Inquiry Oriented Learning in Science

National Forum:
Enhancing Learning in Science through Inquiry and Technology

Faculty of Science

The University of Technology, Sydney (UTS)

Tuesday, 25 September 2012

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UNIVERSITY OF TECHNOLOGY SYDNEY

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Welcome from the University

I'm delighted to welcome you to *Enhancing Learning in Science through Inquiry and Technology*.

This Forum is being co-sponsored by Associate Professor Les Kirkup's Australian Learning and Teaching Council (ALTC) National Teaching Fellowship, UTS: Science and the Office of the Deputy Vice-Chancellor and Vice-President (Research).

This Forum brings a timely national focus to enhancing learning through inquiry, including an exploration of the use of technology to facilitate that learning.

There are contemporary drivers encouraging a re-conceptualisation of the role and nature of inquiry as experienced by university science students. These include the emphasis being placed, through recently published science thresholds learning outcomes, on the capacity of students to critically analyse and solve problems.

At UTS we recognise such attributes are key to any successful research endeavour and are vital if we are to advance knowledge and learning.

Engaging in scientific inquiry is a potent way to involve students in the processes of science and to develop capabilities of life-long value to them, irrespective of their intended destinations.

As the Deputy Vice-Chancellor (Research), I recognise the role of inquiry in inspiring the next generation of talented researchers which is so critical for creating a strong, vibrant and sustainable research culture.

Presenters at the Forum are of national and international standing. I have no doubt that the diversity of perspectives and insights they will bring to the Forum will lead to a broadening and deepening of the national conversation on learning through inquiry.

I would like to thank all those at UTS, many in the Faculty of Science, who have worked tirelessly to make this Forum possible. I would also like to thank the Australian Learning and Teaching Council (ALTC), which recently transformed into the Office for Learning and Teaching (OLT), for making this Forum possible by supporting Associate Professor Kirkup throughout his Fellowship.

Let me wish you once again welcome to UTS and trust you all have a productive, collaborative and inspiring day.

Professor Attila Brungs
Deputy Vice-Chancellor and Vice-President (Research)
University of Technology, Sydney

Welcome from the Office for Learning and Teaching

Les Kirkup's National Teaching Fellowship and the Office for Learning and Teaching (OLT) are both about one year old. Like the OLT, the Fellowship's reach is national and international, as you will discover during today's Forum. And the OLT and Les' Fellowship share the aim of bringing about change in learning and teaching; in this particular case, by encouraging the science learning and teaching community to take part in a national discussion about the importance of inquiry-oriented learning in undergraduate students' experience of university.

Discussion is an altogether inadequate description of the breadth of activity in this Fellowship: the program has included keynote addresses and presentations at conferences in Australia, the United Kingdom and the United States; seminars and hands-on, inquiry-learning workshops at many universities across Australia and New Zealand (including to law and engineering academics); and consultations with students and demonstrators about their perspective on inquiry-learning activities.

In addition, the Fellowship has supported small teams at nine universities around Australia to trial and evaluate experiments for incorporation into their inquiry-oriented curriculum. Les has also brokered a partnership with CSIRO to develop inquiry-learning activities for students.

The OLT takes great pleasure in joining Les, Associate Professor Peter Meier and Professor Brungs in welcoming you to the culminating event of this Fellowship, hosted, fittingly, at Les' own institution, the University of Technology, Sydney.

Office for Learning and Teaching
Department of Industry, Innovation, Science, Research and Tertiary Education
Australian Government

Welcome from the Faculty of Science, UTS

The Faculty of Science warmly welcomes you to the National Forum on *Enhancing Learning in Science through Inquiry and Technology.*

Inquiry and discovery are fundamental to science and if we are to produce graduates who are work ready professionals, then we must ensure that they are well versed in the fundamental skills of inquiry and discovery.

At UTS we strive to develop science graduates with professional skills that situate students in the global workplace.

We deliver a practice-oriented education that integrates research and learning. Inquiry-based learning is a fundamental cornerstone in our pedagogies. It enables graduates to develop lifelong learning skills that will serve them well in their future careers, be that in science or other fields of endeavour.
I would encourage all of my colleagues in the areas of teaching, learning and research in science to adopt and promote an inquiry based approach. I hope that some of today's activities will help inspire and foster new approaches to science teaching and I thank you for attending our National Forum.

Associate Professor Peter Meier
Associate Dean, Teaching and Learning
Faculty of Science, University of Technology, Sydney

Welcome from the Fellowship

It gives me great pleasure to welcome you to UTS and to this National Forum on *Enhancing Learning in Science through Inquiry and Technology*.

The Forum is a special event, organised as part of my Australian Learning and Teaching Council (ALTC) National Teaching Fellowship.

Engaging students in the processes of inquiry has the potential to develop capabilities of tremendous long term value, whether or not they pursue a career in science. As this potential has long been recognised, it is fair to ask why learning through inquiry is under the spotlight at this particular moment in time.

There are drivers within and beyond the Australian Higher Education sector encouraging mainstreaming of learning through inquiry. These include: the recently developed K-12 Australian Curriculum with its emphasis on Science Inquiry Skills; the Learning and Teaching Academic Standards Project which has developed threshold learning outcomes for science which are underpinned by inquiry and; Australia's Chief scientist who recently expressed the view that [the] *teaching of science should resemble the practice of science*. For many people, to practice science *is* to engage in inquiry. These drivers make the Forum particularly timely.

I'd like to thank the Office for Learning and Teaching (OLT) which succeeded the ALTC, for their generous and enthusiastic support of the Fellowship and this Forum. I'm extremely pleased that Ms Siobhan Lenihan of the OLT will speak at the opening of the Forum.

The strong support of Professor Shirley Alexander, Deputy Vice Chancellor (Teaching, Learning and Equity) and Professor Attila Brungs, Deputy Vice Chancellor (Research) of UTS has made this Forum possible. I'm delighted that Professor Brungs will open the event and I thank him for co-sponsoring the event. I also thank my Dean, Professor Bruce Milthorpe, for supporting and also co-sponsoring the Forum.

I'm thrilled that Professors Gabriela Weaver and Mick Healey agreed to give keynote presentations as both are internationally recognised leaders in promoting and supporting learning through inquiry in the undergraduate curriculum.

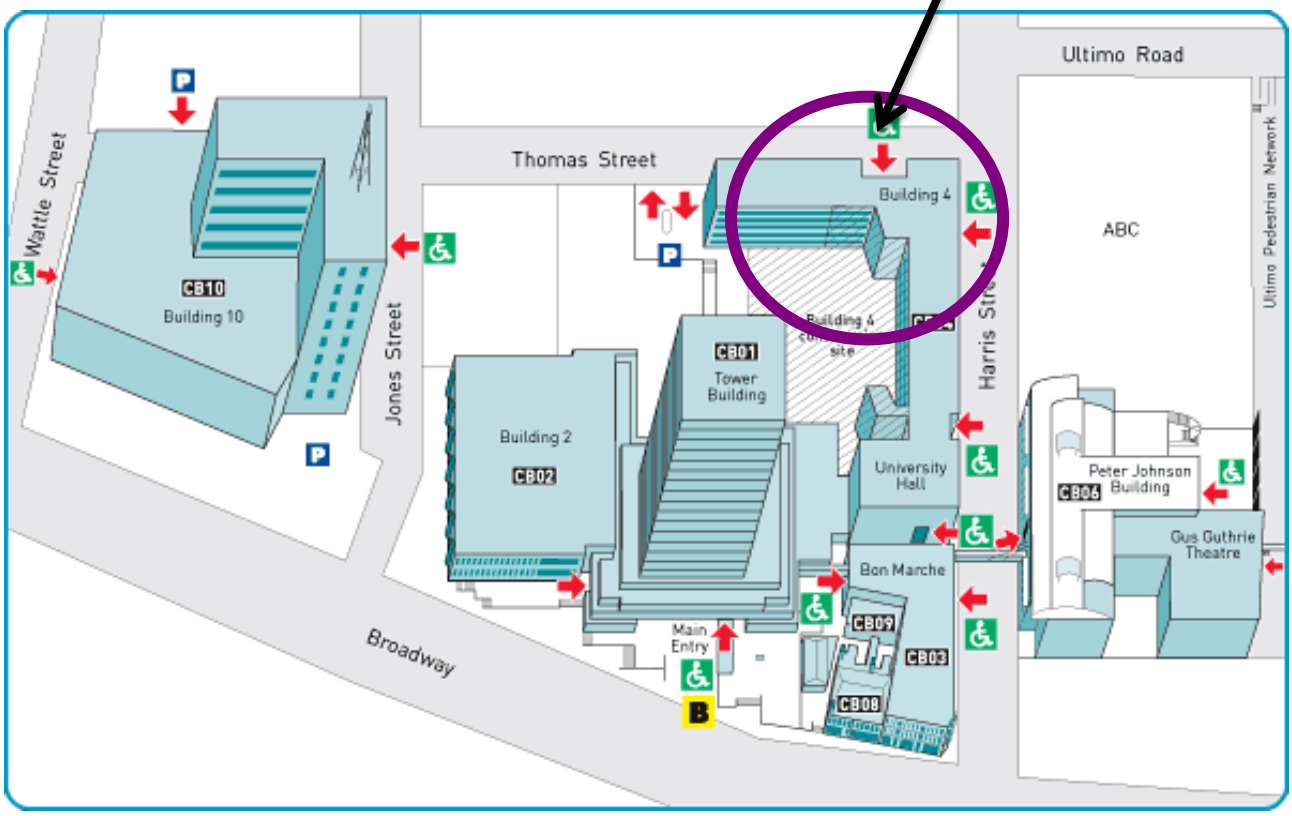
Forum presenters include academics prominent in designing and delivering curricula with a strong inquiry focus, including many who have explored, or are exploring, how technology can be used to assist in enhancing student learning through inquiry. I'm very pleased that students will take part in the Forum. The shared contribution of both students and staff will no doubt prompt rich discussions around promoting learning through inquiry and technology.

There are many people that have made this Forum possible. I'd like to acknowledge the tremendous work of Andrea Mears who until recently was the Program Officer on the Fellowship. Within the Faculty of Science at UTS my grateful thanks go to Nicole Eng, Shima Vahdat, Linda Foley and Stephanie Beames.

Finally, please accept my sincere thanks for coming to UTS to be part of this Forum. I wish you a stimulating and rewarding day.

Associate Professor Les Kirkup
Associate Professor, School of Physics and Advanced Materials and ALTC National Teaching Fellow,
Faculty of Science, University of Technology, Sydney

Building 4, UTS City Campus
Registration is on level 2 foyer, Thomas Street wing



About the venue

The University of Technology, Sydney (UTS) is a dynamic and cosmopolitan university, known for its practice-based learning. Located in the heart of Sydney, i.e. close to amenities and transportation, UTS has a student population over 31,000 on campus.

The Faculty of Science is one of seven faculties at UTS. It is a vibrant faculty, applying technology and creativity to advance knowledge and capabilities. Students learn and experience modern applications of science and mathematics geared towards practice in a nurturing and inclusive environment backed-up with modern, state of the art science facilities.
www.science.uts.edu.au

About Sydney

Sydney Population: 4.5 million; Australian population: 21 million
Sydney's climate: Spring (Sep-Nov) is between 11-24^{o}Celsius

Enhancing Learning in Science through Inquiry and Technology @ UTS
Tuesday 25 September 2012

National Forum: Enhancing Learning in Science through Inquiry and Technology Date: Tuesday 25 September 2012, Location: University of Technology, Sydney		
8.30-9.00	Registration Building 4, level 2 Foyer	
	Morning session Building 4, level 2, room 2.36 Session Chairs: Associate Professor Les Kirkup (UTS) and Professor Tony Baker (UTS)	
9.00-9.10	Welcome and Acknowledgement of Country : Associate Professor Les Kirkup	
9.10-9.15	Welcome from UTS: Professor Attila Brungs, Deputy Vice Chancellor (Research), UTS	
9.15-9.20	Welcome from the Office for Learning and Teaching: Ms Siobhan Lenihan, OLT	
9.20-9.50	Plenary: Associate Professor Les Kirkup: *Inquiry in Context*	
9.55-10.40	Keynote: Professor Gabriela Weaver (Purdue University) *Engaging First and Second Year Science Students in a Course-Embedded Authentic Research Project*	
10.40-11.05	Morning tea: Foyer on level 4 of Building 4	
	Parallel Session A **Technologies driving and supporting inquiry** Building 4, level 2, room 2.36 Session Chair: Ms Kelly Matthews (UQ)	**Parallel Session B** **Inquiry in practice: Enhancing student engagement** Building 4, level 2, room 2.38 Session Chair: Dr David van Reyk (UTS)
11.05-11.25	Dr Gwen Lawrie (UQ) *IS-IT Learning? Implementing collaborative interdisciplinary scenario inquiry tasks in large first-year science classes*	Ms Karen Burke da Silva (Flinders) *Guided Inquiry: the need for a scaffolded approach in large first year courses*
11.30-11.50	Associate Professor Kendal McGuffie (UTS) *Smart stuff with smart phones*	Dr Chris Creagh and Dr David Parleviet (Murdoch) *Inquiry Oriented learning in Physics at Murdoch: A Case Study*
11.55-12.15	Dr Liz Johnson (La Trobe) *Scientific inquiry online?*	Dr Margaret Wegener (UQ) *Heat: An inquiry-based physics lab for biologists*
12.20-12.30	Associate Professor Simon Pyke (Adelaide) *Inquiry & iPads: Introducing first-years to science & scientists*	Ms Helen Georgiou and Mr Matt Hill (University of Sydney) *Multiple representations provide a way of communicating the outcomes of an inquiry task*
12.35-12.45	Dr Charlotte Taylor (University of Sydney) *Virtual worlds and computational modelling engage students in inquiry activities in the high school classroom*	Ms Rita Rapa (UTS) *A student/demonstrator perspective of inquiry in a first year physics subject for non-physics majors*
12.45-1.25	Lunch: Foyer on level 4 of Building 4	
	Afternoon session 1 Building 4, level 2, room 2.36. Session Chair: Associate Professor Peter Meier (UTS)	
1.25-2.10	Keynote: Professor Mick Healey (University of Gloucestershire) *International perspectives on enhancing learning through research and inquiry: from first year to final year*	
2.15-2.45	Plenary: Associate Professor Manju Sharma (University of Sydney) *Identifying and designing inquiry: Perceptions and enactment at secondary and tertiary levels*	
2.45- 3.05	Afternoon tea: Foyer on level 4 of Building 4	
	Afternoon session 2 Building 4, level 2, room 2.36. Session Chair: Associate Professor Jo McKenzie (UTS)	
3.05- 4.15	Q&A session: Facilitated by Professor Roy Tasker (UWS) Theme: Enhancing Learning in Science through Inquiry and Technology Panel Members: Mr Matt Altaie (UTS), Professor Mick Healey (Gloucestershire), Associate Professor Les Kirkup, Ms Jenna Price (UTS), Associate Professor Manju Sharma (University of Sydney) and Professor Gabriela Weaver (Purdue)	
4.20-4.30	Associate Professor Les Kirkup (UTS): *Round up and thank you*	
4.30-5.30	Drinks, generously sponsored by Professor Attila Brungs, Deputy Vice Chancellor (Research) Foyer on level 4 of Building 4	

Keynote

Engaging First and Second Year Science Students in a Course-Embedded Authentic Research Project

Professor Gabriela Weaver
Discovery Learning Centre
Purdue University, West Lafayette, Indiana, US

Time: 0955-1040
Location: Room 2.36, level 2, building 4

Abstract
Through the Center for Authentic Science Practice in Education (CASPiE), laboratory practical experiments were developed that allowed students to be participants in ongoing, authentic scientific research. This approach was specifically designed to engage students in their first and second years of university in research, in order to give them an early experience.

The approach involves not only the in-class practical component, but also a peer-led team learning (PLTL) support system and the use of an internet-based network of research instrumentation that can be accessed and controlled remotely. The CASPiE approach has been used in at least 17 different tertiary institutions in the United State and Australia. This presentation will describe the details of the remote network, the general approach to CASPiE, and will summarize five years of evaluation data, including longitudinal findings.

Professor Gabriela Weaver is professor of chemistry and serves as the Director of the Discovery Learning Research Center at Purdue University. Professor Weaver carries out research in chemistry education at the undergraduate level and science education in K-12 schools. Her work in educational research initially focused on using inquiry-based methods for teaching science and on supplementing traditional instruction with technology tools. She developed novel approaches for use in undergraduate physical chemistry class and for work carried out with middle-school and high-school teachers. Since 2004 she has directed the NSF-funded Center for Authentic Science Practice in Education, a consortium of 17 universities and 2-year colleges that has developed and implemented a teaching approach to provide 1st and 2nd year undergraduate students with authentic research experiences as part of their laboratory coursework. Initially developed for chemistry, this model is now being used for atmospheric sciences, biology and other disciplines. Her recent honours include the 2010/11 Fellow of the CIC Leadership Academy and 2009 Purdue Nominee for United States Professor of the Year.

Keynote

International perspectives on enhancing learning through research and inquiry: from first year to final year

Professor Mick Healey
Emeritus Professor
University of Gloucestershire, UK

Time: 1325-1410
Location: Room 2.36, level 2, building 4

Abstract
The key to mainstreaming undergraduate research and inquiry is to integrate it into the curriculum. Most departments and institutions do elements of this already though they are often not made explicit nor are they strategically integrated across the programmes. This interactive session will explore the variety of ways in which undergraduate research and inquiry based learning are undertaken from first to final year using numerous mini-case studies from different disciplines and departments emphasising the experience in the sciences in Australasia, North America, UK and the rest of Europe.

Professor Mick Healey was one of the first people in the UK to be awarded a National Teaching Fellowship and to be made a Senior Fellow of the HE Academy. He has written and edited over 150 publications on various aspects of teaching and learning in higher education.
He is often asked to act as an advisor to projects, universities and national governments on aspects of teaching and learning in HE. He has advised the ALTC, the Canadian Federal government, the HE Authority for Ireland and the League of European Research Universities on research-based teaching and learning. He is a frequent presenter in Australia.

Plenary

Inquiry in Context

Associate Professor Les Kirkup
ALTC National Teaching Fellow
Faculty of Science, University of Technology, Sydney

Time: 0920-0950
Location: Room 2.36, level 2, building 4

Abstract
Calls for changes to the science curriculum towards more inquiry-oriented approaches to learning have been heard regularly for more than a century, though the take-up of such approaches, especially within the first year of study at university, has been patchy. In this presentation I will explore: national drivers causing a reconsideration of learning science through inquiry in the undergraduate curriculum; why the portents are favourable for the mainstreaming of inquiry in the undergraduate curriculum, and; touch on some key issues such as the use of technology to support learning through inquiry.

"Surely we want students to 'come to learn something about the goals (and values) of trained scientists, the methods and procedures they use, and the ways in which they communicate their results (Boud et al 1989)'. For me, this means that we must give our students opportunities to actively engage in the processes of scientific inquiry (and that engagement must begin as they enter university).*

With over 30 years of experience working in tertiary institutions, Les has significant hands on experience developing laboratory based physics activities for students from a range of backgrounds and who may (but more likely will not) pursue a career related to physics. Through his work with students, Les has observed the value of inquiry-oriented activities (IOL). When properly scaffolded and supported, these activities enhance student engagement, attitudes, learning outcomes and provide rich opportunities for students to be creative, work productively in teams and communicate their ideas. Les is devoted to stimulating and supporting the creation of IOL science activities that enhance learning and engage, challenge and inspire students.

Boud D, Dunn J and Hegarty-Hazel E (1989) Teaching in laboratories (Milton Keynes, Open University Press)

Plenary

Identifying and designing inquiry: perceptions and enactment at secondary and tertiary levels

Associate Professor Manju Sharma
School of Physics, University of Sydney

Time: 1415-1445
Location: Room 2.36, level 2, building 4

Abstract
Inquiry has multiple meanings and interpretations leading to a range of ways through which inquiry manifests itself in classrooms. In 2011 we probed teachers' notions of inquiry using an online survey. This presentation will draw on the 200 teacher responses to illustrate some of the multiple meanings of inquiry. Teachers were also asked to provide examples of inquiry. Similarities and differences between examples provided by school teachers and a particular inquiry activity at the School of Physics, The University of Sydney will be discussed. As students progress through the academic system, having sufficient expertise to undertake meaningful inquiry generates a tension. The implications of this tension will be explored.

"Scientific inquiry if done well can be incredibly valuable, if done poorly can be a disaster. I say this with some 17 years of working with undergraduate inquiry projects in the first year laboratories. When done well, students identify a tentative situation or question. This is followed by solid investigation into the science and methods that can underpin the inquiry. The research question is fine-tuned, methods are sound and the results are robust. Students have understood and implemented the process of inquiry. When done poorly, a question is rapidly defined, the experiment begins and the inquiry unfolds into observing and noting what happens. Explanations are minimal. Of course the role of the tutor is critical in scaffolding the inquiry process, given that students are differently motivated and there are time constraints."

Manju is an Associate Professor and the Director of the Institute for Innovation in Science and Mathematics Education at the University of Sydney. She heads the Sydney University Physics Education Research (SUPER) group. Manju's primary research focus is physics education and she currently supervises Honours and PhD students doing physics education research projects in the School of Physics at the University of Sydney. She has some 70 refereed publications and book chapters in science and mathematics education, and has led projects funded by the ALTC and the ASISTM project.

Parallel Session A: Technologies driving and supporting inquiry

IS-IT Learning? Implementing collaborative interdisciplinary scenario inquiry tasks in large first-year science classes.

Gwen Lawrie[1], Kelly Matthews[2], Lawrence Gahan[1], Peter Adams[3], Lydia Kavanagh[4] and Gabriela Weaver[5]
[1] School of Chemistry and Molecular BioSciences, University of Queensland
[2] Tertiary & Educational Development Institute, University of Queensland
[3] Faculty of Science, University of Queensland
[4] Faculty of Engineering, Architecture and Information Technology, University of Queensland
[5] Discovery Learning Centre, Purdue University, West Lafayette, IN, US

Time: 1105-1125
Location: Room 2.36, level 2, building 4

Abstract
Large-enrolment first-year STEM courses are challenging in terms of engaging students while catering to their diversity in abilities and interests. Collaborative inquiry-based self-directed tasks have been introduced into a first-year chemistry course facilitated by a new web-based task management system. Interdisciplinary scenario-inquiry tasks (IS-ITs) represent a fusion of strategies based on evidenced pedagogical practices for the integration of collaborative and active learning strategies to foster communities of learners. A critical component of the tasks was to introduce interdependency between students enhanced by an over-arching question that was beyond the scope of any individual to easily address. Students were encouraged to create novel solutions to the contextual challenge and creative thinking emerged where a collaborative synergy had been established. The implementation of collaborative small group work in classes of this size requires strategies in group management, task flow and assessment of student learning.

"Problem-solving, critical thinking and creativity are all phrases that we associate with scientific inquiry and, so often, are found in the learning outcomes that we frame for our students. We are born with the ability to implement scientific inquiry as we explore 'what will happen if' phenomena in our immediate environment. This innate way of thinking should be encouraged and extended in undergraduate students by providing learning activities and opportunities which enable them recognise their own thinking processes. Engaging students in scientific inquiry encourages them to formulate questions, design ways to make observations, collect and process data, then evidence and communicate their outcomes."

Parallel session A: Technologies driving and supporting inquiry

Smart stuff with smart phones

Associate Professor Kendal McGuffie
School of Physics and Advanced Materials
Faculty of Science, University of Technology, Sydney

Time: 1125-1150
Location: Room 2.36, level 2, building 4

Abstract
As computer technology has advanced, it has influenced disciplines which use that technology in both very predictable and very unpredictable ways. In addition to faster computation, we have faster response, faster communication and as a result of these, greater participation. Smartphones offer computational resources comparable to early supercomputers, but the opportunities they present are vastly different. In this presentation I explore some of the ways that smartphones might allow students to gain understanding and insights as an alternative to the 'square-bashing' and 'empty vessel' approaches.

Parallel Session A: Technologies driving and supporting inquiry

Scientific inquiry online?

Dr Liz Johnson
Faculty of Science, Technology and Engineering
La Trobe University

Time: 1155-1215
Location: Room 2.36, level 2, building 4

Abstract
We have recently completed an ALTC project which investigated bioscience teaching at Australian Universities to build a snapshot of current practice in teaching scientific inquiry. We collected 26 case studies from nine universities across four states where the priority to teach scientific inquiry skills influenced the design of the teaching approach. Skills that educators aimed to develop included: formulation of research questions and hypotheses; experimental design; critical appraisal of experimental results, literature and ideas; collaboration; communication of findings. In general, the approaches used involved variations of inquiry or problem-based learning that were delivered through laboratory classes, lectures and online environments. Technology has been used to provide solutions for distance and asynchronous communication, collaboration, incorporation of immediate learner feedback, and also to enhance the learning experience. In this presentation I will discuss how technology was used amongst our collected cases to help develop inquiry skills.

"I want my graduates to be both open-minded and also to think rigorously about evidence and data. It takes practice, imagination and focus to think scientifically but then you can see the world in a whole new light. It's so interesting!"

Parallel Session A: Technologies driving and supporting inquiry

Inquiry & iPads: introducing first-years to science & scientists

Associate Professor Simon Pyke
Centre for Learning & Professional Development
University of Adelaide

Time: 1220-1230
Location: Room 2.36, level 2, building 4

Abstract
SCIENCE 1100 ('Principles & Practice of Science I') was first offered as a compulsory course within the Bachelor of Science program at The University of Adelaide in 2011 as a response to an external review of the BSc program in 2007. The two key objectives of this course are to develop students' academic literacies (which include research/inquiry & academic writing) and to introduce them to what it is to 'be a scientist'. Students are introduced to the idea of what it means to 'be a scientist' through discussion of the broad array of scientific endeavour, the integrated nature of scientific disciplines, the importance of scientific process and critical thinking, and through interview of an active researcher within the Faculty. This presentation will focus on how the iPad has been used to support the inquiry elements of the course.

"Inquiry is fundamental to the process of science and is a critical element of the 'way of thinking' associated with being a scientist. So part of learning to 'be a scientist' should include development of the skills of inquiry. It's important that the curriculum doesn't just talk about inquiry skills - students need to experience and develop these skills in authentic contexts."

Parallel Session A: Technologies driving and supporting inquiry

Virtual worlds and computational modelling engage students in inquiry activities in the high school classroom.

Dr Charlotte Taylor
Faculties of Science, University of Sydney

Time: 1235-1245
Location: Room 2.36, level 2, building 4

Abstract
Science curricula are increasingly focusing on inquiry skills associated with designing and conducting investigations (ACARA 2011, NRC 2012), while schools struggle to motivate children to see the relevance of, and to develop an interest in, studying science. This project uses a multidisciplinary collaboration, between computer scientists, science education researchers, ecologists and classroom teachers, to design a virtual world which can be used in high schools to work with computational scientific inquiry. The Omosa VWorld creates a field experience for students to explore habitats, make observations of animal populations, talk with scientists and local people, and devise hypotheses to answer an ecological problem. Students then access the modelling program Netlogo, which is used extensively in ecological research, to test their hypotheses. Their results are presented to peers using PowerPoint slides or posters, and through the submission of an online lab workbook. Evaluations of the students' attitudes to learning, perceptions of the virtual learning experience and their ability to formulate and test hypotheses show that they find the environment novel and interesting, their understanding of testing variables improved, and that they particularly liked the Netlogo modelling exercise. Teachers find the activities relevant to the syllabus, and a useful way to enhance inquiry skills while consolidating content knowledge and improving thinking and reasoning.

"*Science IS inquiry: if we stopped asking questions, science as we practise it would stop! It's the thing which makes us scientists and keeps us excited and moving forward to investigate and solve problems. Why wouldn't we let our students 'in on the secret'? Whenever our students have the chance to inquire, with their own questions, the spark of interest is lit and they're hooked."*

Parallel Session B: Inquiry in practice: Enhancing student engagement

Guided Inquiry: the need for a scaffolded approach in large first year courses

Ms Karen Burke da Silva
School of Biological Sciences, Flinders University

Time: 1105-1125
Location: Room 2.38 level 2, building 4

Abstract
Embedding inquiry into large first year science courses requires small steps, which begin with a great deal of guidance and ultimately lead to students carrying out their own research project by the end of their first year of study. A program developed at Flinders University has found that this approach not only enhances critical thinking and the development of research skills such as hypothesis testing and quantitative analysis of data, but also generates a great deal of enthusiasm and engagement in students. The research project is often the first opportunity for students to conduct authentic research and many of them continue their research into second and third year courses, where they build and improve upon their original findings.

"*Teaching science to university students doesn't make sense unless it is done through an inquiry based approach. Not only will students engage more with their studies but they will acquire the necessary skills that will allow them not only to become scientists but also life- long learners".*

Parallel Session B: Inquiry in practice: Enhancing student engagement

Inquiry oriented learning in Physics at Murdoch: a Case Study

Dr Chris Creagh and Dr David Parlevliet
School of Engineering and Energy, Murdoch University

Time: 1130-1150
Location: Room 2.38 level 2, building 4

Abstract
In England around 1967 school physics classes consisted of a lot of hands-on experimental work and some calculation-like problem solving questions for homework. Over time the focus has shifted so students arrive at university thinking that physics is about solving calculation-like problems.
At Murdoch University we have an atypical student cohort with less than half of our students being school leavers. We also have a large number of external Open University students in first year physics. IOL could be the way to provide a coherent learning experience for all our students. No prior experience needed, no right answer, just a matter of finding things out!

The first steps towards IOL have been taken in trialling do-at-home labs with OUA students and tutorial activities with internal students. The feedback from both groups has been encouraging.

Chris Creagh: "The greatest benefit to students of introducing inquiry into the undergraduate curriculum is that it allows them to express their creativity and actually engage in the scientific way of doing things. I don't think any other student activity in first year physics; lectures, labs, calculation-like problem solving, allows them to do this. IOL activities were the missing jig-saw piece in my units. The benefit to me of IOL activities is, I find it is fun to work with the students using them. IOL activities give me the opportunity to discuss aspects of what scientists actually do, and what they have to take into consideration, in a just-in-time situation, with small groups of students, at the moment where the learning and teaching is most appropriate. I come out of these classes on a high, buzzing!"

David Parlevliet: "Introducing Inquiry Oriented Learning has helped to enthuse students by challenging their creativity and design skills in problem or scenario based activities. Used in tutorials or large group situations this really helps to get people actively thinking about what is going on and applying themselves to the activity. From the activities we have implemented so far the response from students has been fantastic, people are actively engaging in their tutorials which helps motivate them for their studies. The noise and hub-bub of an actively working, investigating and exploring tutorial group is a pleasure to hear!"

Parallel Session B: Inquiry in practice: Enhancing student engagement

Heat: An inquiry-based physics lab for biologists

Dr Margaret Wegener
School of Mathematics and Physics, University of Queensland

Time: 1155-1215
Location: Room 2.38 level 2, building 4

Abstract
We have developed an inquiry-based undergraduate experiment to illustrate concepts related to heat. In the first of two sessions, students in teams follow a guided module involving measurement of heat conduction. Teams then apply their knowledge to construct a simple model house, choosing from a limited range of materials. The house is instrumented and placed outdoors for a 24-hour period, with students able to view their house's internal temperature (and outside conditions) live via the internet. In the second session, students discuss and explain the temperature data of the class houses, and then teams develop a design for a goal of their own choosing (constant-temperature house, greenhouse, etc), based on their acquired knowledge of heat transfer. This structure is tested in a similar manner and students write a laboratory report on their findings. The activity was found to successfully engage students who felt that they had some ownership of design, better motivating them to understand the physics involved. We plan to extend the experiment to include other situations involving heat transfer, for example, insulating characteristics of biological species.

"T*he students are engaged in real scientific activity right from the start of their university study. They think they're doing science, so they act like they're doing science. They are interested in their experiments. They have to deal with problems that arise. They come across other interesting questions as they try to achieve their goal, and learn some more science in the process. Inquiry-based labs are more interesting and more challenging than recipe-based labs for everyone involved – the students, tutors and staff. The extra challenge is worth it."*

Parallel Session B: Inquiry in practice: Enhancing student engagement

Multiple representations provide a way of communicating the outcomes of an inquiry task

Ms Helen Georgiou and Mr Matthew Hill
School of Physics, University of Sydney

Time: 1220-1230
Location: Room 2.38 level 2, building 4

Abstract
Scientific disciplines have unique ways of communicating information. It has been suggested that expertise comes with an increasing literacy of using the disciplinary discourse. While there are often conventional ways of presenting information, these are not necessarily the most efficient or the most natural for individuals and particularly students. In 2011, a survey was conducted of 625 undergraduate physics students to explore how they approached representation-rich problems. It was found that particular groups of students struggled with the questions and that there were often diverse ways that students would respond to work out and present their answers. Implications include considerations of how representations should be taught and modelled in the university context and the importance of freedom in the way that students can approach particular tasks and present results.

Helen Georgiou: "Introducing inquiry allows for systemised approached to be developed amongst undergraduate students which enculturate them into how scientists actually work."

Matthew Hill: "There are different levels of benefit for different students. Some students already model inquiry in their thinking and approaches to learning and laboratories. These students will also be capable when given open-ended inquiry tasks. Ironically, the students who should be encouraged to adopt more inquiry-based approaches in learning are the ones who need a greater level of scaffolding and management at inquiry tasks."

Parallel Session B: Inquiry in practice: Enhancing student engagement

A student/demonstrator perspective of inquiry in a first year physics subject for non-physics majors

Ms Rita Rapa
Faculty of Science, University of Technology, Sydney

Time: 1235-1245
Location: Room 2.38 level 2, building 4

Abstract
I will describe some of the benefits and challenges that inquiry-type experiments present to students and demonstrators from the perspective of someone who has graduated from student to demonstrator in the same first year physics subject. I will also indicate some of the issues I believe those developing inquiry-type experiments should consider.

"The main challenge I think is to make the 'inquiry' concept interesting as well relevant to subject material. High school is very much associated with learning material to pass an exam. Inquiry relies on working things out as you go and thinking independently."

Q&A: Enhancing Learning in Science through Inquiry and Technology

Panel Members:
Mr Matt Altaie, Honours student at UTS
Ms Jenna Price, Lecturer in the Social & Political Change Group, Faculty of Arts and Social Science, UTS
Professor Mick Healey, Emeritus Professor, University of Gloucestershire
Professor Gabriela Weaver, Professor of chemistry and Director of the Discovery Learning Research Center, Purdue University
Associate Professor Manju Sharma, Associate Professor and Director of the Institute for Innovation in Science and Mathematics Education, University of Sydney
Associate Professor Les Kirkup, ALTC National Teaching Fellow and Associate Professor, UTS

Facilitated by Professor Roy Tasker, School of Science and Health, University of Western Sydney

Time: 1505-1615
Location: Room 2.36, level 2, building 4

Professor Tasker is at the University of Western Sydney and has primary teaching responsibilities at first-year level. His interests are in how and what students learn in chemistry using interactive multimedia resources.

In 2011 Roy was awarded the Prime Minister's Award for Australian University Teacher of the Year. In 2008 he received an Australian Learning and Teaching Council Citation for an outstanding contribution to student learning and he has received the Royal Australian Chemical Institute (RACI) Chemical Education Division Medal.

A Fellowship Snapshot
Inquiry-oriented learning in science: Transforming practice through forging new partnerships and perspectives.

Les Kirkup
School of Physics and Advanced Materials
University of Technology, Sydney

The ALTC National Teaching Fellowship awarded to me in 2011 has adopted a number of approaches to promoting the national conversation on learning science through inquiry in Australian universities and engaged not only academics in this conversation, but students, academic policy makers and high profile individuals from beyond the university sector.

There are several contemporary drivers for large scale reform towards inquiry in the science curriculum, including Australia's Chief Scientist who recently stated: *The teaching of science should resemble the practice of science more than it does*. For many people, to practice science *is* to engage in the processes of inquiry.

A powerful driver from within the community of tertiary science educators is the Science Learning and Teaching Academic Standards Statement (2011). The Statement describes through the articulation of Threshold Learning Outcomes (TLOs) what, at a minimum, science graduates should know and be able to do. These TLOs have brought fresh impetus to inquiry in the science curriculum. More specifically, the TLO focussing on inquiry and problem solving requires students be able to critically analyse and solve scientific problems by: gathering, synthesising and critically evaluating information from a range of sources; designing and planning an investigation; selecting and applying practical and/or theoretical techniques or tools in order to conduct an investigation, and; collecting, accurately recording, interpreting and drawing conclusions from scientific data.

To give a flavour of the Fellowship, I will focus on a strand that gained momentum as the Fellowship progressed.

My Fellowship Program Officer, Andrea Mears, and I invited expressions of interest (EOI) from academics intent on developing, trialling and embedding inquiry-oriented activities in their curriculum and supported each successful EOI with a modest sum of money. These activities became known as the ALTC Fellowship Funded Activities (AFFAs). In promoting the AFFAs, we were inspired by Elton (Elton, 2003) who stated:

"*The appropriate collaboration of relevant agencies, both inside and outside universities may be able to use certain systematic strategies to achieve positive systemic change."*

It was our intention to give groups the opportunity to be part of a national, multi-disciplinary group and to share their experiences and progress with others engaged in similar activities at several universities across Australia. Nine applications were funded originating from science faculties at the Universities of Queensland, Adelaide, New England and Tasmania, as well as Charles Sturt, Flinders and Murdoch universities. The core disciplines of physics, chemistry and biology were equally represented amongst the AFFAs.

We encouraged the formation of small teams with diverse backgrounds and capabilities to develop, trial and embed IOL activities within the curriculum; engage institutional leaders, senior academics and educational developers in IOL activity development; enhance recognition for the work being done by academics in developing inquiry activities within their own institution by being involved with a national program of activities, and; act as a seed to attract more funding.

Support from the Fellowship came in several forms; perhaps the most valuable was the running of focus groups with students to explore their experience of, and attitude towards, IOL activities. Participants expressed the view that the AFFA gave them the 'impetus to act'.

The AFFAs have developed IOL activities and successfully trialled them. Details of the individual AFFAs and recent summaries of their work can be found at http://www.iolinscience.com.au/our-iol-activities/new-partnerships-and-networks/. As an example, Dr Chris Creagh and Dr David Parlevliet of Murdoch University developed an activity through which student explore heat transfer. More specifically, students investigate how best to insulate an object from heat flow. Students groups are given cardboard, aluminium foil, tissue paper, news paper, bubble wrap and other miscellaneous materials. Students design a structure that could contain a heat source and insulate it from the outside world. The effectiveness of each of these structures is established using a thermal imaging camera.

In the words of David Parlevliet:

"This activity did capture the student's imagination and they designed some good insulating structures which led to a fruitful plenary discussion session at the end of the activity. With some refinement this activity will be used again in further teaching periods."

Another strand of the Fellowship explored the student experience through hands-on workshops in which full time and casual academics, technical staff and educational developers took on the role of students, unpacked the value and the challenges of inquiry-oriented activities.

Details of this and other strands of the Fellowship can be found at http://www.iolinscience.com.au/ .

References

Elton, L (2003) *Dissemination of innovations in higher education: A change theory* approach Tertiary Education and Management 9: 3, 199-214.

Learning and Teaching Academic Standards Project (2011): Learning and Teaching Academic Standards Statement. Available from http://www.olt.gov.au/resource-learning-and-teaching-academic-standards-science-2011

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