FACILITATING TRANSITION FOR BOTH LEARNERS AND TEACHERS IN THE FIRST-YEAR CHEMISTRY LABORATORY

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ABSTRACT
An induction session for demonstrators was devised and run in 2012 to explain changes to the laboratory program in a first-year chemistry subject and encourage demonstrators toward practices that would make the laboratory an effective learning experience for students. The induction session was an opportunity to explore matters relating to expectations: particularly the expectations that the students could have of the demonstrators and the expectations that the demonstrators could reasonably have of the students. The purpose of the induction session was to help demonstrators focus on enhancing the learning opportunities for students in the laboratory, as the practical sessions were the only small-group teaching opportunity in the week. Running this activity, and paying the demonstrators to attend, was a way of honouring the contribution that casual teachers make to our program and reinforces their status as 'academics-in-training'. The induction session has been run again in 2013, with modifications based on feedback from the 2012 session.

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LABORATORY WORK
Laboratory work has long been a major part of learning in the sciences (Reid & Shah, 2007). There have been arguments whether there is a strong correlation between laboratory work and enhanced achievement in theory exams but it is clear that students who will go on to become professional chemists need training in specific laboratory skills (Bennett, Seery, & Sövegjarto-Wigbers, 2009). It can be argued that students who are kinaesthetic learners will certainly benefit from laboratory work where they can learn by doing (Tobin, 1990). For all students, the laboratory is an opportunity to put ideas into practice and work on problems, which may not be 'real world', but have the virtue that the 'problem' is very real and immediate from the student perspective, being based on data they have generated. Laboratory work also gives students experience in data collection and data handling, making and testing hypotheses, presenting results and discussing data in the light of some theoretical framework (Hofstein & Lunetta, 2004).

A key element in an effective learning experience in the laboratory is the demonstrator (Australian practice) or teaching assistant (TA; US practice). It has been identified through collecting data from TAs and students that the most important skills for a TA to possess are: grades lab reports fairly; is well-prepared for lab; thoroughly understands the lab exercise; makes students aware of safety issues; listens carefully to students and tries to understand their problems; explains and demonstrates necessary lab techniques. In the affective domain it is important that a TA: shows respect for students; is warm and friendly; encourages students to ask questions; is enthusiastic about teaching in the lab; is genuinely concerned with students' progress in the lab (Herrington & Nakhleh, 2003).

Bond-Robinson and Bernard-Rodriques (2006) identify six strategic actions of GTAs to be effective as laboratory teachers:

- Interaction: GTA moves regularly throughout the lab space to interact with all undergraduates rather than waiting for students to approach;
- Safety: GTA models and enforces safety rules;
- Respect / Help: when responding to requests for help, GTA's attitudes is respectful and takes account of the ability of the students to learn;
- Opening Talk: focussed, concise, clear and primarily procedural, with a conceptual overview that illustrates the importance and relevance of the experiment;
- Awareness: GTA notices students having difficulty and moves to assist;

- Guidance: explanations are given at a level commensurate with the understanding and prior experiences of the student.

There is a recent report on a three-day training program for new TAs in General Chemistry 1 at the University of Colorado in Boulder which includes elements such as learning theory, conceptual understanding and problem solving, introduction to course reform and a lunch with experienced TAs. Also included in this program are sessions on the major topics that will be covered in General Chemistry 1 such as stoichiometry, atomic model, equilibrium, thermochemistry, molecular shapes, and intermolecular forces, in order to ensure that TAs can review their basic chemistry knowledge while developing teaching skills (Pentecost, Langdon, Asirvatham, Robus, & Parson, 2012).

There has been a recent study in Australia emphasising the importance of laboratory demonstrators in supporting learning in the sciences (O'Toole, 2012). It has been recommended that greater support be given to casual demonstrators so that they can better fulfil their teaching role. This paper reports on a discipline-specific induction program for demonstrators in junior chemistry classes.

LOCAL CONDITIONS

Chemistry 1 is a large enrolment subject at the University of Technology, Sydney (UTS) that is undertaken by Civil Engineering students and all first-year Science students, other than Maths majors and Traditional Chinese Medicine students. Survey results for the 2012 Chemistry 1 cohort reveal that 38% of students have not studied Chemistry at senior secondary level (Table 1). The pass rate for Chemistry 1 has languished for many years in the 60 – 75% range, with the Autumn Semester 2011 result being particularly low at 59%.

Table 1: Prior Chemistry experience of students in 65111 Chemistry 1 (n = 794)

Highest level of Chemistry	**%**
Year 10	28
HSC Chemistry	50
HSC Senior Science	4
TAFE	6
Another University	6
None	6

In Chemistry 1 weekly contact hours for a student during semester comprise three 1-hour lectures and one 3-hour laboratory session. There is no scheduled tutorial experience. In laboratory classes, the student:staff ratio is approximately 15:1 and this is the only teaching / learning opportunity in this large enrolment subject (n = 794, 2012 and n= 784, 2013) with such a favourable ratio. For a recent school leaver, it is also the class that most closely corresponds to their recent school experience, certainly when compared to a large lecture group where the student:staff ratio may exceed 400:1.

All laboratory teaching in Chemistry 1 at UTS is currently carried out by Honours (4^{th} year BSc equivalent) and higher degree research (HDR) students, usually from within the School of Chemistry and Forensic Science. Our current arrangement is that the more experienced of the two demonstrators is designated as demonstrator-in-charge. In practice, there is little differentiation in the duties of the two demonstrators but the senior demonstrator would usually give the pre-lab talk and is expected to be a good role model for the less experienced demonstrator.

LABORATORY TEACHING AND LEARNING

The laboratory experience in Chemistry 1 has been fairly traditional with the entire 3-hour session, after a brief introductory talk, spent engaged in practical activities, and associated write-up. It was thought that the laboratory session could be modified so that a better learning opportunity could be delivered, rather than having the students spend nearly all of the session on a practical activity, including preparing a *pro forma* report. A key element in achieving more effective learning was engaging the casual teaching staff, the demonstrators, with the changes that were planned.

Based on observation by academic and technical support staff, there was considerable variation in the teaching approach adopted by the various demonstrators but tending toward a passive model where the demonstrator is present as a 'resource to be consulted' rather than taking an active and engaged teaching role. It is probably that they were modelling their behaviours on those of more experienced demonstrators and demonstrators in their own undergraduate laboratory classes (Azer, 2005). Demonstrator behaviour in the laboratory may be related to unreasonable expectations in terms of student prior knowledge and learning experiences coupled with issues around the transition to adult learner. A variation in approach is not unexpected given that for Chemistry 1 there are in the order of 50 laboratory groups, each led by a demonstrator drawn from a pool of about 30 HDR and Honours students (n = 32 in 2012).

Certainly for the Honours students, and possibly for some of the HDR students, the change from being a student learning in lectures and the laboratory to a laboratory teacher (demonstrator, TA) is a significant transition. As an undergraduate the emphasis was on acquiring professional skills that are both generic and discipline-specific, the transition to a laboratory teaching role is an opportunity to acquire professional skills related to teaching, doing so in a discipline-specific context.

There are concerns about the increasing casualisation of the academic workforce representing a risk to quality. With our current practices, casual academics are responsible for all small group face-to-face teaching but we do not believe this represents a serious risk because as HDR and Honours students, the casual academics have a workspace provided by the Faculty and are in regular contact with the permanent academic staff. Doing some teaching allows the HDR and Honours students an opportunity to earn some money in activities likely to enhance their CVs which is important for their future professional careers. Certainly HDR and Honours students represent a future generation of academics for Australian and overseas universities. It was felt that having the demonstrators take a more active part in the laboratory session would not only lead to better learning opportunities for the students but a higher level of engagement for the demonstrators would give them a more positive experience of laboratory teaching. We believe that making their demonstrating experience more satisfying may encourage them to consider an academic career.

The demonstrator pool is made up of young people in their 20s who have shown over several years that they are successful learners in a higher education context. It is likely that they were also very successful in science studies at school, perhaps motivating them to study further in science. We know that only 50% of the students enrolled in Chemistry 1 have studied Chemistry as an HSC subject (see Table 1). Some students will have partly addressed weaknesses in their background by attendance at a bridging course, but not all. Whilst we assume no prior chemistry knowledge in Chemistry 1, the reality is that we are obliged to move fairly quickly through the fundamentals. The consequence is that there is a substantial proportion of the laboratory class who have little background knowledge and are not confident, or practiced, in the knowledge that they have. Based on observation, they do not feel that they can approach a demonstrator with a question and possibly have considerable difficulty in framing a question relating to the topic at hand.

It is noted that because of the relatively small class numbers the laboratory provides an ideal environment for socialising, as well as learning. Such interaction does increase the feeling of belonging for students and assists in developing an identity as a student. A sample quote from student feedback in answer to the open question *What did you particularly like in this subject?* is: “the interaction between the teachers and the students and the hands-on experiments”. We also know anecdotally that good interaction with a demonstrator, and other students, in the laboratory is a powerful influence on student attitudes to learning and future study plans.

CHANGES IN 2012

In a major change in 2012, the focus of the laboratory sessions changed significantly. Prior to 2012, a pre-lab talk discussing the major concepts, practical skills, safety issues and any algorithms relating to that particular practical exercise would be presented over 10 - 15 minutes. Students would then spend the remainder of the 3-hour session engaged in practical activities, doing calculations relating to their data, answering questions in the laboratory manual and completing the *pro forma* report.

We have not dispensed with the pre-lab talk because we believe it is essential to orient the students to the exercise they are about to undertake. They also complete some pre-lab questions to encourage them to be properly prepared for the laboratory session. We have reduced the time spent on practical activities, associated write-up and clean-up so that at the 2-hour point of the 3-hour session, students are ready to complete some practice questions based on the practical exercise just completed. The intention is to reinforce the learning of concepts just investigated with the guidance and support of the demonstrators. In the final 20 minutes of the session, students complete a short quiz with questions directly related to the practical exercise and the practice questions (see Table 2). It is noted that at the University of Colorado at Boulder the TAs are involved in a 4-hour session of which the first hour is 'recitation', which is a problem-solving period with the TAs leading the students through assigned questions (Pentecost, Langdon, Asirvatham, Robus and Parson, 2012).

As well as the changes specifically discussed in this paper, issues that were addressed in Autumn Semester 2012 included: improvement of alignment of practical experiences and lectures, in that previously there were lecture topics that had no supporting practical work and extensive practical work for topics that were only briefly introduced in lectures; some old pracs were deleted; several new pracs were written that related more strongly to the lecture content; and further pracs that introduced the students to a modern instrumental technique were developed, given that first-year students should be exposed to the techniques of modern chemistry, as far as possible. The practical manual was much improved in terms of presentation and was easier to follow than the previous version. Instructions were clear and explicit. Information about safety issues was specifically included at the relevant places and there was a general section on laboratory skills included.

Table 2: Division of time in a 3-hour laboratory session

Activity	Time (minutes)
Pre-lab talk	15
Practical work and associated activities	105
Practice questions	40
Quiz	20

There are positives and negatives with our new approach. An obvious positive is that we are taking advantage of the small group teaching and learning opportunity to reinforce student learning immediately after completing related practical work. The inclusion of an assessment activity, albeit low-stakes, drew comments that it did not allow time to digest the material, although many students welcomed the opportunity to 'close the loop' within the single session, while others have found the immediate testing of newly acquired knowledge quite challenging. Before 2012 a laboratory quiz on the work of the previous week was one of the first activities of the laboratory session.

One obvious advantage of the current arrangement is that misconceptions will be identified quickly and addressed immediately. We may investigate having students complete an on-line quiz outside the laboratory within a specified time period after their lab session. Our concern is that this arrangement tends to isolate a particular topic within one session that might lead to 'fragmentation' of a student's knowledge and understanding.

2012 INDUCTION SESSION

No practical classes run in the first week of semester so an induction session was booked for the Friday afternoon 2 – 5 pm. The demonstrators were paid at the usual demonstrating rate and the attendance rate was 100% (32/32), though attendance was not a condition of appointment.

A primary intention of the induction session was to explicate principles that were noted by Bond-Robinson and Bernard-Rodriques (2006), such as the need for demonstrators to be active and engaged with the task; to be initiators of interaction with the students; to insist that safety rules were followed; and to be aware of students having difficulties. Issues such as equity in marking; preparation for the lab session; giving useful feedback, that had been identified by Herrington and Nakhleh (2003), were also considered important and we were aware of some problems in these areas. The presentations during the induction session and the work in the breakout session specifically addressed these matters (see Table 3 for full details).

The first activity of the induction session was a talk by the Head of School reinforcing the importance of the demonstrators as our front-line teachers, given that they work with the students over an extended period, over several weeks, and with a good student:staff ratio. The coordinator of Chemistry 1 discussed changes to the prac sessions and also discussed the new practical exercises. Other matters discussed included teaching and assessment in the laboratory. Assessment is an important topic from the student perspective and demonstrators are concerned to be equitable and consistent in marking and feedback. Experienced demonstrators were very concerned about ensuring consistent application of 'the rules' relating to lab classes. These rules relate to matters such as late arrival at class, absence on medical grounds, other absences etc as well as the requirement to wear appropriate personal protective equipment (PPE), safe disposal of waste and standards of behaviour required in the laboratory. It is also very important that demonstrators model correct procedures and always wear appropriate PPE at all times (Bond-Robinson & Bernard-Rodriques, 2006).

There was also a breakout session where small groups of demonstrators discussed their perceptions of the role of the demonstrator. Other issues discussed related to the motivation of students and what expectations demonstrators should have of students. There was some discussion of different demonstrating styles with some consideration of the most appropriate approach for the student cohort and some discussion of the role of demonstrator-in-charge.

Table 3: Program of the induction session

Duration	Topic	Presenter(s)
30 min	The essential role of the demonstrator. Teaching in the laboratory: outcomes can we achieve? Changes made to the Chemistry 1 prac program	Head of School
30 min	How the new labs will work, including new pracs. Teaching and assessment in the labs. Handling absences.	Coordinators of PT Teaching and Chemistry 1
30 min	What do you think the role of the demonstrator is? What expectations do you have of students? How do you motivate students?	Break-out groups with reporting back
30 min	*Break*	
30 min	E, H&S Issues, including emergency procedures and reporting safety incidents.	E, H&S Branch representative
30 min	Role of the lab supervisor. Managing absences. Handling harassment / discrimination in the lab.	Academic Liaison Officer and Coordinator Chemistry 1

INDUCTION SESSION FEEDBACK

Feedback on the induction session was collected by a team of two experienced demonstrators through focus groups: one working as the discussion leader and the other acting as scribe. In order to establish if there was any differentiation based on experience, new demonstrators (8) and experienced demonstrators (14) were surveyed separately. There was little differentiation between the two groups. For example, both groups found the safety information less than optimal and asked for safety information that was specific to the practicals they would be supervising.

Both groups of demonstrators liked the informal atmosphere and that the academic staff members most directly involved were present for the afternoon. The participants appreciated the mix of experienced demonstrators with new demonstrators; there was an opportunity for some peer-to-peer teaching. The explicit information on changes to the practical program was found extremely helpful. The experienced demonstrators felt that the session was "useful for new demonstrators as it incorporated almost everything about demonstrating and answered all the questions that they had when they started." All demonstrators appreciated the session explicitly discussing 'the rules'. Clear statements from the coordinator and Head of School on the application of the laboratory rules clarified issues considerably. They particularly appreciated the explicit outlining of the expectations that the School has of the demonstrators and the support that the demonstrators can expect from the School.

Participants particularly enjoyed the break-out session and reporting back. They requested additional opportunities of this nature with different groups being given different questions in future. There was some repetition of material, particularly about the proposed new structure of the laboratory sessions. The participants felt that there could have been more information and discussion on good teaching and interacting effectively with students. The demonstrators also felt that they needed more information on managing students from different cultural backgrounds and strategies for dealing with difficult students.

The safety information was considered to be of little practical help. The presentation on safety was given by a staff member from the central OH&S unit of UTS and the approach may have been too generic and ‘high-level’. The demonstrators wanted to know about responses to incidents that will occur in their ambit.

END-OF-SEMESTER DEBRIEF

We held a debrief at the end of the semester to capture views of demonstrators on the teaching and learning experience in the laboratory. It was also a chance to introduce corrections into the lab manual, and there were several, not unexpected given many of the practical exercises were new. The feedback on the changes to the laboratory session structure was very positive, though there were some concerns about completing the practical work in a short time-frame, given that some students were very inexperienced and perhaps inherently slow in practical matters. There were suggestions for changes in the arrangements around the practice questions and quiz also. These included changing the level of challenge and volume of work in the ‘tutorial session’ and structuring the quiz quite differently from the practice questions.

This session was very useful and gave full-time staff a chance to hear from the experts, i.e. the demonstrators who had implemented the new practical course in the teaching laboratories. We have acted on this feedback and have explained in the 2013 induction session how we have done so. Working with the demonstrators in this way draws them clearly into the staff dimension, rather than the student dimension, and honours their status as academics-in-training. An experienced demonstrator reported that the debrief was the most valuable activity of the semester from his perspective.

2013 INDUCTION SESSION

The induction session in 2013 was held in the first week of semester. There are no practical classes for Chemistry 1 in the first week of semester and the lab attendance in the second week has traditionally been a registration session and safety briefing. By the first week of semester we had assigned students to the various lab sessions and appointed demonstrators for each of the lab classes. For the 2013 induction we used the opportunity to have the demonstrating teams, i.e. the demonstrator-in-charge and the other demonstrator in a lab session, meet each other. Clearly there are great advantages if both the staff teaching in a common space / time share their views with respect to the task. More time was spent on break-out sessions than in 2012 and experienced demonstrators discussed their experiences, including the positives and negatives. There was a safety session designed to address problems that may arise in the teaching laboratories and give demonstrators clear instruction on calling for assistance and the proper reporting of an incident.

OUTCOMES

There was a remarkable and significant improvement in pass-rate for 65111 Chemistry 1 (84% in Autumn Semester 2012), that cannot be attributed to any one cause but the concerted reform that has been implemented. However a key element has been the changes in the prac experience for both teachers and learners. Demonstrators were acknowledged as key to our teaching & learning in the laboratory and responded by engaging with the task more strongly. They were given encouragement and feedback throughout the semester and responded positively by giving feedback immediately on new pracs and possible improvements in the new lab manual, *inter alia*.

Following Autumn Semester 2012 we collected, for the first time, student feedback on the laboratory experience of Chemistry 1 students, through the university-wide system. It was noted that 12 demonstrators received a rating over 4.5 on a 5-point scale on the question *Overall, I am satisfied with the teaching of this staff member*.

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