 2010. A POGIL workshop, shorter and not dealing with process development, was presented by Vicki Minderhout and Renee Cole at the same meeting. The 20 attendees at the workshop were from over 13 mixed disciplines from 12 institutions. This presentation was re-presented at a local Western Australian Branch of HERDSA seminar 'Rekindled' (3 September 2010 with 20 participants).

Uniserve 2010

A POGIL workshop was presented for the discipline day at the UniServe conference. The workshop was similar to that presented in 2009, so the chemistry group met separately during the conference to discuss writing POGIL type activities, and experiences in implementing active learning methods into their classrooms. The workshop was run jointly with the biology and physics discipline days, with about 25 people attending. Questionnaires again indicate that the workshop was extremely valuable, and informal feedback was overwhelmingly positive.

Dissemination to Chemistry Professional Bodies

Two articles have been published in *Chemistry in Australia*, the monthly publication of the RACI. The first of these articles explained the project and the reasons behind the project (December 2008); the second article gave an update one year into the project (June 2010). A final article will be published next year detailing the results and findings of the project. The specific references may be found at the end of this document.

Dissemination to Colleagues in other disciplines

More thorough discussion of some of these points follows below:

Charles Sturt University - Bedgood has been working closely with LTC staff and educational designers in developing and presenting seminars about student-centred teaching methods. Bedgood has also given seminars and workshops on



L&T innovation on five of the Charles Sturt University campuses, in person and by videoconference, as well as university L&T PD for new staff. Presentations showcasing the ALIUS project have been made at CSUEd conferences for three years. Bedgood has contributed a 'Teaching Tips' segment to monthly School and Faculty L&T newsletters; each 'Tip' promotes a particular teaching innovation tool for use in classrooms, with examples of how the tool might be used.

Artifacts Produced

Learning activities produced can be found at ALIUS website; details can be found in Chapter Six. Two seminars have been produced: one is a review of the literature that *science* academics would find convincing. The review demonstrated the benefits to students learning in a student-centred environment. The second seminar includes an activity through which academic participants can experience what learning together in a team is like, as well as presentation and discussion of classroom management tools, assessment, and resources. These powerpoint presentations can be found at the ALTC website with this report. Analysis of the value of these workshops, based upon participant surveys, can be found below.

Two articles have been published in the monthly industry journal of the RACI – Chemistry in Australia, as described above. These articles are professional industry papers, not refereed academic papers.

The first refereed journal article for the project was published in the Journal of Learning Design Volume 3 number 3 in October 2010 (<http://www.jld.qut.edu.au/publications/vol3no3/>)

References for these three papers can be found in the list of references at the end of this document

Observations regarding Learning and Teaching Innovation

- ALIUS is not just an Australian version of POGIL. While the team recognises the value of POGIL activities, and the value of the collaborative approach to student-centred learning that POGIL advocates, we view POGIL as one of many classroom tools - there are other ways to actively engage students in classroom learning. This view will be demonstrated by the resource methods and materials available on the ALIUS website. We will not only provide descriptions of active learning tools, but also specific chemistry examples to demonstrate how each tool might be used in class. The expectation is that over time the ALIUS website will provide examples and resources not only for chemistry instruction, but other science disciplines as well.
- The expansive roll out of student-centred activities at The University of Sydney by Bridgeman has underscored the problem with delivery of the syllabus whilst doing all this. Bridgeman fell behind in all of his classes and had to rush or remove some material. In CHEM1101, where the syllabus is huge, he gave the students reading to do to catch up. Adam quite liked doing this – although some students did not – as some of the descriptive material just doesn't suit Adam's lecturing about it. A frequent criticism of student-centred teaching is that it takes more time than traditional lecturing, and requires putting more onus on the students for their study. There's also been a workload issue with Adam trying to write worksheets (and then model answers) for several classes at once. Of course, this will be easier next time around. Adam's experiences in managing student work and expectations will serve as a model we can use in an Australian context.



Workshop Evaluation and Comments

Seminars and workshop have been presented over 40 times since the beginning of 2009. Several versions of evaluation forms have been used to gauge participants' views on the value of the seminar or workshop, views on their teaching experiences and satisfaction, and views on barriers to implementing modelled changes into their teaching. Feedback from these evaluations indicate (five point Likert scale):



- 87% of respondents strongly agree/agree the material and methods covered in the seminar/workshop are useful (n=317)
- 87% of respondents strongly agree/agree the approaches identified would positively impact student learning (n=317)
- 54% feel confident in their ability to adopt workshop methods into their classrooms (n=181)
- 36% feel confident in their colleagues ability to adopt workshop methods into their classrooms (n= 179)

the two largest barriers to implementing active learning methods is lack of classroom materials, and lack of time to prepare such innovative

The surveys included a number of open ended questions to explore participants' views of the seminar or workshop, barriers to changing their teaching practice, teaching objectives, success of their teaching approach. Of 165 comments, the most commonly mentioned barriers to changing their teaching practice were:

Need to prepare classroom activities	38
Time required to prepare classroom activities	37
Too large class size	19
Available time in class to cover material	13
Student resistance	12
Classroom infrastructure	9
Instructor confidence	8
Shared teaching with multiple instructors	8
Distance/remote teaching	4

NOTE that by far the *most commonly mentioned barrier to implementation of active teaching methods as presented in the seminars and workshops is a **lack of useable classroom resources***. While the POGIL project has developed a large amount of materials for use in chemistry classes, these are largely useless in Australia as students cannot be required to purchase the resources. Additionally, there has been considerable interest from academics from a myriad of non-chemistry disciplines - disciplines for which there are no resources available.

An informal survey of 78 workshop participants a few months after the ALIUS workshop indicated that 14% have tried approaches or methods from the workshop in their classrooms. The individuals teach at James Cook University, Charles Sturt University, Murdoch University, Monash University, Flinders University and



Macquarie University.

Australian and international universities with staff that have attended ALIUS workshops or seminars:

Auckland University of Technology	Macquarie University
Australian and New Zealand College of Anaesthetists	The University of Melbourne
Australian Catholic University	Monash University
AUT University, New Zealand	Murdoch University
Beijing Business and Technical University	Queensland University of Technology
Charles Sturt University	Royal Melbourne Institute of Technology University
Curtin University of Technology	Swinburne University of Technology
Deakin University	University of Tasmania
Edith Cowan University	The University of Adelaide
Epworth Freemasons Hospital	University of Auckland
Flinders University	University of Canterbury
Griffith University	University of New England
Holmesglen Institute of TAFE	University of Newcastle
James Cook University	University of Otago
LaTrobe University	The University of Sydney
	University of Tasmania
	University of Waikato
	University of Wollongong
	University of Queensland
	The University of Western Australia
	Victoria University Wellington

Disciplines from which academics have attended ALIUS workshops or seminars:

Academic developer	Journalism
Accounting	Library/information
Allied health - nursing	Marketing
Clinical nurse educator (CNS)	Mathematics
Arts	Medicine
Biochemistry	Nursing
Biology	Physics
Biomedical science	Physiology
Business	Public health
Careers and employment	Sport exercise
Chemistry	Science/clinical exercise
Computer science	Physiology
Education and design	Statistics
Engineering	Vet medicine and biomedical sciences
English/academic writing	Creative arts, film
Environmental science	Study skills
Ethnics/Sociology	Anatomy
Finance	Microbiology
Fluid mechanics, materials science	Pharmacology/toxicology
Health	Agriculture
Health education	Nutrition and dietetics
Industrial design	Information technology
	Medical imaging

Comments from ALIUS members and colleagues:



- The teaching innovation component of meeting one, in which a POGIL facilitator from the US led a workshop, led to epiphanies for some of the participants as to how student-centred teaching might look, the structure of activities that can be used in class, and the logistics of using such strategies in large classes. One member after working through an activity in his group cried out “**Now** I know what this is all about! I can do this!”
- Brian Yates had the following comments about Rick Moog’s POGIL workshop at University of Tasmania:

‘I just wanted to say how impressed I was by Rick’s workshop in Hobart today. It really inspired me to think about the advantages of teaching in a POGIL-style and I think I finally got a sense of what it is all about! I can see that the processes students go through and the skills that are acquired are much broader than the discipline-specific content, and they’re exactly the sort of thing we would hope an education can provide. I am enthusiastic about the approach and I will discuss with Michael Gardiner to see if there are more opportunities for us to incorporate this style in our teaching’.

- One colleague at Charles Sturt University, after observing the first use of a POGIL type activity in a large class, with hired facilitator help, commented:

‘the activity ran a lot more smoothly than I expected. Students seemed to easily adapt to the task and worked well in groups’.

Following this observation and these comments, this colleague volunteered to teach a class in the absence of the normal instructor (an ALIUS member), with a POGIL type activity developed by the normal instructor – to ‘give it a try’.

Another colleague at Charles Sturt University intentionally sought out contact with visiting POGIL Facilitator while at Charles Sturt University to specifically discuss development and implementation of activity sheets with students in upper level instrumental and analytical chemistry classes.

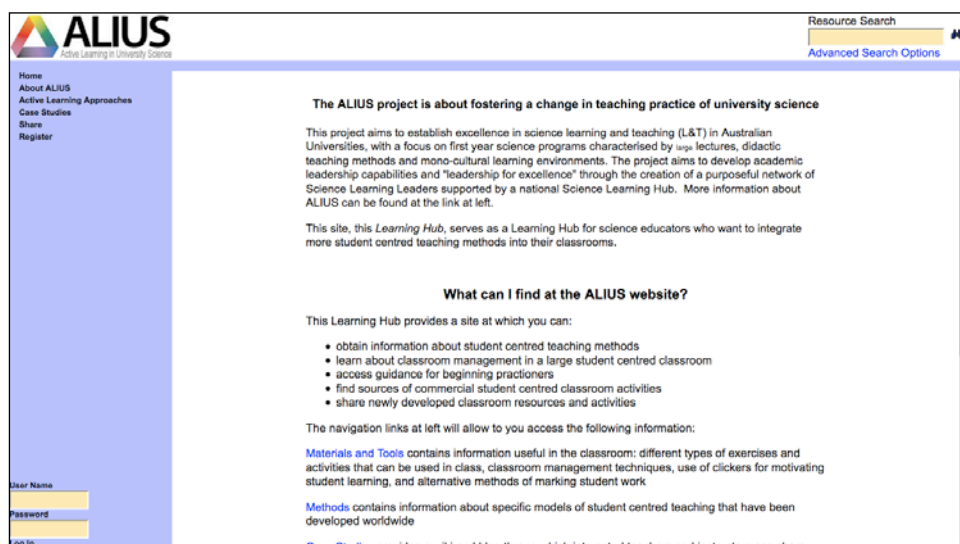


Chapter 6 Outcomes - The Learning Hub

Plan

The ALIUS website – the *Learning Hub* – is intended to provide guidance and support for those who want to increase the amount of active learning that occurs in their classrooms.

The *Hub* can be found at www.alius.edu.au



The Hub presents information about active learning tools and approaches, assessment mechanisms, and a database that allows individuals to share classroom resources.

University Ownership

Several participants in workshops have expressed concerns about copyright and university ownership of materials they produce. It seems some Universities are extremely protective about the sharing of resources developed by their staff. This will become more of a problem as Australia moves into the post-2012 environment of increased competition in attracting undergraduate students. There is a tension between individual academics and work units sharing and collaborating across institutions, and the perceived need for institutions to have a competitive advantage over other institutions, especially in the teaching-and-learning space.

To alleviate these issues ALIUS has used creative commons, with a URL not associated with any institution, to allow authors the opportunity to post their own work.



Usage

Monthly page counter data from the site is listed on the following table:

TABLE 6: Monthly Website Usage by Page Counts

Page Title	2010										Total Hits
	September	August	July	June	May	April	March	February	January		
Home	20	95	149	140	131	49	44	100			728
About ALIUS	9	22	19	35	47	8	10	6			156
Current Project	4	9	10	19	12	7	5	1			67
Background	4	9	10	13	13	5	3	3			60
People	4	10	12	14	15	7	5	3			70
Events	4	8	4	11	9	5	5	2			48
Contact Us	1	4	2	6	7	7	4				31
Active Learning Approaches	6	26	28	38	66						164
Stand Alone Approaches	5	9	23	19	27						83
'Whole-istic' Approaches	4	7	14	22	29						76
Tools and Management	3	8	17	22	17						67
How do you use activities?	1	6	17	17	28	6	5	4			84
Marking	1	2	5	10	11	3	6	2			40
Management	2	6	12	16	21	4	5	5			71
Clickers	1	1	7	12	15	3	9	6			54
Case Studies	4	13	22	32	14	11	12	11			119
Wiki	2	4	7	18	3	3	6	8			51
Blog	2	1	5	10	5	5	4	1			33
Share	2	7	17	21	20	6	6	9			88
Chemistry	2	4	4	9	2	2	3	2			28
Physics			1			1	1	1			4
Contributed Materials	2	3	5	12	7	3	1	5			38
My Resources	1	1	1	3	6	2		2			16
Add Resource	1			1	4	1		2			9
Register	1	2	6	9	11	3	3	7			42
Grand Total	86	257	397	509	520	141	137	180			2227

Note the *Hub* was reorganised in May, hence the new pages associated with Active Learning Approaches.

This data indicates that visitors to the site are most interested in information regarding how to implement active learning in the classroom. Since the creation of the Active Learning Approaches pages, by far the highest hit rates occur on these pages. Note that for all the pages, the hit rate increases after workshops and seminars - in particular this year a number of workshops and seminars were presented in April and June/July.



The first resources were posted in January 2010. The hit rates for resources are:

TABLE 7: Monthly Hit Rates on Newly Available Classroom Resources

Resource Title	2010								Total Hits
	September	August	July	June	May	April	March	February	
CHEM2 Introduction to quantum mechanics and spectroscopy	1	4	4	3					12
CHEM3 Ligand field theory and reaction mechanisms	1	4	2	9	10	12	15	9	62
Grand Total	2	8	6	12	10	12	15	9	74

Note that even though only a few resources are available, and they are only chemistry related, the hit rate on these resources is very high. This supports the workshop/seminar survey data reported in Chapter Five that indicates that perhaps the largest barrier to implementing active learning methods into classrooms is the lack of time to prepare resources.

More work needs to be done on this site. While the grant is finishing, the ALIUS team will continue to upgrade the *Learning Hub* by adding examples from different disciplines, adding resources and adding explanatory information. Additional disciplines will be added to the site as material is developed and submitted.



Chapter 7 Australian Implementation Challenges

Uniquely Australian Challenges and Solutions

Compared to the implementation of POGIL methods in US universities (see brief description in Chapter Three), there are particular issues associated with using student-centred methods in large Australian university classrooms. Three issues in particular are critical to overcome:

1. The legal constraint that Australian students cannot be required to purchase published textbook resources, including books of activities, for use in class
2. The lack of financial support in Australian universities for classroom facilitators
3. The emotional reluctance of some Australian students to engage with 'foreign' (American) teaching and learning methods

For systemic change in teaching across the sector, there must be Creative Commons resources developed across disciplines

Through discussions and experiences with different implementations ALIUS makes some suggestions to address these challenges:

1. Until Australian students are required to pay for their learning resources, there is no easy solution to this problem. We must respect copyright, and so cannot simply photocopy published resources. The only solution is the production of resources that are freely available - Creative Commons. Lack of time to prepare resources is uniformly the most frequently suggested barrier to adopting such active learning methods by workshop and seminar participants. **The development of high quality, pedagogically rigorous resources could prove to be the single most important barrier to widespread implementation of teaching innovations as presented by the ALIUS project. For systemic change in teaching across the sector, there must be resources developed across disciplines available through Creative Commons.**
2. Classroom facilitation is vital to the success of students working in teams to actively engage with and construct knowledge. A single academic can reasonably guide about 40 students; for implementation of activity based active learning methods in large classes (300, 500 students) there will need to be help! These ideas followed on from a discussion between Bedgood and Yates and Gardiner and colleagues at University of Tasmania:
 - hire postgraduate teaching fellows as facilitators; funds for this come from unfilled instructor positions (as is also done at The University of Sydney)
 - PASS (Peer Assisted Study Sessions) program leaders serve as facilitators in class
 - 'lecture/tutorials' plus a formal tutorial. This frees up instructor's time that can be used as a demonstrator in laboratory. These extra instructors frees up money by not hiring demonstrators for laboratory. This money can be used to hire facilitators for lectures (like strong second or third year students); this model is being used at University of Tasmania
 - work with School of Education to create new subjects with small credits. Prospective secondary science students can register for these subjects, which entail training in facilitating students, and give



experience by acting as facilitators for the large classrooms. This provides benefits to two groups of students

- at Charles Sturt University money received for teaching awards (internal and Carrick) was initially used to hire Science/Education double degree students as classroom facilitators. During this project such support was funded by admin/teaching relief funds from this grant.
3. ALIUS members were surprised to find some Australian students aggressively unreceptive to teaching methods from the US. *“The American education system is not that flash and I don’t think we should be emulating anything from there.”* (Deakin University student). While there will always be some students resistant to different teaching methods, we have found that persistence and experience leads the vast majority of students to recognise the benefits to their learning of more active learning approaches in classrooms. It is also vital to elaborate on the motivations for change in pedagogy by careful explanation of how and why students learn in this mode. Where this is addressed early in a course the student perceptions and engagement can be dramatically improved. Where this is done poorly, the student perceptions can be exceptionally negative and the engagement poor. However, it is important to note that student performance is maintained or improved by moving to an active learning strategy.



Chapter 8 Lessons Learned

Challenges

A number of challenges arose during the time of the project, including issues associated with project member contributions and consultant travel. Two project members could not attend the fundamental meeting October 2008; one of these individuals moved institutions to work with two project members, and so could address the absence by working with colleagues at the meeting. This group of three are working together to develop a local community of practice to share experiences and resources.

The second project member was able to get up to speed by attending the Leadership meeting in Hobart, and attended the two seminars presented at University of Tasmania. He has access to audio recordings of the fundamental meeting that he is using as a resource. Meetings have been organised with the principle project leader, and observations of classroom practices are being organised to help bring the individual up to speed. Despite high motivation of both participants, some universities make it extraordinarily difficult for staff to get replacement lecturers to teach their subjects.

The sponsored speaker from the US, - leader of the NSF funded POGIL project - had his flight cancelled from Los Angeles to Sydney. This prevented him from attending the ChemEd08 conference and providing important dissemination and information experiences for the attending chemical educators. The project leader altered his presentation to address more student-centred teaching methods, and another speaker invited to the conference from the US, who has been involved in the POGIL project, ran a workshop on the history and ideas of the POGIL student-centred teaching methods. While the information and experience provided to conference attendees was not of the depth and engagement that was planned in the project, we did the best we could with only one day notice. Books and other resources sent by the POGIL project for use in the intended workshop were left out for examination by conference attendees, and were given away to interested workshop participants at the end of the conference.

For the Future

Our informal discussions – essential open ended focus group discussions – along with the PD experiences, have led project members to an understanding of what student-centred teaching methods look like, and how such methods can be employed in the classroom. Already feedback from colleagues about seminars and workshops, and through tea room chats, is leading to interest in chemistry instructors as well as colleagues in other disciplines.

The Australian implementation of student-centred teaching practices, as used in the POGIL project model, will be somewhat different from the US in that, for example, Australian instructors will not be able to get the amount of classroom support typical in the US – support from postgraduate students, for instance, in facilitating student-centred activities in class, or marking such activities. Hence it is worthwhile evaluating the effectiveness of POGIL in different Australian settings in order to have local data to help influence and convince our colleagues. Gail Morris, Educational Designer from Deakin University, is working with Kieran Lim and discussing ways of doing such evaluation for the Deakin University environment.

Lessons for Future Projects

1. It is very difficult to identify an individual willing to act as project manager, even when we have a lot of money. This is due to several factors, including



- the difficulty of finding a qualified person for a part-time fixed term appointment or of seconding experienced permanent staff to a short-term project
2. Teaching innovation is more easily sold to colleagues when experienced by those colleagues. People need to see a new teaching-and-learning model in action to understand how it works and to visualise how it might be adapted and implemented in their own classroom. The workshops were vital in this regard, as the method of explaining the theoretical concepts of active learning was itself a model of how active learning actually works, followed by discussion of adaptation and implementation
 3. 'Subverting the young' is being enthusiastically adopted as an approach to foster change in our colleagues; we are bringing young, enthusiastic academic colleagues into the fold. This can and should be linked to the professional development programs that are required of new academics at many institutions.
 4. In order to bring about change in teaching practice, it is necessary to:
 - demonstrate a convincing benefit to student learning
 - show that beyond an initial input of effort, classroom innovations will not take more time than what is now done
 - maintain a prominent exposure among colleagues – repeatedly give seminars, workshops, and everyday conversations. Talk about teaching innovation. Talk about easy tools to use. Invite people to your classroom. Engage colleagues in regular peer review of classroom practice.
 - It is important to have a project leader, someone for whom the project is paramount and will push it forward
 - It is very important to meet face-to-face.

Lessons for Sector-wide Implementation of Active Learning Methods

Experience with ALIUS workshops and seminars, and networking and conversations with academics from many different disciplines, has led to a number of important lessons for implementation of teaching innovations in large university classrooms.

- Workshop participants – independent of discipline – overwhelmingly view active learning approaches as promoted by ALIUS as useful in their classrooms
- There are a significant number of resources available to the academic, largely developed for first year classes in an American context, which can serve as a model, or be adapted for, an Australian audience
- For sustainable success and long-term adoption a step-wise approach to implementation is recommended. Wholesale change of pedagogy can have unintended consequences on staff workload and student perception or satisfaction
- Students should be fully informed of the motivation for and benefits of change in the teaching style. Where this is done well the students can recognise the benefits to their learning and engage more fully
- There needs to be support and buy-in from individuals in administration to foment systemic change in an institution – a grass roots approach led by a few zealots does not appear to be enough
- Where such a level of support exists, for example at Curtin University of Technology, a wide-scale implementation can be executed successfully
- Future efforts must involve the creation of communities of practice, within disciplines, institutions and at a national level
- The efforts of the ALIUS team have been centred on creation of new materials, or adaptation of existing materials, for use in the classroom. Many of the sources for adaptation are not in the public domain and in the Australian context students cannot be compelled to purchase them. **There needs to be a nationwide project developing such resources for the Creative Commons for there to be a significant increase in uptake.**



Chapter 9 Appendices

Appendix 1 contains additional implementation narratives
Appendix 2 contains a complete list of all dissemination activities
Appendix 3 contains the project timetable

Appendix 1. Implementation Narratives

Deakin University

Lim's main teaching is at 1st-year undergraduate chemistry. Prior to the project in 2008 he did experiment with active learning activities based on observations and practice at secondary level. This previous 'active learning' consisted of questions-and-answers in a traditional lecture. In addition, he used videoclips, simulations and visual aids, such as toys, to increase student interest and encourage engagement, in what were otherwise traditional lectures.

In the first half of semester 1 2009, Lim used the POGIL-model of active learning activities to introduce each new topic. Hence there was an average of one POGIL-type lesson per week. This was in the 1st-year undergraduate chemistry unit (SBC131 Principles of Chemistry) on the Geelong campus at Waurn Ponds, with 140 students. The same unit was taught by another experienced lecturer on The University of Melbourne campus at Burwood. Both Lim and the other lecturer had taught SBC131 in 2007 and 2008, and the timetable on both campuses was unchanged in the three years 2007-2009. The other lecturer used the same lecture style in each of the three years 2007-2009.

Lim used POGIL activities taken from the POGIL books without alteration. As many of the POGIL classes are longer than the standard Australian 50-minute class, students were asked to complete the POGIL worksheets 'as homework' and to discuss them in tutorials or in the unit's on-line discussion area. Some students liked the POGIL activities, but a significant number did not, as is evidenced by the following anonymous student feedback and anonymous comments:

- *feels less like a lecture which leads to greater concentration and greater conversations between students, and between students and lecturer (April 2009)*
- *Good to work with peers and to help each other (April 2009)*
- *The POGIL exercises were very helpful and Kieran's teaching style was very good at helping me to understand the key concepts (June 2009)*
- *POGIL was fun, I liked the in-class discussions. The tutorials helped a lot with revision and understanding topics a little more. Kieran was an awesome teacher! (June 2009)*
- *However POGIL can feel a bit 'slow', moves slowly and the pacing can be a bit of a plod (April 2009)*
- *Students who were more critical still seem to recognise the benefits more globally for the whole cohort, while not necessarily feeling challenged or extended personally (April 2009)*
- *Students who completed Year 11 chemistry - very helpful, great to work and discuss with peers (April 2009)*
- *I did not like the use of POGIL exercises (June 2009)*
- *POGIL delivery - not sure if it's that effective (June 2009).*

The feedback in April 2009 indicated that students who were more critical still seem to recognise the benefits of POGIL-style active learning more globally for the whole cohort while not necessarily feeling challenged or extended personally.



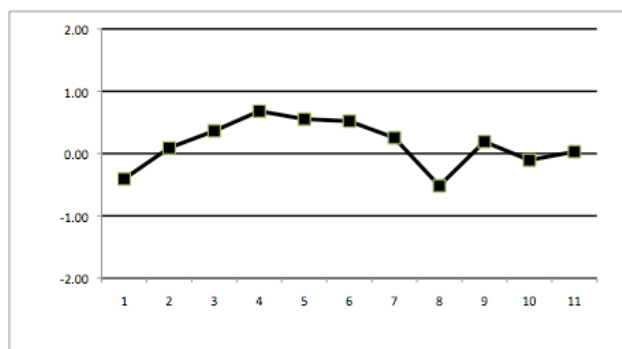
For the remainder of semester 1 2009, Lim embedded group-work questions into his lectures rather than having entire classes devoted to POGIL-type activities. This seemed to be much better appreciated by the students.

- *the POGIL exercises! I think I learnt best from those as of working in groups* (June 2009)
- *the unit was good and surprisingly fun but a balance between POGIL and 'traditional lectures' is still the optimal goal* (June 2009).

The feedback from students indicates they liked to alternate between small blocks of lecture material (five-15 minutes) and active learning in the form of group-work activities (two-five minutes).

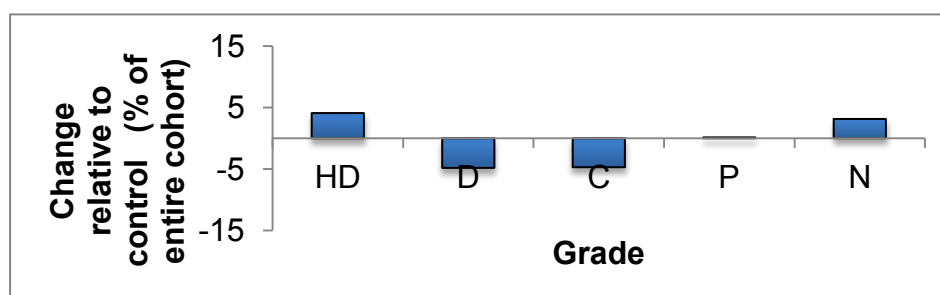
The fact that the same unit was taught on two campuses with the same lecturers, timetable, etc, meant that the Burwood cohort could be used as control group to measure any change in learning outcomes. The unit has a number of on-line quizzes for each topic. It is evident from the graph below, there is a small but insignificant change in the relative performance of the two cohorts from 2008 to 2009: the vertical axis indicates that the average quiz mark increased by an average of 0.15 out of 10 *relative* to the Burwood cohort, which is not statistically significant.

Figure 2: Comparison of grade distribution for two cohorts using traditional learning methods



The change in grade distribution of the Geelong (active learning) cohort *relative* to the Burwood cohort (no change in teaching) is shown in the next graph. While the *average* and *median* grades have not changed, it can be seen that the introduction of active learning activities has increased the proportion of high-distinction (HD) and fail (N) grades while decreasing the proportion of distinction (D) and credit (C) grades. The increase in high-distinction grades suggests that the active learning group-work activities do enhance learning, but the increase in fail grades could be due to a number of factors including Lim's inexperience in using POGIL activities 'turning off' some students who have then failed.

Figure 3: Change in grade distribution for active vs. traditional learning methods



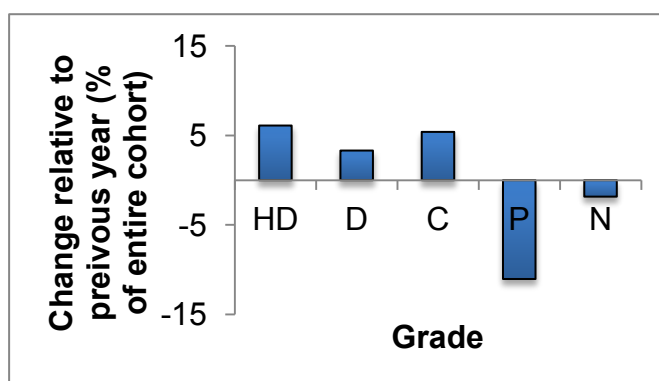
In semester 2 2009, Lim again taught the 1st-year chemistry cohort on the Geelong



campus, but the class was shared with other lecturers and he used much fewer active learning activities than in semester 1, because of an increase in his administrative duties. Hence there were no objective measures of the use and impact of active learning activities.

At the start of semester 1 2010, Lim transferred to the Burwood campus, following the retirement of the academic who had previously taught 1st-year chemistry at Burwood. Lim taught the SBC131 unit (340 students) for half the semester, alternating with another lecturer. Lim's lectures incorporated alternation between small blocks of lecture material and group-work activities, while the other (inexperienced) lecturer had no active-learning activities. The following graph shows that there has been a significant increase in the proportion of high-distinction (HD), distinction (D) and credit (C) grades while decreasing the proportion of pass (P) and fail (N) grades on the Burwood campus between 2009 and 2010. However, this change in grade distribution is due to many factors including change of lecturer(s), minor changes to timetable, as well as the introduction of some active learning activities in approximately half the lectures.

Figure 4: Increase in distribution of higher grades for active vs. traditional learning methods



In evaluating the success or otherwise of Lim's active learning activities, the anonymous student comments are very informative. (Note that emphases have been added to highlight active learning and student engagement).

- *Kieran's lectures were the best. He made the unit enjoyable and taught in a way that interacted with us*
- *fantastic, kept everyone engaged and made the often complex content easier to grasp ...*
- *I enjoyed the enthusiasm of his teaching methods and the use of examples and thought the use of 'Quick Checks' were a good aspect*
- *very different way of teaching- but one of the best lecturers I've had as he explains things so well so we all understand. Great teacher.*

Increased awareness of the learning cycle through ALIUS/POGIL professional development has helped Lim improve his tutorials. Being able to classify revision questions as Exploration, Concept-Invention/Term-Introduction, or Application activities helps students understand what is being asked and clarifies assessment expectations, through improved student metacognition. The learning-cycle classification is simpler for students than Bloom's taxonomy. A more-aware instructor can better help students know about how to learn. Furthermore instead of just using tutorials to model how to solve chemical problems and clarify concepts (teacher-centred tutorials), Lim has also used more active learning in his tutorials, with increased student participation. Generally this has been well received, but as with the lectures, there are a small proportion of students who prefer passive



learning.

- *I found myself benefiting from attending all of his tutes*
- *Kieran made learning chemistry fun and his teaching methods really worked for me*
- *I was too intimidated to go to tutes because he'd put you on the spot and make you read and answer questions. I'm a very shy person, I hate public speaking, I wanted to learn properly but his techniques just don't suit me I guess.*

Another lesson learned from this project is confirmation of the belief that 'student evaluation' can be a disincentive for change, because innovation usually leads to a drop in 'evaluation' scores in the first year that a change is implemented. The following table shows that student satisfaction with Lim's personal teaching significantly decreased when he introduced active-learning activities, and that it takes more than one year to fully implement a new teaching-and-learning method.

TABLE 8: Student satisfaction with instructor teaching in active and traditional methods

	Students expressing satisfaction with Lim's teaching	Difference between students expressing satisfaction and dissatisfaction	Comments
Semester 1 2008	84.8%	77.2%	Traditional lectures by Lim at Geelong (190 students)
Semester 1 2009	69.0%	54.9%	POGIL and other active-learning activities introduced into lectures by Lim at Geelong (140 students)
Semester 1 2010	71.9%	63.7%	Mixture of active-learning and traditional delivery in lectures by Lim at Burwood (340 students)

Charles Sturt University

Chemistry at Charles Sturt University involves three large first year classes - CHM1A (now 630 students) and CHM1B (450 students) for science students, and Chemistry Fundamentals essentially for Agriculture students (220 students). All of these subjects are offered internally and by distance. At the beginning of this project there was also a veterinary chemistry class (45 students), offered internally. Bedgood taught this veterinary chemistry class for several years with some mix of lectures and student centered activities - largely use of clickers (audience response units), and asking questions and having students respond - write answers on board, discuss, etc.

In 2006 Bedgood was on study leave in the United States; this study leave was to observe the classroom practice of a noted chemical education researcher, to learn how to incorporate more student-centred teaching methods into his teaching practice. At the Biennial Conference on Chemical Education he attended a seminar on the POGIL method. Impressed with the approach, and the developed resources, Bedgood attended an intensive one day workshop months later, and returned to Australia inspired and energised to make changes in his veterinary chemistry class.

He changed the entire class, utilising adaptations of POGIL activities about twice a



week, more actively engaging students in classroom examples and demonstrations. These experiences led to this ALTC funded project.

Veterinary chemistry students were asked in week three of the semester, when they had been using clickers for only a week or so, if they thought the use of clickers helped their learning. Note from the diagram to the right that there was strong agreement (light coloured bars). Students were asked the same question at the end of the semester and the response was even more positive.

Figure 5: Results of student survey questions in Veterinary Chemistry Autumn 2007 (n = 43)

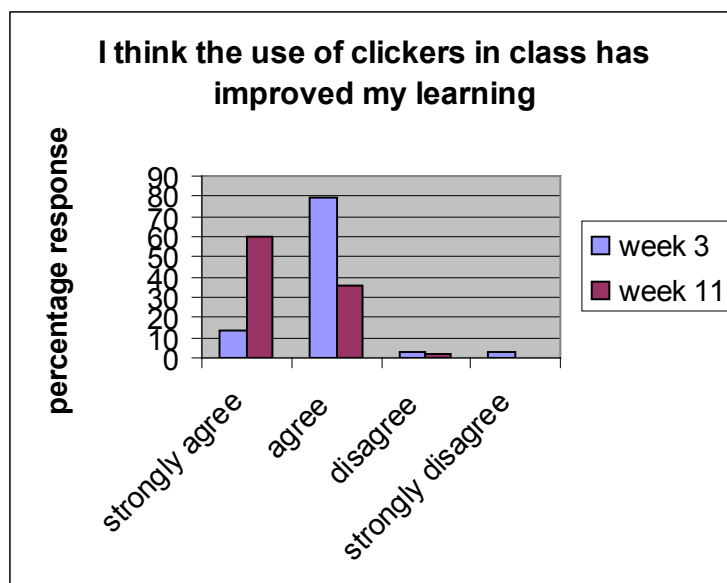
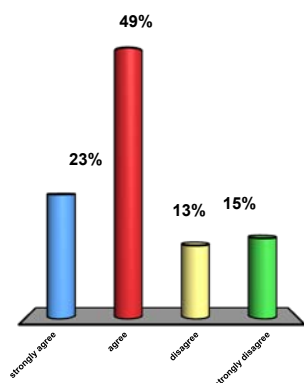
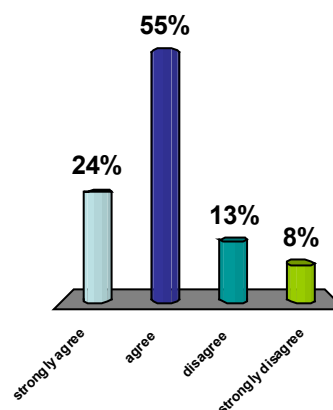


Figure 6: Results of student survey questions in CHM1B Spring 2009 (n = 98)

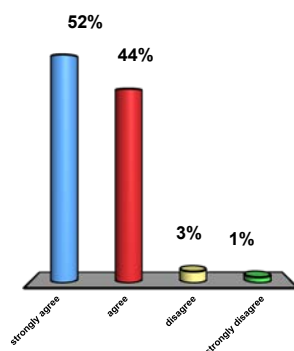
I think the first [POGIL] activity we did in class Monday helped me learn.



I enjoyed working more closely with my classmates on Monday



I think the clicker questions in class help my learning.



With some experience in the Veterinary chemistry class, Bedgood invited fellow chemists and others to attend his classes. One chemist in particular picked up the use of clickers to engage students, and after two years of continued attempts with Bedgood managed to get the School of Agriculture and Wine Science to purchase enough clickers for use in Chemical Fundamentals semester 1 and Chemistry 1B semester 2. He has since taken the lead in use of clickers in the chemistry classes, as well as managing the clicker system.

Bedgood began running workshop and seminars in schools around the Wagga Wagga campus to encourage academics in other disciplines to try more active learning methods.

ALIUS leaders discussed the need for workshops; Bedgood put together workshops, trialed with Charles Sturt University schools, and ALIUS leaders critiqued and revised these seminars and workshops. Clickers are now being used in Biochemistry at Charles Sturt University, and there is interest from veterinarians and others - cost is the big barrier.

One instructor in statistics is now using team folders to distribute and collect class activities; physicists very interested in adapting materials from published physics books for use in class. There is great interest from other disciplines including anatomy and physiology and indigenous studies. Specific workshops and discussions have been held with agriculture and beef production (which has



implemented some ALIUS promoted teaching methods).

Specific comments from Charles Sturt University colleagues regarding ALIUS promoted active learning teaching approaches:

- After watching the first instance of using a POGIL type activity in a large classroom at Charles Sturt University, observing chemistry colleagues commented:
“The activity ran a lot more smoothly than I expected. Students seemed to easily adapt to the task and worked well in groups. Having the three extra facilitators present helped set the students on the right track, and students seemed to appreciate this more interactive model”; *“students are clearly active and engaged”*
- *I just wanted to tell you about our experiences using your active teaching strategy in our first year Botany subject. After going to your talk I decided to try one of the strategies you suggested in the middle of a lecture. As you know I team teach Botany with a colleague and he was not aware of what I was going to try as I had only recently been to your talk and thought of giving it a go mid-lecture. Let me set the scene. I had just gone through a difficult concept in the lecture and wanted to make sure all the students got it before they left the lecture and that they would remember it. So I put them into groups of five and asked them each to first write down an answer to the question I was about to give them. That way they were committed to an answer. Once each student had written their answer, I asked them to negotiate, as a group, what they thought the right answer was. The colleague and I walked up and down listening to the conversations. It was amazing! Students were engrossed in discussion trying to convince each other what the right answer was and why. After five minutes the groups had reached consensus and all had the right answer! I remember Geoff turning to me while the students were talking with a big smile on his face and he commented later how good the exercise was of engaging the students in their own learning. As students left at the end of the lecture many commented on how good it was. We are so impressed by the immediate positive impact of just one of your ‘techniques’ that we are planning to do a lot more in the next session. (Botany academic)*

The Botany academic above said he went to my seminar/workshops three times before he was hit in class when things weren't working - like usual - and tried something new. This suggests in order to provide encouragement and motivation for colleagues to innovate in the classroom there is value in *repeatedly* presenting seminars/workshops and discussing with colleagues the methods and benefits of active learning methods in the classroom.

... in order to provide encouragement and motivation for colleagues to innovate in the classroom there is value in *repeatedly* presenting seminars/workshops, and discussing with colleagues the methods, and benefits, of active learning methods in the classroom

The University of Sydney

Around 2000 students take first year Chemistry units in semester 1 and around 1800 in semester 2 at The University of Sydney each year. As the Director of First Year Studies at Sydney, Bridgeman has introduced active methods into first year tutorials across all streams and units in 2010 (approximately 80 tutorials per week). These used newly written activities which have been made available to the wider



community through the Learning Hub. The activities supplement the lecture courses and homework.

Previously, these sessions had been used to go over homework and answer questions and thus were only successful when students had adequately prepared. One of the main strengths of the new approach has been that students have been required to take a much more active approach. They are now much more responsible for their own learning. Both tutors and students have commented repeatedly that the new approach is more enjoyable. By utilising group dynamics, tutors are able to concentrate on facilitating at a more individual level and are not driven to a didactic role. Students work through guided problems that build steadily to show them how to solve problems. Many students have commented that they now receive more effective feedback on their performance, something which is otherwise very difficult to provide for large cohorts.

Bridgeman has also introduced this style of tutorial work into his second year tutorials with very similar results. Attendance and student preparation for these classes is, traditionally, quite poor. This situation has been reversed through the adoption of active learning activities (commonly three-four page worksheets which are only available in hard copy in class). Through encouragement, word of mouth and particularly student pressure, this approach is now being utilised by colleagues in other second year courses.

Alongside this introduction of active learning approaches in first and second year tutorials, Bridgeman has also introduced and facilitated their use in first, second and third year lecture classes. In his own classes, he now divides all lectures into a roughly 50:50 split of conventional 'didactic' teaching and POGIL style activities. Each lecture is divided into 10 minute sections alternating between 'chalk and talk' and group activities to maximize student attention. The group activities are used to both introduce new concepts through guided inquiry and to review and problem solve. On student evaluations, students commented that they liked this "tutorial style lecture" with its immediate feedback. As in the tutorials, the additional activities were only available for those attending class although short answers were provided online.

The majority of students are very open to this 'new' style of teaching and have commented (positively) that it is much more like high school. Others made the same point as a criticism during the course but in both 2009 and 2010 the same students commented that they felt much better prepared for their exams as (i) their lecture notes were shorter and (ii) they had already tackled and been guided through the type of problem solving that we aim to assess.

He has also used this approach in second and third year courses with similar results. In each case, students appreciate the more informal style, the opportunity to ask each other and the lecturer questions, the scaffolding of the learning process and the continual nature of the feedback that is available.

At the University of Sydney, this particular implementation of the POGIL approach has been found to work well in large, medium and small class even in rooms not designed to facilitate group work. In large classes, informal groups work better than those in which roles are assigned. The complexities of timetables and student timekeeping means that efforts to enforce roles lead to stifled discussion and a little student resentment.

Noise can be an issue in large classes but this can be alleviated by a few simple house rules and, most importantly, the division of the group activities into five-10 minute chunks. Longer activities lead to student inattention and off topic discussions. In very small classes, the success of the activities is very dependent on



the students present. Peer pressure to engage is a very strong driver for genuine engagement.

Alongside discussion of these activities at teaching and learning committees at the school and faculty level, a workshop for School of Chemistry academics was held in 2009. The facilitation and effective running of active learning activities in tutorials are now a formal part of the training of tutors.

The University of Adelaide

Simon Pyke's position of Associate Dean (Learning & Teaching) in the Faculty of Sciences is full time (1.0 FTE) with a reduced teaching load. He teaches into Chemistry 1B (~450 students) and Chemistry III (~50 students). Active learning strategies (particularly collaborative problem solving) are used in both courses. This approach has been particularly successful in Chemistry III. Given that a significant proportion of his time is taken up with administrative duties (at both the faculty and university level), he has been well placed to influence thinking about classroom practice. This 'influence' has spilled over into a POGIL trial at Flinders University.

Curtin University of Technology

The Department of Chemistry has been active in implementing active learning strategies into its core teaching practices. There has been significant leadership for effective change displayed at Curtin University of Technology as a critical mass of project participants located at the Bentley (Perth, Western Australia) campus. The change has been significant at first year, where a number of units have this as the dominant mode of classroom teaching.

Chemistry 101/102

Chemistry 101 and 102 are core units in Curtin University of Technology's undergraduate Science (chemistry, nanotechnology and extractive metallurgy) and Engineering (Chemical and Petroleum) degrees with around 380 students enrolled across two campuses. These units utilise a suite of approximately thirty activities adapted from existing materials (Moog & Farrell, Hanson) and developed from scratch.

The students have also shown a significant positive attitudinal change to the implementation of in-lecture activities following the POGIL model.

- *The exercises we get through the lectures, they help me understand the level of expectations from my unit*
- *I particular enjoyed going to Daniel's lectures because he would have 'activities' to complete during the lecture. It helped me understand what he was teaching*
- *Very interactive and the various tasks keep me from slacking off. Overall, the new teaching strategy used in this unit is great!*
- *The lecture exercises and 'clicker questions' are helpful and make lectures more interesting and interactive*
- *The clicker questions during the lectures were very helpful as they were interactive and allowed you to apply the knowledge you just learnt in the lecture to questions and then you were able to get feedback after. I felt I learned a lot during these sessions and reinforced the theory I just learnt*
- *The most useful aspects in this unit are the in-class exercises. But rather just answering questions we should also go through the exercises in groups and get them done in lecture time. I think I fully grasp each lecture's material much better that way. The questions in the exercises done with the clickers are generally*



- really good*
- *Being placed into groups has been very beneficial for me. When you are in a group you are able to discuss things and can ask each other questions. So the combined knowledge of all group members aids in a better overall understanding of ideas. Also it has given me good friends. The Active Learning is awesome and encourages discussion between peers. It definitely makes lectures less boring*
 - *The lectures with the clickers and the activities in groups because it forces me to pay attention instead of getting bored and day dreaming. I actually learn better in the group. This is something new to me. Usually other people don't really help me out. I think the groups and activities together work.*

These units are taught onshore at the Bentley campus and offshore by local staff at the Miri (Sarawak, Malaysia) campus. The local staff in Malaysia have been particularly supportive and enthusiastic with the implementation of active learning strategies, including POGIL and audience response systems (clickers):

“POGIL is great. Students like it, perhaps better with clickers. I'm saving some \$ from TPI for the clickers.” (Associate/Professor Chua Han Bing, Pers. Comm., 25 May 2009)

Chemical Structure and Spectroscopy 201

Daniel's interactive lectures keep the class focused, and work much the same way as educational kids' shows - you're having fun, so you're not concentrating on the fact that you're actually learning something.

Activities were great, doing the activities and discussing them with group members really helped me to understand the course content in a way that I would not have otherwise.



Appendix 2. Learning and Teaching Dissemination Activities

Below find a list of workshop and seminars presented during the project. There will continue to be more workshops and seminar presented after the completion of the project; for example, workshops are already planned in February for the University of Wollongong and University of Tasmania, Launceston.

TABLE 9: Workshops and seminars presented during this project

Date of activity	Activity title, location (city only)	Brief description of the purpose of the activity	Number of participants	Number of higher education institutions represented	Number of other institutions represented
1 December 2008	CHEMEd08 Perth	Introduction of ALTC project	45	many	many
January 2009	Towards student-centred teaching in large science classes, Perth	Teaching and Learning Forum. A two day event with participants from all five Perth universities	15	5	4
11 December 2009	Why we should change teaching - benefits to students Charles Sturt University, Wagga Wagga	Teaching seminar	12	1	0
18 February 2009	Poster - present project, University of Tasmania	ALTC Leadership workshop	50?	many	?
4 March 2009	Tools to change what we do in class, Charles Sturt University, Wagga Wagga	Teaching seminar	8	1	0
18 March 2009	Tools to change what we do in class, Charles Sturt University, Wagga Wagga	Teaching seminar	15	1	0
25 March 2009	Tools to change what we do in class, Charles Sturt University, Wagga Wagga	Teaching seminar	6	1	0
25 May 2009	Tools to change what we do in class, Charles Sturt University, Wagga Wagga	Teaching seminar	18	1	0



4 June 2009	Why we should change teaching - benefits to students, Curtin University of Technology, Perth	Teaching seminar	32	3	0
5 June 2009	Teaching seminar, Edith Cowan University, Perth	Tools to change what we do in class	22	1	0
18 June 2009	Enhancing student engagement through active learning activities in large science lecture classes The University of Melbourne	Deakin Teaching and Learning Conference	100	1	2
14 August 2009	Teaching seminar, The University of Adelaide	Should we change the way we teach?	55	1	0
18 August 2009	Deakin University 'Challenge' seminar series	Student Engagement through Active Learning in Large Science Classes	5 Presentation recorded for asynchronous delivery	1	0
21 September 2009	University of Tasmania, Hobart	POGIL workshop	10	2	0
22 September 2009	The University of Sydney	POGIL workshop	12	1	0
23 September 2009	Curtin University of Technology, Perth	POGIL workshop	40	1	0
25 September 2009	Curtin University of Technology, Perth	POGIL implementation	12	1	0
25 September 2009	ERGA Conference, The University of Adelaide	Should We Change the Way We Teach? Introducing the ALIUS Project	35	8	0
28 September 2009	Uniserve Conference, the University of Sydney	POGIL workshop Rick Moog	35	13 (two international)	0



29 September 2009	Uniserve Conference, University of Sydney	ALIUS: Active Learning in University Science - Leading Change in Australian Science Teaching	40?	Many	?
15 October 2009	The University of Sydney	POGIL workshop and discussion	20	10	0
10 December 2009	LaTrobe University, Melbourne	Active Teaching Methods workshop	16	1	0
10 December 2009	LaTrobe University, Melbourne	Active learning in large Science classes workshop	20	1	0
4 February 2010	Tertiary Chemistry Education Symposium 2010 Victoria University, New Zealand	Active Learning in the Sciences - Facilitating active learning in large classrooms	20	6	1
17 February 2010	ALTC Leadership projects meeting	Poster - ALIUS	40?	Many	?
5 February 2010	Victoria University, New Zealand	Active Teaching Methods workshop	16	1	2
23 February 2010	The University of Sydney	Active Teaching Methods workshop	18	1	0
26 February 2010	The University of Sydney	POGIL workshop	18	1	0
9 April 2010	ACELL/ALIUS meeting, The University of Adelaide	Active teaching methods workshop	25	4	0
23 March 2010	The University of Melbourne	Improvements in teaching and learning, Research seminar sponsored by LaTrobe University	30	1	
12 April 2010	Charles Sturt University	L&T Publishing Workshop Jennifer Lewis	6	1	0



13 April 2010	Charles Sturt University	Active Learning Workshop	5	1	0
14 April 2010	Curtin University of Technology	Faculty of Science & Engineering T & L Forum 'Implementing active learning in large chemistry classes: ALIUS at Curtin University of Technology'	120	1	0
15 April 2010	The University of Melbourne	ALIUS Workshop 'Active learning in large lectures', by Professor Jennifer Lewis, hosted by Deakin University	??	1	
17 June 2010	Queensland University of Technology	POGIL workshop Vicky Minderhout	16	3	0
30 June 2010	The University of Melbourne	ALIUS Workshop 'Active learning in large lectures', by Professor Vicky Minderhout and hosted by Monash University	40	2?	1
1 July 2010	The University of Melbourne	ALIUS Workshop 'How to Write Active Learning Activities', by Professor Vicky Minderhout and hosted by Deakin University	7	1	
6 July 2010	HERDSA conference	ALIUS Workshop 'Active learning in large lectures', by Vicky Minderhout and Renee Cole	20	12	
7 July 2010	HERDSA conference	Distributing change in university science: Building capacity in active learning	40?	many	



8 July 2010	RACI Conference, The University of Melbourne	Seminar: ALIUS: Active learning in university science leading change in Australian science teaching through active learning	40	many	
8 July 2010	RACI Conference, The University of Melbourne	ALIUS Workshop 'Active learning in large lectures', by Vicky Minderhout and Renee Cole	25	> 6	
18 August 2010	'Student engagement through active learning activities in large classes' The University of Melbourne	'Student engagement through active learning activities in large classes', Institute of Teaching and Learning Professional Learning program, Deakin University	10	1	
3 September 2010	Charles Sturt University, Orange	Active Teaching Methods workshop	10	1	
12 September 2010	Taipei	21st International Conference on Chemical Education 'Implementing active learning strategies in large first year chemistry classes: ALIUS at Curtin University of Technology'	25	15?	15?
14 September 2010	Charles Sturt University, Dubbo	Active Teaching Methods workshop	4	1	
29 September 2010	UniServe Conference, The University of Sydney	POGIL workshop; experiences discussion	20	several	
30 September 2010	UniServe Conference, The University of Sydney	ALIUS – project report	60?	Many	



1 October 2010	Queensland University of Technology, Science Educators' Symposium	The Development of Teaching Skills to Support Active Learning in University Science- ALIUS	100	5?	
	University of New England, Armidale	POGIL workshop	12	1	
21 October 2010	Queensland University of Technology, Brisbane	POGIL workshop	26	1	
10 November 2010	CSUEd conference, Bathurst	POGIL active teaching workshop	15	1	
11 November 2010	CSUEd conference, Bathurst	ALIUS project seminar	17	1	
17 November 2010	Macquarie University, Sydney	POGIL/ALIUS active teaching workshop	32	1	
11 February 2011	University of Wollongong	POGIL/ALIUS active teaching workshop	27	1	



Appendix 3. Timetable

	Spring 08	Autumn 09	Spring 09	Autumn 10	Winter 10	Spring 10
Project Management						
Recruit admin assistant, Project Manager, website designer (website development) Set up independent evaluation group Ethics approval		Management of all activities				
Development of Learning Leadership Action Plans						
PD on leadership	Workshop 1	Workshop 2		Evaluation at meeting 7		Workshops for local institutions
PD on pedagogy	Workshop 1		Workshop 2 (advanced)			Workshops for local institutions
Fostering change in colleagues	Discussion at meetings 1 and 2	Discussion at meetings 3 and 4	Discussion at meeting 5 and 6	Evaluation and planning for roll out at meeting 7	Via interaction and through Learning Hub	
Development of resources	Planning and discussion at meetings 1 and 2, prepare materials	Discussion at meetings 3 and 4, prepare materials	Discussion at meeting 5 and 6	Discussion at meeting 7, revise materials	Continues	
Practice-Based Innovation trials						
Activity		Start of trial Discussions at meetings 3 and 4	Evaluation and discussion at meeting 5 and 6	Discussion about implementation at meeting 7	Evaluation of effectiveness at meeting 8	Realization
Science Learning Hub						
Resources	Plan initial requirements and functionalities	Development of website and blogs, develop and test resources	Development of resources	Continues		
					Evaluation of effectiveness at meeting 8	
Dissemination						
Activity	Introductory workshop at Chem Ed conference Conference paper	Development of website and blogs, Contact with local institutions	Introductory Workshops for colleagues, local institutions	Support for implementation in local institutions, Evaluation at meeting 7 Write manuscript	RACI conference paper	Introductory and Advanced workshops and Final report

Meeting 1 combined with Workshop 1 at RACI offices Melbourne, Meeting 2 at ChemEd conference, Freemantle, WA, Meeting 3 at RACI offices Melbourne, Meeting 4 combined with Workshop 2 at RACI offices Melbourne, Meeting 5 via conference call, Workshop 3 at RACI offices Melbourne, Advanced workshops at each regional centre

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