THE ADVANCING SCIENCE BY ENHANCING LEARNING IN THE LABORATORY (ASELL) PROJECT: THE NEXT CHAPTER

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ABSTRACT

Most researchers agree that the laboratory experience ranks as a significant factor that influences students' attitudes to their science courses. Consequently, good laboratory programs should play a major role in influencing student learning and performance. The laboratory program can be pivotal in defining a student's experience in the sciences, and if done poorly, can be a major contributing factor in causing disengagement from the subject area. The challenge remains to provide students with laboratory activities that are relevant, engaging and offer effective learning opportunities.

The Advancing Science by Enhancing Learning in the Laboratory (ASELL) project has developed over the last 10 years with the aim of improving the quality of learning in undergraduate laboratories, providing a validated means of evaluating the laboratory experience of students and effective professional development for academic staff. After successful development in chemistry and trials using the developed principles in physics and biology, the project has now expanded to include those disciplines. This paper will discuss the activities of ASELL and provide a report about the first ASELL science workshop held at the University of Adelaide in April 2010.

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INTRODUCTION

Laboratory activities have an important and characteristic role in science curricula (Hofstein & Mamlok-Naaman, 2007). Science educators have suggested many benefits of laboratory work in terms of both knowledge and skill development (Bennett & O'Neale, 1998; Hegarty-Hazel, 1990; Hofstein & Lunetta, 1982, 2004; Moore, 2006). It is acknowledged/accepted that effective experiments do not utilise a 'follow the recipe' structure (Domin, 1999) where students can "go through the motions... with their mind in neutral" (Bennett & O'Neale, 1998, p. 59). Experiments need to be designed to support student autonomy whilst allowing for cognitive engagement (Skinner & Belmont, 1993). This can be achieved by having students work together collaboratively to solve problems (Shibleym & Zimmaro, 2002), incorporating inquiry-based learning activities (Green, Elliott, & Cummins, 2004), or designing open-ended investigations (Psillos & Niedderer, 2002) (noting that pure discovery activities tend to be ineffective as they lack structure (Mayer, 2004)). Such activities not only improve motivation (Paris & Turner, 1994), but students can also scaffold each other's learning (Coe, McDougall & McKeown, 1999).

Each year across 35 Australian universities, about 20,000 students undertake chemistry units (Barrie, Buntine, Jamie, & Kable, 2001a). Almost half of student time is spent on laboratory activities (Royal Australian Chemical Institute, 2005), and these figures are assumed to be similar in the domains of biology and physics. So it is important that the opportunities afforded by these learning environments are realised. A challenge facing many educators is to provide laboratory programs that are relevant, engaging, and offer effective learning outcomes within existing constraints. A further dimension of this challenge lies in the demonstration of the laboratory as a unique learning environment (Rice, Thomas & O'Toole, 2009).

THE ADVANCING SCIENCE BY ENHANCING LEARNING IN THE LABORATORY (ASELL) PROJECT

The Advancing Science by Enhancing Learning in the Laboratory (ASELL) project provides a multi-institutional, collaborative approach for improving the quality of undergraduate laboratories and providing effective professional development for academic staff. ASELL is the expansion of the previous Australian Physical Chemistry Enhanced Laboratory Learning (APCELL) (Barrie et al., 2001a, 2001b, 2001c) and the Advancing Chemistry by Enhancing Learning in the Laboratory (ACELL) projects (Buntine *et al.*, 2007; Jamie *et al.*, 2007; Read, 2006a, 2006b). A(P)CELL began in 2000 when a number of chemistry academics noticed increasingly high levels of student dissatisfaction with their undergraduate chemistry laboratory courses. It was also apparent that many of the academics who taught chemistry at the tertiary level were not familiar with educational research related to students' experiences in the laboratory. Therefore, the project team designed professional development activities that enhance both academic and student understanding of issues affecting student experiences in the laboratory.

One of the tangible outcomes of the A(P)CELL project is a database of educationally-validated undergraduate experiments on an open-access website (www.acell.org). For an experiment to be accepted onto the ACELL database, it passed through a rigorous evaluation process (see Figure 1). Submitted experiments also included student notes, demonstrator notes, technical notes, hazard/risk assessment, and the ASELL Educational template. The Educational Template provides information on the context in which the experiment is run, the educational goals which it serves, how these goals are achieved, and an analysis of student feedback data providing evidence of students' perceptions of the experiment.

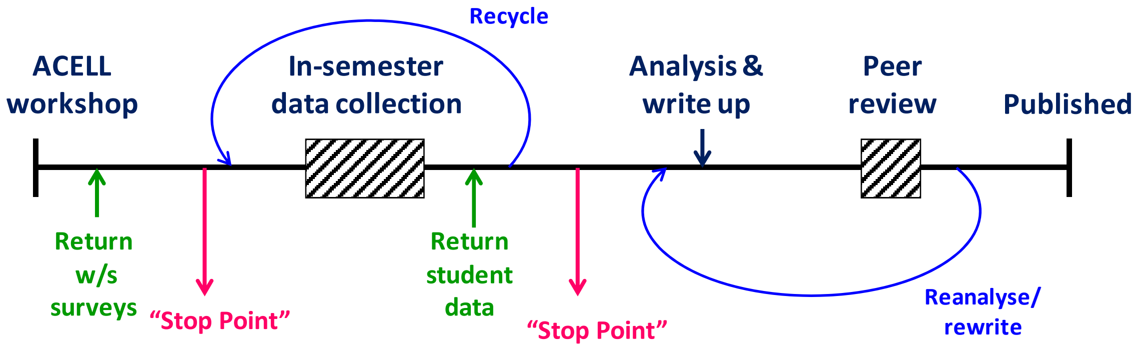

Figure 1: Schematic of the ACELL process

The first stage of the ACELL process involved the third-party testing of submitted experiments at a workshop by both academics and students and the evaluation of the educational and scientific merit of the exercise. The first APCELL workshop took place in 2001 and the first ACELL workshop was held in 2006. See Table 1 for a list of past workshops. The aims of the workshop were twofold – firstly the testing serves to demonstrate that the experiment is transferrable to a new institution, by having it set-up and run away from its home laboratory. The technical notes and student notes supplied need to provide sufficient information to anyone who is unfamiliar with the experiment. Secondly, testing provides valuable feedback to submitters on the strengths and weaknesses of the experiment. At the workshop, a community of practice is also fostered where discussions of practical educational theory take place.

After an experiment completed workshop testing, it was returned to its home institution where modifications could be made before further student data was collected using the A(P)CELL Student Learning Experience (ASLE) survey. The ASLE survey consists of Likert-scale and open-response items, and the student evaluation part of the Educational Template must include a summary of the Likert-scale data and a content analysis from the open-response items. The project team and the website provide guidance as to how the analysis can be completed, including examples.

Table 1: Summary of past A(P)CELL workshops

Experimental workshop
Feb, 2001 (Sydney)
Nov, 2002 (Melbourne)
Feb, 2004 (Hobart)
Feb, 2006 (Sydney)
Jan, 2007 (Adelaide)
July, 2009 (Sydney)

Following the analysis and provided the student data meets certain criteria, the submitter would be in a position to finalise the Educational Template and write the manuscript for publication. Complete submissions are then sent for peer review by 3 referees – a student who has participated in a workshop, a staff member of a university, and a member of the project management team. Normal editorial processes are followed where the submitters can respond to referee's comments. Acceptance of the submission leads to the inclusion of the experiment on the ACELL website. If the submission included a full manuscript, this would result in automatic acceptance for publication in either of two chemistry education journals – *Chemistry Education Research and Practice* or the *Australian Journal of Education in Chemistry* (subject to minor editing for the appropriate journal).

In 2007, the ACELL project team started to explore the possibility of applying the principles and processes developed in chemistry to other science disciplines. Exploratory workshops based on the ACELL process were held for physics (late 2007) and biology (early 2008). The success of these preliminary workshops in disciplines other than chemistry resulted in the establishment of ASELL in 2009. ASELL has four distinct goals:

1. to provide for the professional development of science academics by expanding their understanding of issues surrounding learning in the laboratory environment;
2. to facilitate the development of a community of practice of laboratory educators by providing mentoring in educational theory and practice, regular workshops, and a presence at scheduled education conferences;
3. to provide a sustainable mechanism, through involvement of the Australian Council of Deans of Science, to embed this cultural change as standard institutional practice; and
4. to conduct and enable research into learning and teaching in the laboratory environment.

It was expected that the core activity for achieving the first two goals would be through the experimental workshop model using the process for evaluation of laboratory activities developed in ACELL (as shown in Figure 1). Educationally-validated undergraduate experiments that meet the acceptance criteria will be published on an open-access website (www.asell.org – this will also include all previously accepted ACELL activities). Journals for publications in the areas of physics and biology education are currently being negotiated.

THE ASELL WORKSHOP – THE UNIVERSITY OF ADELAIDE, APRIL 2010

The first ASELL Workshop was held at the University of Adelaide in April 2010. At this workshop 39 experiments were submitted for evaluation in parallel sessions across the three disciplines, biology, chemistry (including 2 biochemistry experiments) and physics. Testing of these experiments was completed over a four day period by a team of 42 academics and 41 students. In addition, a special 2-day workshop was run for Deans, Associate Deans and/or their representatives (13 delegates). Although this is the second ACELL/ASELL workshop the Deans have been invited to, it is the first workshop where there has been such a great representation. Table 2a provides a summary of the delegates who represented 15 different institutions. Table 2b shows the number and some of the types of experiments tested at each workshop. Delegates were invited to the workshop as teams (1 academic and 1 student) and paid a team registration fee. The Deans of Science at each of the participating institutions agreed to provide financial support for a team from each of the three disciplines at their institution to attend the workshop. Thus, the workshop was self funded and did not rely on external funding to run, which was the case in the past.

Table 2: (a) Summary of the delegates who attended the ASELL Science Workshop and (b) Number of experiments and some of the types of activities tested at the ASELL Workshop

(a)	Biology	Chemistry	Physics	Total
Academics	12	16	14	42
Students	12	12	14	41
Deans	5	6	2	13
Directors	1	4	1	6
Total	30	41	31	**102**

(b)	Biology	Chemistry	Physics
Total	12	13	14
Types of labs	Dissection	Titration	Pendulum
	Botany	Synthesis	Radioactivity
	Enzymes	Analytical chem	Optics
	Genetics	Biochemistry	Oscilloscope

The workshop was organised following the procedure shown in Figure 2. Delegates were sent an invitation to submit an experiment and attend the workshop. Academic staff delegates submitted an Expression of Interest for the experiment they wanted to evaluate. After consideration of the types of experiments submitted, academics were notified whether their experiment was accepted to be evaluated at the workshop. Following the acceptance notification, academics were required to submit all the necessary documentation for the experiment. These documents included:

- Student Notes – containing the background information and experimental notes which are provided to students who are undertaking the experiment in its home institution
- Demonstrator Notes – containing information and instructions for the supervision of students as they do the experiment.
- Technical Notes – containing all information required by technical staff in order to set up an experiment, including a list of equipment and chemicals, estimated costs, settings for instrumentation (if appropriate), safety measures that need to be taken in the laboratory, and any other information which technical staff might require.
- Hazard / Risk Assessment – this addresses both chemical and physical hazards associated with the experiment, as well as describing safety precautions.

The technical notes, experiment notes and risk assessments were passed onto the technical staff and PhD students who were employed to set up the workshop. Using the notes provided the experiments for the chemistry and biology workshops were set up in the corresponding laboratories at the University of Adelaide (setup commenced about 2 weeks before the workshop). Academics that submitted physics experiments were asked to send or bring their own equipment, except for common equipment provided on a list by the host institution. Equipment for biology and chemistry activities was provided by the host institution. Not all the experimental activities were easy to set up and some experiments required assistance from other disciplines. For example, two biochemistry experiments that were run at the chemistry workshop required equipment that was provided from biology. If there were any materials that could not be provided by the host institution, the submitters were asked to either send these beforehand or bring it with them (this was kept to a minimum). Fortunately, in most cases, enough laboratory space was available for the majority of experiments to be set up the day before they were due to be run. The PhD students who set up the experiments acted as technical staff throughout the workshop.

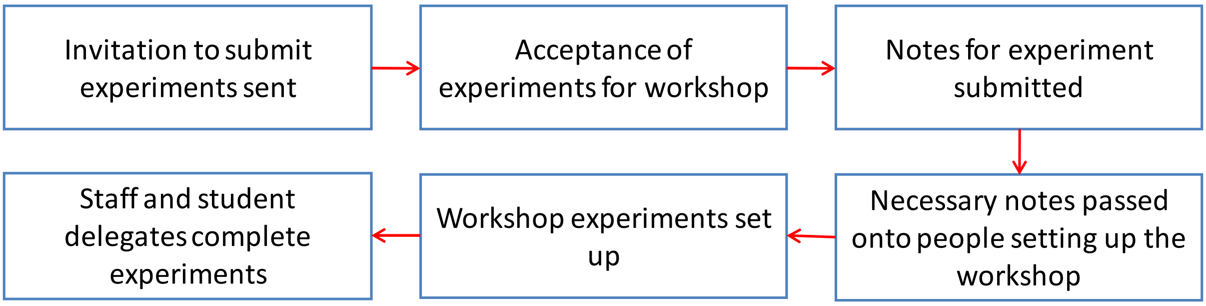

Figure 2: The process undertaken to set up the ASELL Science Workshop held at the University of Adelaide

The workshop itself had a very packed schedule. A flowchart of a typical day's events is shown in Figure 3. Each day involved early morning discussion sessions focussing on the educational aspects of laboratory work where delegates were guided through an educational analysis of their submitted experiment (this provided scaffolding for completion of the ASELL Educational Template). Morning and afternoon laboratory sessions (each 3 hours long) were separated by a communal discipline lunch break. The Deans started participating on the second day of experimental work and completed the same activities as the other delegates.

In the laboratory sessions, academic staff delegates took on the role of a student in testing the experiments, with the exception that the academic who submitted the experiment acted as the demonstrator. All delegates (academic staff and students) were assigned to work in pairs and with different people in each laboratory session, fostering networking opportunities and furthering ASELL's community of practice aims. The pairs that were assigned consisted of student+student, academic+academic, and academic+student. The Deans were treated as academic staff delegates and were also assigned a partner. Often, delegates, especially academics and the Deans, were forced to move beyond their comfort zone by undertaking experiments outside of their area of expertise. This was important in allowing academics to experience what students feel when confronted with a new experiment in an unfamiliar environment.
An important part of each day was the debrief and discussion sessions held at the conclusion of the day's activities. Delegates were asked to critically evaluate the experiments they undertook that day in a discussion forum with the submitter. Delegates approached these sessions very seriously, with many discussions continuing over dinner. One participant commented by saying
"It was good to have discussion session in the evening to allow everyone to think about the experiments and potential improvements. It also allowed me to discuss certain experiments with people who had not actually done those experiments before, which at times led to novel ideas being developed".

In the evenings, the delegates who were not grouped by discipline, enjoyed some downtime over dinner therefore allowing for cross discipline interaction. These were the key times people from different disciplines would interact with each other due to the packed workshop schedule. Although this is the first time a workshop of this nature has been run, a delegate even felt that they wanted *"…more interaction across disciplines and would have like to see some of the other experiments that were run. Perhaps even a session akin to a poster session where one could view and discuss a range of experiments".*

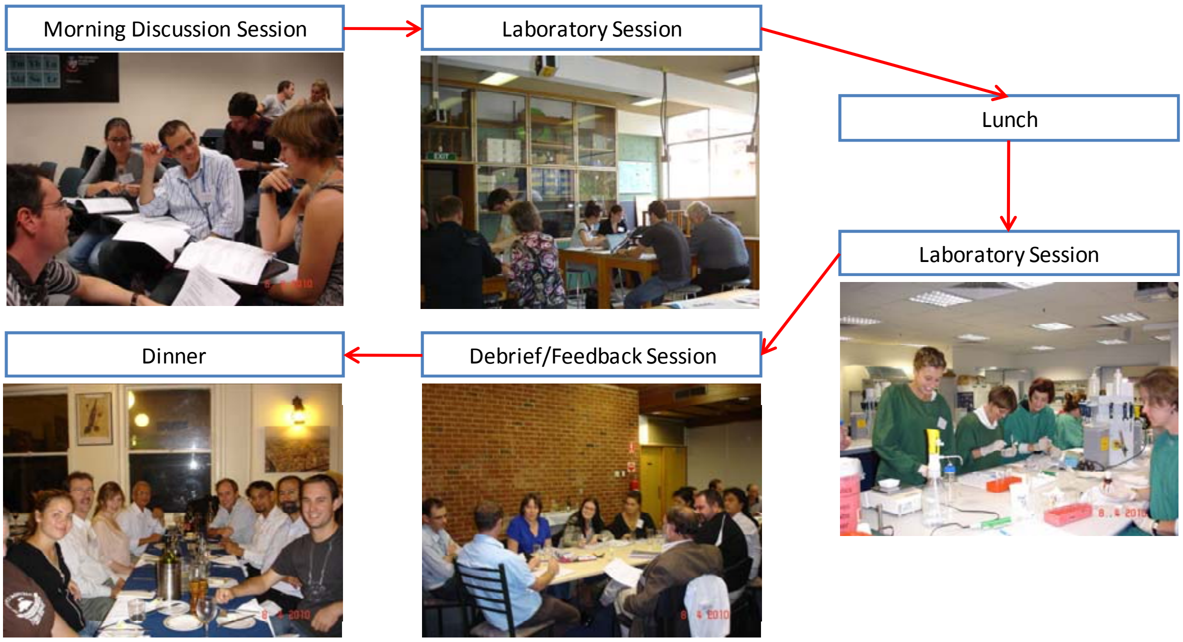

Figure 3: Flowchart of a typical day's events at the ASELL Science Workshop

IMPACT OF THE ASELL WORKSHOP ON THE HOST INSTITUTION

Hosting the workshop raised the profile of not only 'what makes a good experiment' but also the similarities of these factors across what had previously been considered to be a lack of any common ground. In concert with other curriculum renewal activities currently in progress, the workshop has provided increased opportunity for development of a more holistic approach to curriculum design, particularly in the core Level 1 discipline areas, with a focus on improving the student experience within the laboratory programs.

CONCLUSION

The ASELL Workshop held in April 2010 at the University of Adelaide was the first workshop of its kind organised by ASELL. In the past, discipline-specific workshops had been organised, in particular for chemistry. The April workshop is the first example where experiments from all three disciplines were tested at the same time, while also allowing for cross discipline interaction during free/social time. The representation of Deans at the workshop was also much greater than at any previous workshop. The April 2010 workshop marks the start of more cross discipline interaction, conversations with the Deans and discussions about laboratory activities in the future.

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