Demonstrator development: Preparing for the Learning Lab

A Report For
The Australian Council
of Deans of Science

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"I believe that education is a regulation of the process of coming to share in the social consciousness; and that the adjustment of individual activity on the basis of this social consciousness is the only sure method of social reconstruction."

John Dewey

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Paddy O'Toole

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1 Executive Summary

The Australian Higher Education environment holds significant challenges for universities in general and science faculties in particular. With the establishment of the Higher Education Standards Framework and the removal of caps on student loads, science faculties will face increased pressure to provide excellent teaching and learning opportunities to a diverse range of students. Science faculties will also need to show their effective management of these opportunities and related issues. In addition, Australian science enrolments and retention of science students in universities are a cause for considerable concern. Demand for enabling science subjects (mathematics, chemistry and physics) is relatively declining where higher education undergraduate enrolments are increasing. The majority of students undertaking science subjects require service teaching, and discontinue science after first year (Dobson, 2012; Office of the Chief Scientist, 2012). Also, government-sponsored secondary school curricula, supported by the science education literature, promote inquiry-based learning as the gold standard for science teaching and learning, which will affect the expectations of those future undergraduates who undertake a science degree.

Teaching laboratories are acknowledged as a unique learning environment enabling scientific discovery and inquiry-based learning, but the value of these environments has not been harnessed to full effect. The impact of the challenges posed above justifies investment in the development of demonstrators' competencies, both at the individual and group level, to realise the potential of science teaching laboratories that in turn will help justify their cost.

The Demonstrator Development report provides a snapshot of science faculties in regard to how demonstrators learn to meet the demands of their role. The study reported inquires into the professional development opportunities available to demonstrators in first year teaching labs in Australian universities, and the nature of those opportunities. The overall goals of the study have been to determine the prevalent professional development rationales and strategies involving demonstrators, and to showcase effective practice in selected laboratories.

The study includes a literature review of professional development for demonstrators in Australia, the United Kingdom and the United States of America. A search of publicly available Australian university webpages reviewed the available demonstrator development activities from centralised facilities. A survey was also conducted seeking the responses of first year science coordinators to questions concerning the learning opportunities of demonstrators, and related information.

Innovative development practices were identified from the survey and coordinators were approached for interviews. Emails were also sent to demonstrators in the same units requesting interviews. In total six coordinators and 17 demonstrators were interviewed. In this study, it was found that the majority of demonstrators are drawn

from the ranks of PhD, Masters, Honours and third year students, with PhD students predominating. Notably, where coordinators had selected some demonstrators with professional experience, the demonstrators drawn from the ranks of students benefited from exposure to this experience. The experience in these labs indicates that faculty coordinators should consider a diversity-based strategy to demonstrator recruitment and selection. Leaders of science faculties have claimed the learning of generic skills by enrolled students to be one of the benefits of undergraduate lab work (Rice, Thomas, & O'Toole, 2009). It is logical that hiring demonstrators with proven generic skills will facilitate the learning of such skills by enrolled students, as well as by demonstrators.

The majority of professional learning was conducted by the coordinator's faculty or department. In the great majority of cases, this learning consisted of teaching and learning principles and practice, occupational health and safety protocols and procedures, procedures for submission, marking and return of laboratory reports, and raising awareness about the content and significance of lab manuals.

It is important to note that although many of the demonstrators are students, they form the staff of a workplace, that is, the teaching laboratory. Therefore, their professional learning should be thought of as workplace competency development rather than further learning for a particular student cohort. During the study, examples were found of teaching labs where a learning culture was fostered through team development. In these environments demonstrators' professional learning took place in a climate of engagement, mentoring and feedback. The development of such a culture means that, with leadership from the coordinator and senior team members, demonstrators with less experience are encouraged to form positive habits of mind that welcome new ideas and improved practice. In effect, communities of practice emerged that enable the sharing of knowledge and create some sustainability in terms of retaining expertise in the teaching laboratory. In particular, such a workplace culture facilitates and sustains the realisation of the potential of teaching laboratories to foster inquiry-based learning, develop graduate capabilities, and to identify and address the diversity of student backgrounds and aspirations.

An issue that arose with some frequency was payment and work conditions of the demonstrators. Issues concerning fair payment for time, sessions allocated, and general working conditions affected the attitudes of the demonstrators towards the job of demonstrating. This issue is clearly one that has been raised over a period of time, and some faculties had reviewed their payment structure to ensure that demonstrators were paid to reflect the time spent. Other coordinators saw the matter of pay as an issue that they were powerless to affect. Some of the demonstrators employed externally raised concerns such as the ability to get a key to the lab, a place to store their gear and so on. These frustrations detract from the engagement and willingness to learn that are necessary elements of a learning culture.

Demonstrators are constantly cited as having a critical impact on the teaching and learning experience in the teaching laboratory. How our demonstrators are equipped to cope with the impact of the challenges related above will greatly depend on the effectiveness of the development opportunities that their employers provide. It is urged that Australian universities implement the following recommendations to turn teaching labs into learning labs.

RECOMMENDATIONS

Demonstrator recruitment and selection

+ Groups of demonstrators should encompass a wider range of experience than university science research. Faculties should consider policies for including, where appropriate, experienced science professionals to provide leadership and expertise to the demonstrator group, as well as a link to the more diverse backgrounds and aspirations of students.

Demonstrator competency building

+ An explicit vision for the teaching laboratories should be articulated that provides focus for demonstrator development as well as teaching and learning for students.
+ Demonstrator development should be planned within a framework focused by the vision, which could include:
  - formal professional learning sessions that are linked to lab practice
  - pre-lab briefing sessions
  - formal and/or informal mentoring during the semester
  - promotion of a learning culture where demonstrators share ideas and knowledge, and where new knowledge embedded in the documents and practice of the lab
  - debriefing or "lessons learned" sessions at the end of the semester.
+ Laboratory program coordinators should provide feedback (both positive and developmental) to demonstrators at regular intervals and encourage feedback from demonstrators.
+ Student feedback mechanisms on demonstrator performance should be established

Demonstrator working conditions

+ Science faculties should review the pay arrangements for demonstrators to promote fair payment for effort and time spent in demonstrator-related activities to encourage learning cultures in the laboratories.
+ Science faculties should review working conditions for demonstrators, particularly demonstrators who are not students of the university, to ensure that these demonstrators have the resources to perform their work.

Contents

Table of tables

Table of figures

3 Introduction

For many scientists, the prospect of a science education without laboratory work or other practical sessions is unthinkable (Rice et al., 2009). Laboratory work and field-work are commonly thought to be fundamental to a science education on the grounds that science is empirical in nature, and because they provide a unique learning environment that supports graduate attributes, such as independent learning, group work and communication skills (Elliott, Boin, Irving, Johnson, & Galea, 2010; Rice et al., 2009). The essential nature of laboratory work, however, is coming under challenge on the basis that the great majority of students enrolled in science subjects, particularly first year subjects, will never work in the field or in laboratories. The majority of students undertaking science subjects require service teaching, and discontinue science after first year (Dobson, 2012; Office of the Chief Scientist, 2012), and generic graduate attributes can be acquired more efficiently in other ways. In addition, although the laboratory has been shown to be a unique learning environment, various elements that impact upon the students need to be in place before that potential can be harnessed (Rice et al., 2009). A major element in this unique learning environment is the demonstrators.

The doubling of university enrolments over the last 20 years has brought significant challenges for demonstrators and for the people managing laboratory programs. The removal of caps on student load will further expand the system, and the advent of the Higher Education Standards Framework (HESF), interpreted and promoted through the activities of the Tertiary Education Quality and Standards Agency (TEQSA), will bring greater pressure on universities, not only to meet these challenges, but to show their effective management.

Such challenges are already evident where science departments have been amalgamated into broader faculty conglomerates and laboratory classes reduced as a cost saving measure. A more concerted national challenge may well arise through TEQSA, since it is not limited to reviewing institutions but has the power and the intention to undertake "thematic reviews". Although labs and fieldwork may not feature prominently in TEQSA's activities during its formative years, debates around such issues as the provision of costly laboratory instruction and its role in a science education can be expected to result in future thematic reviews.

Leaders of science faculties that offer laboratory programs need to be able to articulate the role and value of the science education experiences enjoyed by the wide variety of students who pass through the doors of science teaching laboratories. Further, their demonstrator workforce must manifestly be able to deliver on the promises of their science faculty leaders. There is evidence that some faculties and departments are not so well prepared in this regard (Rice et al., 2009).

On the other hand, there is an increasing effort being made to:

+ articulate the laboratory demonstrating skills, the pedagogical skills, the ability to relate to student diversity, as well as necessary discipline knowledge; and
+ identify and provide the learning activities necessary to ensure that demonstrators can develop these knowledge and skills.

This report outlines the findings of a study designed to elicit the thinking of science faculties and departments about the role, practice and need for demonstrator competency development. The report is intended to provide a starting point to locating where Australia's university science faculties are at on this issue, and allow some visibility of the variety of ideas being advanced and efforts being made. It focuses on two broad aspects; firstly, how science faculties currently encourage and promote the learning that individual demonstrators need in order to fulfil their role effectively, and secondly how can demonstrator development be managed to strengthen the structures and processes that underpin collective learning.

The specific questions that guided the planning of the study were:

+ What underlying purposes shape competency development of these demonstrators?
+ What learning opportunities are available to first year science laboratory demonstrators in universities? How do demonstrators perceive the competency development they experience?
+ How is excellent practice manifested in terms of the competency development of demonstrators?

These questions guided the literature review, survey, a series of interviews and a web search. The empirical part of the research focused on first year science teaching laboratories. More information on the research method can be found in the appendices.

In addition to the recommendations formulated from the findings, this study raises questions concerning the assumptions underpinning demonstrator competency development. These assumptions involve the understanding of the character of demonstrators, the nature of demonstrator engagement and whether the demonstrator competency development budget is perceived as a cost or an investment. These assumptions will affect the decisions made by science faculties when planning demonstrator competency development, and are further explored in the literature review, findings and conclusion.

learning laboratory/ies
professional learning
undergraduate science education
higher education
collective learning
inquiry
laboratories
engagement
professional learning
undergraduates
engagement
demonstrators
science
continuous improvement
undergraduates
science teaching and learning
team culture
demonstator
professional workforce
engagement
feedback
graduate teaching assistants
undergraduate science education
selection
graduate teaching assistants
inquiry
selection
team culture
science teaching and learning
laboratory
higher education
feedback
graduate teaching assistants
team culture
inquiry learning
continuous improvement
higher education
selection

4 A review of the literature

4.1 Introduction

This section shows a review of the available literature concerning science laboratory demonstrators, their contribution to science learning and teaching and issues and challenges concerning their competency development. Although demonstrators are recognized as a key element of laboratory teaching, the available literature is comparatively sparse. This review draws on predominantly journal articles written in the USA, with other literature drawn less frequently from the UK, Canada and Australia. The predominance of literature from the USA seems to be due to the prevalence of postgraduate students involved in undergraduate teaching compared to other countries (Alpay & Mendes-Tatsis, 2000). Literature from other disciplines has been included to introduce future directions for demonstrator competency development, namely demonstrator engagement and a collective learning culture in the labs.

The literature review has three sections. The first and most lengthy section deals with current knowledge on demonstrator competency development, including recommendations from the literature. The second section is based on the underpinning assumption that demonstrators form a workforce, and that issues related to various workforces will also apply to demonstrators. The third section involves the future challenges of the Higher Education Standards Framework in Australia.

4.2 Current knowledge of demonstrator competency development

Demonstrators are mostly part of the casual teaching assistants who contribute to teaching and learning in Australian universities, but, with the exception of specific issues shown in section 4.3, this review has focused on the concerns of science laboratory demonstrators. The nature of science disciplines, the physical nature of science experiments, issues of Occupational Health and Safety and other factors make science demonstrating a specialist field, and it was deemed to serve no useful purpose to introduce literature on issues generally related to casual teaching staff in the classroom.

This section explores:

+ the role of the demonstrator;
+ who are the demonstrators?
+ the importance of demonstrator development;
+ approaches to demonstrator competence development;
+ the enquiry-based learning lab;
+ challenges of demonstrator development; and
+ recommendations from the literature;

Some clarification in terminology is needed due to the international sources. In Australia the position is referred to as a "demonstrator", whereas in the U.S. the phrase "teaching assistants" (TAs), sometimes also referred to as "graduate teaching assistants" (GTA) is employed as a more generic term, which can cover a range of activities including tutoring, lab demonstrations and marking assignments. Future references to TAs or GTAs will assume that the people involved carry out roles of lab demonstrators, and sometimes also as tutors and assessors.

4.2.1 The role of the demonstrator

Demonstrators are influential because of their pronounced impact on the teaching of undergraduate students. In a study of 158 tertiary institutions in the USA, it was found that "91% of the biology laboratory instruction at research universities and 71% at comprehensive universities was provided by GTAs" (Baumgartner, 2007, p. 17). Luft, Kurdziel, Roehrig and Turner (2004, p. 229) stated that "GTAs have an essential role in universities and colleges". Rushin et al. (1997, p. 86) agreed that:

… graduate teaching assistants (GTAs) are used extensively in lower division laboratories...and...in many cases the GTAs have more direct contact with undergraduate students than do professors.

Over 20 years ago, Wood (1990, p. 11) argued that demonstrators should have the following competencies.

Demonstrators should know about the experiments that they are demonstrating, they should be prepared, understand how to use the instruments, and know how to do the necessary calculations. They should enforce safety rules and good laboratory behaviour. They should know what students are supposed to learn and why they have to learn these things.

Apart from this somewhat simplistic description, Wood also includes an interpersonal dimension:

Most of all they should circulate among the students, ask questions on a friendly basis, and they should start this behaviour from the very first laboratory class.

In a long-range study in New South Wales, however, Panizzon and Pegg (1999) identified three major elements in the job of demonstrator, which were:

+ Academic, involving helping the students to learn the experiments, how these experiments link to concepts; helping the students learn relevant technical skills and how to think scientifically.
+ Personal, involving encouraging teamwork, participation; motivating the students through their enthusiasm and interest, showing compassion and fairness for students, and acting as mentors for the students.
+ Professional, involving identifying at-risk students, providing support to the lecturer, and supporting other demonstrators.

Panizzon and Pegg's position on the role of the demonstrator obviously differs from the perspective of Wood. The role described by Wood denotes the demonstrator as mainly having a support function, providing a lecturer with more hands with which to deal with students. Panizzon and Pegg's position on the role of the demonstrator involve the demonstrator playing a leading role in facilitating learning and supporting the student, of being a significant component in the organisational system of the teaching lab. It is argued that the difference in the roles encompasses the differences in what and how the students learn in the lab. Wood's description of the effective demonstrator would be satisfactory in the recipe lab where surface learning is deemed a sufficient return on the resources expended on the teaching and learning effort. Rich, inquiry-based learning that fosters "deep learning", however, requires demonstrators who engage with the roles outlined by Panizzon and Pegg.

Demonstrators provide face-to-face instruction for undergraduate students, particularly in their most common form of employment, namely first year practicals (labs) (Scott & Maw, 2009). They help students link concepts back to lectures (Dotger, 2010) and can 'set the tone' for the type of learning that goes on in the laboratory. GTAs will be influential in creating labs with a more inquiry-based approach, so their development in this area is of paramount importance (Roehrig, Luft, Kurdziel, & Turner, 2003).

O'Neal, Wright, Cook, Perorazio, & Purkiss (2007) conducted a study on the impact of demonstrators on student retention in the sciences, and showed that demonstrators have many influences on student retention. Although students did not cite demonstrators themselves as a major influence on retention/attrition, many factors under the control of demonstrators were listed as having a significant influence on students' course decisions, such as "lab climate... course grades, and learning about careers". Their recommendations from this were to target demonstrator training in "retention", fostering a "positive lab climate" and "modeling possible science careers' to students, as well as better communication with students regarding their progress in the subject and 'explicit grading standards" (O'Neal et al., 2007, pp. 28-29). Dotger (2010, p. 71) also supported the importance of demonstrators in student retention:

Historically, students who choose to leave science and engineering report that one reason for doing so is the quality of instruction that they received in their courses…Therefore, to improve the quality of instruction in undergraduate science courses, the GTA must be recognized as a key stakeholder.

This highlights the importance of developing demonstrators appropriately.

4.2.2 Who are the demonstrators?

Postgraduate demonstrators/TAs are widely used. They are highly available, as many are participating in their own further study with the department: "Almost all (97%) of the biology graduate schools surveyed utilize graduate teaching assistants in laboratories and/or lectures" (Rushin et al, 1997, p. 87). According to some authors, TAs are also in a position to relate better with undergraduate students than are other faculty, often because they are close to them in age and have only recently completed their undergraduate studies. In addition, they are often still students themselves, so have an affinity with the students they teach and can seem more approachable than professors (Lawrenz, Heller, Keith, & Heller, 1992; Wood, 1990) Disadvantages to using postgraduate TAs include a frequent lack of knowledge for making the learning experience relevant for students, and a tendency to use a "lecture approach" as this was their own experience of being taught at tertiary level (Lawrenz et al., 1992, p. 106). The impact of a TA's own educational experience on his/her teaching methods will be discussed in more depth later on. In this study, it is shown that in Australian universities, the majority of demonstrators are drawn from the ranks of honours, masters, and PhD students.

The importance of developing demonstrators

The development of demonstrators is of vital importance to university students and to the discipline itself. Firstly, trained demonstrators are more effective than untrained ones (Lawrenz et al., 1992). Wood (1990, p. 11) concurred, saying "[Demonstators] constitute an extremely valuable resource, but they need to be trained and monitored." Secondly, many demonstrators are future university faculty, so an investment in TA training has repercussions into the future of the discipline. Baumgartner (2007, p. 17) called GTAs "professors-in-training", and emphasizes the need for teaching strategies to be a focus of GTA training. This has been seen to be lacking: as Rushin et al. (1997, p. 86) stated "If the professional preparation of doctors was as minimal as that of college teachers, the United States would have more funeral directors than lawyers". Of course, these statements are underpinned by the assumption that demonstrators are, in fact, students who will pursue academic careers, which may not be the case.

Thirdly, demonstrator development is important because there seems to be a reliance on assumed knowledge rather than specifically taught knowledge for demonstrators. It is clear that areas such as lab safety, use of equipment and procedures are a necessary part of any demonstrator development, but there is a strong focus in recent literature about incorporating teaching techniques as an integral part of demonstrator training. Dotger (2010) commented that few demonstrators have teacher training, and it is assumed by faculty that knowledge of content is the only vital knowledge required

to do the job of a GTA. Luft et al. (2004, p. 212) pointed out that most demonstrators have an undergraduate degree and "are expected to be an expert in the discipline and in teaching … GTAs have an essential role in universities...but without proper instructional support they may not achieve their potential" (p. 229). Baumgartner (2007, p. 17) argued that GTAs should:

… be provided effective professional development on teaching strategies in addition to their training on...weekly lab meetings that only cover the logistics of conducting labs, without targeting the strategies needed to help students think critically about the concepts that the lab work is meant to convey.

Fourthly, there is a strong call for change in the way labs are conducted, moving towards an "inquiry-based' approach" (Elliott et al., 2010; Roehrig et al., 2003). Roehrig et al. pointed out that since most lab instructors are GTAs, the GTA training is going to allow this change in focus to happen. This argument is supported by the work of Kirkup, Pizzica, Waite and Srinivasan, (2008), who found that the introduction of inquiry learning in the lab would require a change in the professional development of demonstrators.

These arguments add weight to the argument of Rushin et al. (1997, p. 86), who noted that "It is really hard to be interested in undergraduate teaching and not be interested in training teaching assistants [demonstrators] since they play such an important role".

4.2.3 Approaches to demonstrator competency development

The way that demonstrator development has been approached varies widely among universities. The various approaches, synthesised from the work of Rushin et al. (1997) and McComas and Cox-Peterson (1999) can represented as follows:

Table 1: Typical approaches to demonstrator development (Adapted from Rushin et al. (1997) and McComas and Cox-Peterson (1999))

Laissez-faire approach	No formal training offered. Demonstrators rely on their own experience.
Generic workshops for new teaching assistants	Provision of an introductory workshop, often involving other sessional staff that does not address the needs of a discipline area
Discipline-specific workshops	Provision of series of workshops within an individual department.
Staff member-specific mentoring	Based on an apprenticeship model with demonstrators working closely with an individual academic staff member in the department
Partnerships with discipline-specific educators for support and mentoring	Establishment of formal partnerships between demonstrators and science education graduate students with experience of science methods.
A formal mandatory teaching course	Demonstrators are required to undertake formal development before working in a teaching lab.

It should be noted, unlike McComas and Cox-Peterson's original work, that Table 1 shown above does not indicate a particular order of effectiveness. It is argued that the merit and value of a development approach is largely dependent on the quality of the design and provision of the learning. Thus, with the exception of the laissez-faire approach, each approach will have strengths and weakness depending on implementation. Another important issue with the approach to demonstrator competence development is the context. Where the numbers of demonstrators are small, an emphasis on mentoring may be preferred to a more expensive mandatory teaching course. It will be argued, later in this report, that where numerous demonstrators are employed, more than one approach is necessary to optimise demonstrator development.

A more recent perspective is given by Scott and Maw (2009, p. 2), who commented on the "proliferation of training programs to the extent that most GTAs in the USA are expected to undertake training, although the nature of that provision is still variable". Their own study, however, focussed mostly on the UK, where they concluded that all except one of the higher education institutions surveyed provided training for GTAs and most expected it of the GTAs: "This reflects changing policy over recent years when previously training was often recommended but not required" (p. 8).

Training in the UK institutions, like their US counterparts, was sometimes a blend of university-wide training and specific department training. Interestingly, 82% of departments reported providing specific training in demonstrating, which was higher than the figure for any other aspect of training, for example, general teaching, lab techniques, marking or small group managing. This seems to imply a high value placed on demonstrating as a skill, alongside the more recent acknowledgement of the importance of teaching skills. Teaching, however, was still important, as "all bar one of the departments provided training in teaching for the GTAs and for 74% of the departments training was compulsory before the GTAs were allowed to teach'. The UK institutions they studied, therefore, seemed to show the interesting trend, as did some of their US counterparts, of emphasizing the teaching aspect of GTA development. This focus on teaching was also emphasized by the abundance of teaching and learning centres in many US college campuses (Rushin et al.,1997), although the authors make the point that these centres vary "from a faculty committee that occasionally arranges special seminars or presentations dealing with pedagogy to an actual paid staff with a director, support personnel, and teaching resource materials" (p. 87).

Case studies on demonstrator competency development programs

There have been several studies carried out on the nature of specific GTA training that occurs in universities. Unfortunately most of these were based in the USA, making it difficult to extrapolate the findings to apply to a wider field. They show different emphases between laboratory specific skills and generic teaching skills.

Rushin et al. (1997) described two "best practice" scenarios: one from Florida State University at Tallahassee and the other from the University of Missouri. The training at Florida State University was in the form of a week-long workshop (a requirement for all graduate students) and a weekly meeting (presumably during the semester which dealt with the next laboratory. Skills and techniques covered in the week long workshop included a strong teaching focus, that is:

+ methods of instruction;
+ learning styles;
+ preparation;
+ challenges by students;
+ time and stress management;
+ ethics;
+ evaluation; and
+ recorded lessons with feedback provided.

The weekly meetings dealt with topics specific to the laboratory, that is:

+ planning introductory comments for a lab; and
+ negotiating with others, that is, moderation of grades (p. 88).

This type of training was both intensive and ongoing, and allowed for a range of laboratory specific issues and general teaching issues to be covered.

The University of Missouri was the second best practice scenario covered by Rushin et al (1997, p. 89). This, again, was a combination of laboratory specific and teaching skills, with an emphasis on 'laboratory teaching behaviours'. In one three hour workshop, GTAs covered:

+ a brief review of the research literature of science education;
+ practical tips on enhancing student learning in the laboratory; and
+ video and discussion of misconceptions on student learning in science (Rushin et al., 1997, p. 89)

Like the previous example, this one-off workshop was complemented by follow up sessions and weekly staff meetings to deal with test writing and other aspects. It is noteworthy that students evaluated the effectiveness of the GTAs who had undergone the training at 87%, compared to 71% before the training. Both GTAs and students were more satisfied with their experiences after the training (Rushin et al., 1997).

The Lawrenz et al. (1992) study did not specify the university but also examined a substantial GTA training program - a subject of 30 hours in length which combined both demonstrator specific skills and teaching skills. Topics covered included:

+ course philosophy and content (in this case, physics);
+ nature of students;
+ problem solving;
+ novice versus expert solutions;
+ comparison of grades to make sure papers are marked fairly;
+ student concepts and misconceptions;
+ thorough knowledge of the lab exercises, including completing the labs themselves;
+ lesson planning (interestingly, this incorporated teaching techniques such as "good lesson structure", "cooperative learning" and "questioning techniques" (p. 108); and
+ watching tapes of old laboratory sessions and having a chance to critique them.

In addition, the instructor "emphasized pedagogical principles" when aiding the students in refining their lesson planning. Once they began teaching, the GTAs met with their instructor for 2 hours per week and were also visited to be observed and feedback given. Their students were even interviewed by the evaluator to provide more comprehensive levels of feedback. This is going even further than the previous examples in terms of the attention given to GTAs once they embark on their teaching experience.

The third case study on best practice demonstrator development in the USA came from Roehrig et al. (2003) in their study on an unnamed research-based university (p. 1206) in the area of chemistry. They begin by pointing out that 37% of universities provided no formal GTA learning activities, and of those that did, only 17% spent more than one day on such activities (p. 1206). Their focus institution combined lab specific and teaching skills, similarly to the example above. After a 2 day generic training course the GTAs were given a 4 day department specific course where the following aspects were covered:

+ introduction to department and lab facilities, responsibilities and expectations;
+ lab safety;
+ equipment checkout procedures;
+ what to expect from undergrad students;
+ responsibilities as instructors; transitioning from student to teacher; and
+ rehearsing prelab lectures, grading lab reports (ibid).

Lab specific skills were further honed by weekly meetings that dealt with "logistics and content of laboratory to be taught the following week" (p. 1207).

Teaching skills were emphasized in the college teaching seminar (once per week) which covered the above topics and included peer observation and feedback. A new method for this approach was the inclusion of practice laboratories, where GTAs were measured on their competence in the laboratory and their ability to explain concepts coherently. From this, it was decided whether GTAs were more suited to work with science majors or non-science majors.

Alpay and Mendes-Tatsis (2000) reported on a experiential-based program called the Postgraduate Certificate of Demonstration offered in the Department of Chemical Engineering , Imperial College. This program required four terms of participation by demonstrators over two academic years. The program consisted of working with students, and the opportunity to discuss and reflect on issues and scenarios encountered during the student contact at twelve workshops conducted over the two year period. In total, the demonstrators experienced approximately 100 hours of student contact time, which also included peer observation of other demonstrators. The demonstrators were issued with a log book in which they were expected to reflect on teaching and learning. Reading on teaching and learning was also encouraged. The workshops attracted other academic staff, who shared their own experiences with the demonstrators. Issues could then be re-visited in future sessions with students. Demonstrators were assessed through participation and a review of the logbooks by the coordinators.

Efforts have also been made in Australia to improve demonstrator development through the development of workshops, development of C-Ds and weekly meetings (Mocerino, n.d.; Mocerino, Yeo, & Zadnik, 2009; Williamson, n.d.). Two of these initiatives were published through the Coordinators Leading Advancement of Sessional Staff initiative, funded by the former Australian Learning and Teaching Council.

Other insights on 'best practice' development

Dotger (2010) points out other aspects of GTA development that may seem to some to go beyond a formal program, but are nevertheless significant in the development of a demonstrator: effective, ongoing communication between faculty and GTAs, peer discussion amongst GTAs, learning through trial and error and a forum where GTAs can reflect on their practice. In addition, she highlights the importance of philosophy in the education process moving away from being "transmissionist" : "a shift toward more student-centred teaching must occur with both faculty and GTAs who work with them" (p. 75).

Scott and Maw's (2009) study on UK universities showed that both teaching AND demonstrating skills were viewed as significant for GTA development: "All post 92 unis gave general teaching training to GTAs, but only 60% of pre 92 unis. BUT all pre 92 unis gave specific training in demonstrating, compared with 2 out of 7 of post 93 HEIs." It seems that GTAs who just demonstrated in laboratory sessions had minimal training, as it was all covered inside the department and did not include "specific training in laboratory techniques" - instead the GTAs were encouraged to visit the laboratory in advance if they needed help.

Despite their observations about the growing levels of GTA learning activities in the UK and elsewhere, there are obviously gaps, as is evidenced by the following comment by a participant in the study (Scott & Maw, 2009):

The training given in our institution is very minimal and by no means equips students for demonstrating duties. The majority of skills have to be learnt 'on the job' making a students' first demonstrating very daunting. (p.6)

The authors summarise:

The mixed views of staff regarding the quality of the training suggest a significant range from comprehensive programmes to those that are considered sketchy and informal, showing that this remains little changed over recent years. (p.8)

4.2.4 The inquiry-based teaching lab

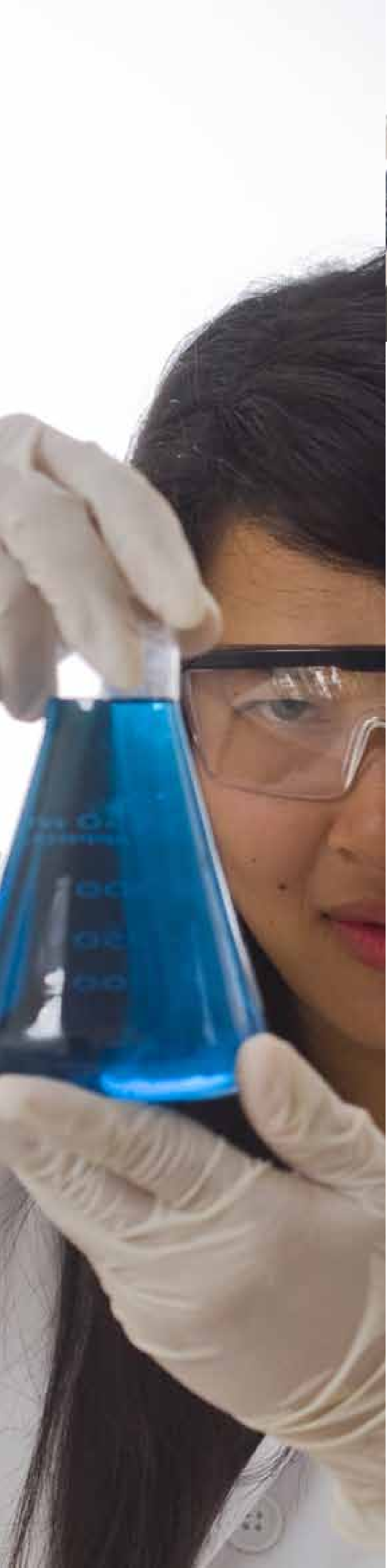
Significant observations arising from the literature include the necessity of a new approach to teaching laboratories in general - an "inquiry-based" approach. The "cookbook" type of laboratory procedure (Baumgartner, 2007, p. 16) is being slowly superseded by the pedagogical understanding that 'laboratory experimentation and discovery stimulate the learning process' (Howard & Boone, 1997, p. 383). This shift in emphasis will automatically affect the nature of any demonstrator development.

Many authors have advocated for a more inquiry-based approach to laboratories. Polacek and Keeling (2005) outlined two approaches to promote inquiry in a laboratory course: written student questions before and after laboratories, and student-designed experimentation (also advocated by Shah, Riffat, & Reid, 2007). Lawrenz et al. (1992) pointed out that TA input into lab design made the laboratories more "productive", but also observed that many TAs "were unsure of the value of the problem-solving strategy and cooperative group learning" (p. 108). The authors' conclusion was that "more focused TA training in the problem-solving strategy and how to effectively conduct the cooperative group, inquiry-based laboratory sessions was needed" (p. 109). When this was done the TAs were measurably more effective. Dotger (2010, p. 72) also focused on the nature of laboratories and the importance of a more 'constructivist' approach, rather than the transmissionist one that was observed. She suggested that the context of the laboratory could differ:

Laboratories would provide greater opportunity for student input, rather than be focused on following a predetermined set of steps and answering a predetermined set of questions at the end of the experience.

In her study, the GTAs gave eight suggestions to the faculty about laboratories (pp. 73-5), which are paraphrased as follows:

+ Define the purpose of the laboratory...and communicate this information to the TAs;
+ Organize the laboratory to align more closely with the lecture;
+ Work with the GTAs to create policies for managing the classroom and support them as they enact these policies (eg attendance and homework);



+ Consider the previous knowledge undergraduates need to complete the exercises successfully;
+ Be clear about what 'help' GTAs may provide to students;
+ Clarify the priority of GTA's assistantship duties compared with their other responsibilities (i.e. balancing their research commitments with teaching);
+ Work with GTAs to evaluate and update lab activities; and
+ Drop in on labs to see how the GTAs and students are doing.

Luft et al. (2004) commented that in their study, many teaching techniques were missing in laboratories:

Notably absent was the use of cooperative learning, dialogue among students about results and conclusions, opportunities to process the laboratory experience in a small or large group, student presentations to the class, assessment of students' prior knowledge, and alternative assessment (p. 226)

The emphasis on faculty responsibility for GTA development and support is backed up by Wood (1990, p. 11), "the course coordinator is responsible to see demonstrators are prepared".

Roehrig et al. (2003) advocated for more inquiry-based learning, but point out the difficulties that this can entail - sometimes resistance from the GTAs themselves. Their study focused on attitudes to inquiry-based learning and proposed GTA training that would be effective. They found that the GTAs had three main obstacles to an inquiry-based approach. Firstly, the GTAs had had bad experiences with inquiry-based learning themselves as students, and so based their own instructional methods on what they had found enjoyable or successful in their own learning. Because of this their prelab lecture was focused on methods rather than "the dynamics of the process and how to work as a group" (p. 1208). They did not believe students were capable of inquiry-based learning by themselves. Secondly, the GTAs did not have instructional skills needed in an inquiry-based environment. They were more likely to help students by correcting technique, giving them the answer or doing the experiment themselves, than they were to question them strategically. Thirdly, the GTAs believed students were unmotivated and learned 'passively', leading them to the helping techniques described above. This attitude was reflected in faculty, perhaps explaining the transmissionist approach found in the laboratories. The conclusions of the authors about GTA training were:

The majority of GTAs have a desire to learn more about "how to teach" and "how to assess" for their specific teaching assignment. GTA training programs need to be structured to meet these immediate needs for new instructors; however, there is clearly a need to go beyond the mechanics of teaching and individual course content if inquiry-based instruction is the desired outcome.

Schussler et al. (2008) come to some similar conclusions about the necessity of an inquiry-based approach:

Currently, students spend most of their time verifying pre-determined results and have little time or motivation to think about the science principles being applied...Labs can be discovery/problem-solving focused instead of expository.

The response of a GTA who had begun to redesign a lab to an inquiry-based approach, however, was somewhat ambivalent:

My partner and I attempted to modify an introductory biology lab from an expository course to a lab that was more guided-inquiry-based. We outlined several goals for the course, but reaching these goals by altering how concepts were presented and how lab activities were carried out was harder than we thought! Thanks to this exercise, I have a better understanding of why faculty members are hesitant to change 'cookbook' labs and I have a greater appreciation for the creation of labs in general (p. 35).

A similar response was found in a study carried out at the University of Western Australia on problem-based learning, which differed from the traditional method of teaching in a first year biology practical setting (Teakle, 2009). It was found that:

The demonstrators' perceptions of the PBL format were varied. Some found this teaching method successful and beneficial for students. Others were uncomfortable with their role change from 'teacher' to 'facilitator' and did not see the benefits from using PBL

Adams (1998) advocated for a balance between inquiry-based approaches and the traditional "cookbook" format. On the other hand, a more positive response for inquiry-based learning in laboratories, however, is found in Baumgartner (2007, p. 16) who found that students who learned through inquiry were more positive about science, although their content knowledge was not significantly different to peers who learned through traditional methods.

Whether or not inquiry learning is currently embraced in university teaching labs, demonstrator development remains a challenging issue, as shown in the next section.

4.2.5 What challenges are associated with demonstrator development?

A recurring theme in literature is the lack of, or inappropriateness of, training for demonstrators/GTAs. Shannon, Twale and Moore (1998, p. 441) outline some of these problems:

Lack of training or ineffective training is often the case due to an incongruence among the following factors: When training should occur, who should conduct it, how long it should be, what it should include, whether native and international TAs should receive identical training, and how training should be evaluated.

The challenges in developing an effective and relevant development program for laboratory demonstrators, according to the literature, appear to be:

+ Poor length, depth and follow-up from development;
+ Training is not specific enough;
+ Does not deal enough with inquiry-based approaches;
+ Not enough focus on teaching skills;
+ Demonstrators have limited access to workshops and money for training; and
+ Fighting a ‘research’ culture as opposed to a ‘teaching’ culture.

These issues are discussed further below.

Poor length, depth and follow-up from training

It is clear from the literature reviewed so far that there is a wide disparity in the quality of competency development for demonstrators. The best practice scenarios mentioned in previous sections show depth and in some cases, follow up mechanisms during the demonstrator’s semester of laboratory demonstration work. Nevertheless, this is not the case in all places, leading to the claims above. McComas and Cox-Peterson’s (1999) study showed that demonstrator competency development can range from comprehensive to minimal. Comments such as:

The training given in our institution is very minimal and by no means equips students for demonstrating duties (Luft et al., 2004, p. 219)

and

Even when there is some formal structure in the GTA training program such as workshops, seminars and courses, these experiences are often brief and follow-up activities are loosely defined or non-existent (Rushin et al., 1997, p. 90)

show that there was improvement needed in demonstrator development in some institutions.

Training is not specific enough

Lack of training specificity is highlighted by Dotger (2010, p. 71), who states:

Rarely do they [induction programs] address specific needs of the GTAs associated with the specific content they will be responsible for teaching...Thus, the guidance provided to GTAs by faculty when GTAs are learning to teach a laboratory...is key.

Luft et al. (2004) agreed with the need for faculty guidance, although highlighting a different area of specificity, stating that training programs tend to be generic to science rather than subject specific. They also point out the lack of research in how GTAs learn to teach: 'little research exists regarding how science GTAs learn to teach' (p. 230).

Not enough emphasis on inquiry-based approach

If an inquiry-based approach to the teaching of science is to be adopted in undergraduate laboratories, then it follows that laboratory demonstrators need to be trained in teaching using an inquiry-based approach. Baumgartner (2007) used her course as an example of one which has made GTAs better teachers. She pointed out that the "step-by-step cookbook laboratories" do not prepare students as well for the "real-world problem solving strategies valued by professional scientists" (p. 16), implying support for a more inquiry-based approach to training. Luft et al. (2004, p. 226) agreed, claiming that most laboratories are run in an old-fashioned way "with little or no emphasis on the nature of science or scientific thinking". In their study they found that laboratory instruction was mostly directive. Activities carried out by demonstrators were things such as "asking for results, telling students about the meaning of the data, and correcting procedures" (p. 225). A comment about using an inquiry-based approach was "GTAs often felt that though these experiences were frustrating for students, they did have the potential to be beneficial" (p. 224). They argue that one of the issues in introducing a consistent inquiry-based approach is poor faculty knowledge of inquiry-based learning methods:

GTAs need guidance in creating these new environments, such as using inquiry strategies, but they often have limited access to faculty and staff who can provide appropriate educational support (p. 213)

This is supported by Roehrig et al. (2003, p. 1209), who claimed that a "problematic area" in GTA training is "prelaboratory activities for inquiry-based laboratories". They point out that a possible cause of this is the lack of role modeling for GTAs, as more experienced GTAs have often moved on and are unavailable for advice.

Not enough focus on teaching skills

It has already been pointed out that aspect of laboratory training can include both technical skills and pedagogical skills. One of the criticisms of demonstrator training is that it does not include enough of the latter. The need for good teaching and facilitation skills, however, is an important aspect of demonstrator work. Phillips et al. (2007, p. 23) noted that:

… as lab mentors we have found that supervising the science is only half the job. The other half is facilitating interactions among students working together in teams

Luft et al. (2004, p. 213) agreed, saying most training programs offer limited opportunities for in-depth development of pedagogical skills, few offering sustained follow-up on classroom instruction, and little assessment being conducted with regard to improved teacher practices.

This is also supported by Roehrig et al. (2003, p. 1209), who pointed out that

It would be beneficial for GTA training to go over the content of the laboratory and also how to teach the content. In other words, GTA training must focus not only on what to teach but also on how to teach it... GTAs need explicit training on teaching strategies to meet the intended instructional goals.

McComas and Cox-Peterson (1999) argued that TA professional development rarely includes teaching skills. Jensen, Farrand, Redman, Varcoe and Coleman (2005, p. 20) agreed, stating that "what to teach is often emphasized over how to teach" in the training TAs for leading discussion groups. Druger (1997) also highlighted the necessity for pedagogical training for TAs. He comments "...college faculty earn a doctorate in science content and have limited teaching experience". His solution is to target TAs for pedagogical training, to induct them as future college professors.

Limited access to and frustration involving workshops and training

If demonstrators are lacking in quality training, what is the reason? Luft et al. (2004, pp. 229-30) argue that it is not the unwillingness of the GTAs and laboratory coordinators, but their lack of resources:

On the other hand, the limited support for professional development of GTAs and laboratory coordinators has not been discussed in the literature... GTAs and laboratory coordinators at this university wanted support and assistance in their instruction but were constrained by their additional responsibilities, the limited financial resources to gain additional information, and the absence of appropriate and related on-campus workshops. (pp. 229 – 230)

In addition, some GTAs were frustrated with training they received. Generic training from the university was found in one study to be "too generalized and diffuse to be useful in their instruction", although the department specific training was too "abstract" or people talked too much and "could be improved with the inclusion of information about effective laboratory instruction..." (Luft et al., 2004, pp. 219-220).

Fighting a 'research' culture as opposed to a 'teaching' culture

The university emphasis on research over teaching is reflected in the inadequacies of GTA training. This is demonstrated in absence of faculty during laboratories, the turnover of GTAs and the attitude to teaching and research activities. Faculty may attend laboratories on an infrequent basis, or stay for only a little time. This results in a limited presence of faculty in the laboratories, leading to less input for demonstrators (Luft et al., 2004).

Faculty may talk about the importance of teaching, but during the department reviews the focus is on research and funding (p. 222).

Experienced GTAs move on to other roles, leaving a gap in experienced role models for less experienced GTAs to benefit from (Baumgartner, 2007). Many demonstrators themselves who are GTAs do not view their teaching role as significant to their ultimate career. They themselves are under pressure to balance their own research and teaching commitments, and research is viewed more favourably than teaching (Luft et al., 2004). As Luft et al. (2004, p. 214) put it:

GTAs perceive their work as important but feel that their interest in teaching does not contribute to their overall professional development as scientists.

The problems with demonstrator competency development shown in the literature thus range from simply poor design to structural and cultural issues at the university level. The literature, however, also provides solutions to resolve at least some of these issues.

4.2.6 Recommendations for improving demonstrator competency development from the literature

Despite the perceived improvements have been made over the years in the form of journal publications, seminars, funding initiatives and targeted communities (Luft et al., 2004, p. 229), a strong focus in the literature indicates that there are still areas of demonstrator development which deserve attention and resources. These areas relate to improving standards by teaching reflective pedagogy, particularly utilizing a social or mentoring approach. In addition, the importance of peer support, reflective learning, a student-centred approach, drawing on current science teaching literature, valuing teaching in institutions, access to training and utilizing experience are also advocated.

An informal and social approach...

Jensen et al. (2005) suggest an informal training approach, that "GTAs should learn about teaching through discussion with other GTAs and the course supervisors" (p. 24). Herron (2009), after a study aimed at designing "a biology laboratory program based on constructivist learning theory" (p. 8) also advocated for more 'interpersonal skill development' in the training of educators. The laboratory, after all, is a social space, and GTAs will utilize social skills within their demonstrator work - to "focus, question and challenge students" (Roehrig et al., 2003, p. 1210). Luft et al. (2004, p. 221) also state that training should "be created in a manner conducive to development of effective instructional practices", which include communication, leadership, conflict management and other skills in addition to lab experiments (Phillips et al., 2007).

Another offshoot of a social approach is the recognition that language skills play an important part in a demonstrator's role. Druger (1997, p. 424) raises the issue of non-English speaking TAs, giving an example of Syracuse University Biology department where "spoken English proficiency" is an important prerequisite for TAs before they work in the classroom.

Peer support and reflective learning...

Peer support is an important factor in the training of demonstrators, particularly in encouraging ongoing reflection and practice. Luft et al. (2004, p. 228) found that to improve, GTAs talked with each other: "Overwhelmingly, GTAs found their greatest support in each other. As often as possible they shared what worked and did not work when instructing certain laboratories" and "GTAs agreed readily that monthly meetings with other science GTAs would be useful in learning the tricks of the trade." It is significant that this shows that demonstrator training cannot simply be regarded as a one-off session or even series of sessions completed before the actual job begins. Much is still to be learnt once demonstrator work has begun, and peer support and reflection are methods which can support demonstrators in their ongoing learning about their roles. Reflection in the form of self-analysis is advocated by Roehrig et al. (2003), who suggest that trainee GTAs record themselves as they teach and analyze their performance.

Mentoring...

Both the Druger (1997) and the McComas and Cox-Peterson (1999) approaches stress the importance of mentoring. This was supported by Shannon, Twale and Moore (1998), who highlighted the importance that TAs themselves place on this approach: 'When asked to make suggestions to improve training efforts, TAs have consistently recommended mentorship opportunities' (p.442). However, problems with this approach are the heavy time commitment involved and the availability of willing faculty members. McComas and Cox-Peterson (1999) have also focused on a mentoring approach as a workable solution for TA training. They have developed their own TA instructional strategy called G-STEP (Graduate Science Teaching Assistant Enhancement Program) which focuses on linking TAs with science education Graduate Students (experienced teachers who are studying advanced degrees in education). The science education students formed a mentoring relationship with the TAs which included workshops, observation and communication.

Student centred focus...

One of the outcomes from the G-STEP program (McComas & Cox-Petersen, 1999) that was particularly pertinent to laboratory demonstrators' role was the emphasis on student-centered labs, with more active participation by students and less directive instruction. In addition, one of the participants commented that he/she had learned in the course of G-STEP about:

Using follow-up or closure at [the]end of [a] lab instead of just letting the lab end with no recap. (p. 124)

Overall, the TAs who participated in the program "learned to apply a more interactive style in their laboratory or discussion sections..." (p. 125). This is particularly noteworthy when it has been claimed that 'instructors from science and math use the least variety' of teaching and assessment methods in their courses (Shannon, Twale & Moore, 1998). Other advocates of the student-centred approach are Howard and Boone (1997, p. 387), who list aspects of what makes laboratories fun for students:

The science content should be varied, connected to real-world applications, and where possible involve items like liquid nitrogen that are outside of the student's usual range of experience. Smooth operations are also important: well-paced experiments, procedures error-free from the outset, and easily mastered manipulations all provide students with a feeling of accomplishment. Finally, addressing the social aspects of laboratory - a design that allows students to work cooperatively, sharing information, and learning together - produces a positive atmosphere that students value highly.

A student-centred approach can also incorporate inquiry-based learning. Roehrig et al. (2003) recommend frequent stops during a three hour laboratory for students to meet together, discuss and share feedback, with a chance for demonstrator input. This would happen at the expense of the traditional 30 minute 'pre-lab lecture' for students.

'Active participation' mentioned above may lead to the incorporation of groupwork skills. Teaching TAs to train students in developing group-work skills is also an important focus for TA training. Phillips et al.(2007, p. 23) in their study on investigative labs, stated:

as lab mentors we have found that supervising science is only half the job. The other half is facilitating interactions among students working together in teams ... encouraging open communication and evaluation of leadership, trust and conflict management are just as important as trouble-shooting experimental problems. (p. 25)

Their targeted strategies to deal with group conflict include a lab notebook (a record of details about what tasks have been done and who has completed them, checked regularly by the lab mentor) and a weekly meeting between the students and the lab mentor to focus specifically on teamwork and science, providing opportunity for conflict resolution. Teakle (2009) also stresses the need for training for the PBL method to work.

The results highlight the need for both students and staff to be well-trained in the theory of PBL for its implementation to be successful.

Current literature and theories to inform teaching practice...

There is a strong focus in the literature about the impact that educational literature and theories need to have on demonstrator training. Luft et al. (2004, p. 221) argue that literature on science teacher education should have a strong focus for those who construct GTA training programs. Roehrig et al. (2003) agree, pointing out the need for educational literature given the somewhat narrow view held by some GTAs that assumes all students will learn as they did. This may not be without its challenges, however, as is the case with one GTA interviewed for Luft et al.'s (2004) study, who "acknowledged the ideas in educational research, but ultimately disregarded them for his own views of student learning" (p. 227). In addition, the skill of teaching was viewed in different ways by different parties. Academics tended to think the ability to teach was innate, whereas lab coordinators believed "clarity, well-prepared laboratories, and hard work on the part of the student" (p. 228) was just as important. With such different views on what construes teaching, perhaps it is no wonder that it is a difficult area for which to develop comprehensive development activities. There was, however, general agreement in the Luft et al. (2004) study that

There is a knowledge base about teaching science, and teachers of science should have access to this knowledge.... By learning about learning and teaching in science, GTAs and laboratory coordinators can certainly enhance the instructional environment of the laboratory (p. 229)

They conclude by emphasizing the importance of drawing on education research to ensure that advances in pedagogy are an integral part of demonstrator training.

Teaching to grow in prestige as a skill within institutions...

Luft et al. (2004) link the value of teaching with the training of GTAs. Once teaching is recognized and valued as a skill within institutions, it will enhance GTA training:

By acknowledging what is recognized as essential - teaching - in the merit review process, the scholarship of teaching will be elevated and valued within science departments. This will ultimately support the education of GTAs (p. 223).

They suggest the following strategies be employed: "peer consultancy", "professional development at a distance", "the development of curriculum by groups of faculty", "study groups", "action research" and "case discussion". One of their conclusions emphasizes that rewards, incentives and accountability for academics are needed in terms of undergraduate education.

Access to learning opportunities...

Luft et al. (2004) also noted that professional learning opportunities for demonstrators are sparse.

...professional development opportunities to learn how to improve laboratory instruction were limited to on-campus programs, which were often general and did not address laboratory instruction directly. Laboratory coordinators often felt there was a double standard in regard to their work and the work of faculty members. Whereas faculty members had access to various mechanisms to develop professionally, laboratory coordinators had few options, if any (Luft et al, 2004, p. 229).

Experience…

Experience was also an important factor in TA effectiveness. Shannon, Twale and Moore (1998, p. 456) found that “TAs with either K-12 or college teaching experience were consistently rated as more effective than those without such teaching experience”. In summary, their recommendations for TA training programs were:

+ place more emphasis on pedagogical methods and less time on university policies and procedures;
+ make it more interactive;
+ use cases, simulations and microteaching for more effective learning;
+ supervise TAs as they perform their teaching;
+ provide opportunity for practice and feedback; and
+ more involvement from faculty and administrators (pp. 458-60)

The ability to access those with experience was also seen to be important. Roehrig et al. (2003) suggested that trainee GTAs should observe an experienced person to learn important questioning strategies.

In conclusion, the literature on demonstrator development suggests that development for demonstrators should be socially oriented and be based on sound pedagogy. These recommendations thus seem to have an underlying assumption (which was probably true in most, if not all, cases) that the demonstrators were students rather than a professional workforce, and in particular not a professional workforce whose members may choose not to become permanent academics.

4.3 Demonstrators as a workforce

In the previous section, much of the literature has also seemed to assume that the demonstrators are self-motivated to develop competence, which is not always the case. In a previous study (Rice et al., 2009), it was noted that the attitudes and beliefs of demonstrators significantly influenced their performance in the teaching labs. Not surprisingly, committed, interested demonstrators tend to perform more effectively than disengaged, bored demonstrators. Where does engagement come from? Is engagement simply a property held by individual demonstrators, or is engagement something that can be fostered in the teaching lab? The issue of engagement is one that is relevant to workplaces generally and the literature from the field of human resource management is drawn on to explore demonstrator engagement and disengagement.

4.3.1 The issue of demonstrator engagement

Engagement is a significant concern in the workplace. It has been estimated that over 70% of employees are disengaged (Wollard, 2011). Various studies have shown that engaged employees are more productive, safer, healthier and more likely to stay employed with the organisation (Shuck, 2011; Wollard, 2011). “Employee engagement”, according to Kahn (1990) is:

the harnessing of organization members' selves to their work roles; in engagement, people employ and express themselves physically, cognitively, and emotionally during role performances. (p. 694)

Employee engagement is at least partially dependent on the employee's treatment by the employer (Cartwright & Holmes, 2006; Kahn, 1990; Shuck & Herd, 2012; Wollard, 2011), which places at least some responsibility on universities and science faculties in terms of demonstrator engagement.

The great majority of demonstrators form part of the casual workforce in Australian universities, with their ongoing employment, from year to year, often contingent on sufficient student enrolments to justify a certain number of demonstrators. In their survey conducted in 2010, Bexley, James and Arkoudis (2011) found that 27.7% of casual academics undertook demonstrating/practical teaching. In the USA higher education arena, the majority of staff are not tenured or on tenure-track, and universities rely on an increasingly contingent workforce. In Canada and the UK, over 50% of academic staff are on temporary contracts (May, Strachan, Broadbent, & Peetz, 2011). It is likely that demonstrators have proportionally higher numbers of casual staff due to the extensive use of GTAs.

The RED report (Australian Learning and Teaching Council, 2008) warned that, generally speaking, the management of this casualised workforce in Australia universities, in terms of assuring quality teaching and learning, was "inadequate" (p. 2), although there were instances of effective practice. Brown, Goodman and Yasukawa (2010), in their study of admittedly self-selected respondents, found that casual academics suffered from alienation, financial insecurity, and quality of teaching and learning was dependent on the sacrifices of the casual academic, that is, working more hours than paid for.

Teaching and learning quality has been closely associated with the provision of professional development, which in turn is dependent on how demonstrators are regarded, as shown by this quotation by Chan et al. (2007, p. 1) involving casual tutors.

One view of casual tutors is that they are like shelf stackers – there to deliver a prepackaged product to the consumer. Another way of viewing casual tutors is to see them as apprentices to be trained for future contribution to the academy.

Other literature suggests that teaching and learning quality issues are broader than simply providing professional development. The working arrangements of demonstrators as casual staff impact on their personal lives, in terms of whether they can get a housing loan, being able to plan for the future and lack of access to sick leave and annual leave (Ewart, 2011). Issues related to the personal lives of demonstrators is beyond the scope of this report except where these issues impact on teaching and learning quality in faculty teaching laboratories. This impact, it is suggested, could be caused by disengagement from the university, faculty and teaching program if the demonstrators do not feel embedded or valued in the organisation.

Employee disengagement has been raised as a significant issue in organisations in terms of reducing productivity and creating poor interactions with stakeholders. Wollard (2011, p. 528), for example, noted that disengaged employees "tend… to withdraw emotionally, lack energy for the work, and become uninvolved and uncaring about the people and tasks they encounter at work". Rousseau (1995, p. 105) created an attachment map

to illustrate the intersecting dimensions of relationship duration (long-term and short-term) and the degree of embeddedness in the organisation (insider/outsider). Embeddedness is fostered through socialisation, professional learning opportunities and duration of employment. The longer the time spent in an organisation, the greater the likelihood that the employee comes to rely on and value the relationship with the organisation.

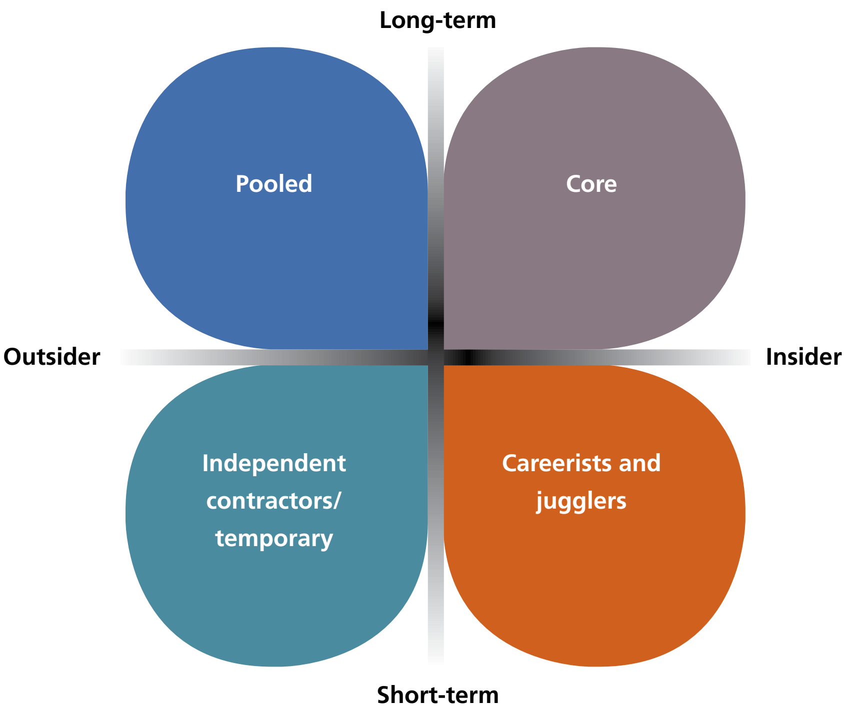


Figure 1: Attachment map

According to Rousseau (1995), core employees (long term/insiders) are key to the organisations. Core employees are generally acculturated into the beliefs and values of the organisation, and hold work as a central interest. These employees tend to show commitment to the organisation. The work arrangements can be highly relational in nature, based on mutual expectation rather than specific terms of a work contract. In Higher Education, the permanent full-time academics or long-term contract employees may be regarded as the core employees.

The careerists, on the other hand, can be thought as loyal to the sector rather than to one particular organisation. An organisation is a stepping stone to better things, and organisations that provide development opportunities may be well-regarded. The careerists can be seen in the bulk of the demonstrators drawn from the student ranks. These demonstrators will generally wish for a career related to science, but may not expect or even want a career as an academic. The more far-sighted students will value the experience of being a demonstrator in terms of their future credibility as scientists, but commitment to the role of demonstrator will be variable depending on the perceived costs and benefits of the role.

Pooled workers tend to work irregularly with one organisation, to enable the organisation to have flexibility of an extended workforce. Arrangements tend to be transactional, although a relationship can develop over a prolonged period of time. In the teaching labs, these pooled arrangements were seen in people who had their degrees, but needed the benefits that a casual job could give them. These pooled workers could have parenting responsibilities, be retired but still interested, and/or have a number of jobs at different universities.

Independent contractors and temporary workers are used to meet short term needs. The degree of expertise amongst these workers will range from highly skilled to fairly low skills. This type of worker in teaching labs will often vary according to the difficulty that science faculties have in recruiting demonstrators, but it seems logical that highly skilled individuals would try hard to find other opportunities with higher pay and/or more career opportunities.

The competency levels of demonstrators are often dependent on the professional development provided. Where a science faculty treats demonstrators as temporary workers, that is, as short-term outsiders, it is likely that the professional development provided will be sparse or only undertaken in terms of teaching the demonstrators the procedure of the experiments. Where this is the case, the teaching and learning knowledge would need to be explicated in manuals, checklists and so on that are very comprehensive, in effect so that the knowledge is captured in the resources rather than in the heads of the demonstrators.

Blackler (2002) noted that where people operate in familiar situations, knowledge can be embedded in procedures and routines rather than invest in developing the people themselves. Although this form of management streamlines the operations and reduces the professional development costs, it means that the people involved in these activities have trouble coping with novel situations. Where teaching laboratories involve the ‘cookbook style’, the routine nature of the teaching and learning experience may very well mean that little development beyond engendering familiarity with experiments may be required, particularly if effective engagement with students is not a priority.

Where teaching and learning encompasses an inquiry approach, or where the learning involves generic skills, then a routinised approach to demonstrator competency development will not create the learning that is needed to guide students effectively. It is suggested that a faculty that develops a learning culture among the lab staff (and others for that matter) will reap the benefits in terms of ongoing improvement in teaching and learning both in terms of increased knowledge and skills and in engagement and commitment.

4.3.2 Developing a learning culture

Universities are producers of new knowledge, both from the perspective of creating new knowledge through research initiatives, and facilitating learning in others through coursework degrees. For organisations to work effectively, the notion of alignment becomes salient. In universities, there has been evidence of alignment in terms of teaching, where course and subject goals, assessment and delivery are designed to support each other (Adams, 1998; Herron, 2009; Jensen et al., 2005) and in terms of strategic alignment, where the resources of the university are in alignment with the strategic aims of the university (Druger, 1997; Phillips et al., 2007). What appears to have less prominence is the alignment of the development of demonstrators in the teaching labs with the goals of the courses undertaken by university students. Such goals typically embrace more than learning the steps in a scientific experiment.

In the past 25 years, a series of related constructs have emerged in organisational and management literature that promote learning as a unifying feature that promotes effectiveness of the organisation and development of people in a systemic and reinforcing framework. Although variations of the framework have been created, the literature is consistent in the importance of creating a learning culture that impacts on the organisation, the team and the individual. Organisational learning refers to collective learning that engenders organisational capacity building (Argyris, 1992/1999; Senge, 1992). Thus, the learning is more than creating skills and knowledge in individuals; organisational learning also concerns improving collective effectiveness to meet organisational goals through a culture of 'inquiry, feedback, reflection and change' (Gill, 2010, p. 10). Organisations that embrace an organisational learning approach have been able to bring about "sustainable education reform" through an ability to innovate and respond to challenges (Bui & Baruch, 2011, p. 3). In addition, the collective learning that this approach stimulates can pass across generations of workers rather than knowledge being lost as individual employees leave (O'Toole, 2011).

One mechanism that achieved prominence in recent years is the community of practice. Although more recent literature promotes the structured community of practice, initially communities of practice were represented as emergent groups who shared knowledge, and organisations who wished to harness the power of communities of practice ensured that spaces and opportunities for group participation existed (Lave & Wenger, 1991; Orr, 1990)

Although creating an organisational learning approach at the university or faculty level is beyond the scope of this report, it is argued that creating a learning culture at the level of the teaching lab is well within the scope and means of universities; in fact many science academics have already embedded elements of a learning culture in terms of their practice with demonstrators, albeit not always within a systemic framework.

The actions that could be taken to foster a learning culture in a science lab would be to:

+ create a vision for laboratory learning that aligns with program and faculty goals, which is shared with demonstrators and other employees.
+ question assumptions held by science staff that downgrade the role and place of demonstrators as a professional workforce in the science faculty.
+ enable demonstrators to dedicate time to formal and informal learning that enhances their capability.

+ create a team-oriented environment that encourages employees to ask questions and learn, from each other as well as from academic staff and technicians.
+ develop learning events that are linked to the relevant goals.
+ make visible artefacts of learning, such as a small library, spaces for conversation, and computer access to resources.
+ build ongoing feedback and reflection into practice.
+ create systems of evaluation. (Gill, 2010; Senge, 1992)

It will be shown in the Findings section that many of these elements are already present in some teaching labs in Australian universities, and some have been raised in the preceding literature review. It is argued that a learning culture approach prepares labs (and faculties) for future challenges, such as the Higher Education Standards Framework.

4.4 The Higher Education Standards Framework

Much of the preceding discussion has had an underpinning assumption of a sincere commitment to the need to create effective, even compelling, learning opportunities for science students in Higher Education. Contemporaneously with calls from academics to improve practice, global and national forces have had an impact on Higher Education systems in terms of the imposition of quality systems of various forms to improve or maintain sufficient standards of quality.

In Australia, the Bradley Review (2008) noted that Australia needed to maintain a high level of student outcomes and appropriate standards if Australia's Higher Education system was to remain internationally competitive and if graduates were to cope with an increasingly complex environment (Commonwealth of Australia, 2011). The Federal Government's response has been to establish the Higher Education Standards Framework, with the Tertiary Education Quality and Standards Agency as the quality regulator.

The Higher Education Standards Framework is intended to provide coherent and consistent standards in relation to the registration and accreditation of Higher Education providers, teaching and learning standards and qualification and information standards. At the time of writing, the teaching and learning standards have not been released, and the Federal Government has been challenged to provide teaching and learning standards that simultaneously promote quality improvement, or at least, maintenance, without constraining innovation and academic contribution to university degrees. (Edwards, 2012; Thompson-Whiteside, 2011)

It should be noted, however, that inquiry-based learning is a significant feature of the Australian National Science curricula, and it seems logical that this expectation would be carried forward into university education. Further, the legislative reforms that have occurred since the Bradley Review indicate that Australian science faculties will come under increasing pressure to demonstrate that the practice in the teaching labs at least meets externally determined standards.

4.5 Conclusion

This section focuses on the existing literature concerning demonstrator development. This literature gives rise to various development mechanisms and structures for improving demonstrator competence. The science education literature related to demonstrator is reviewed, but it is argued that the underlying assumption for much of this literature is that demonstrators are graduate students who will one day join the ranks of the academics. This means that although social modes of learning are encouraged, demonstrators are treated as individuals who need to learn rather than as part of a group who need to build sustainable competency as a professional workforce. Sustainable competency in this sense means that knowledge is retained and increased over time, leveraging the cost of providing formal learning opportunities.

It is therefore argued that the issue of building demonstrator knowledge and skills needs to be viewed from the perspective of demonstrators forming part of a workforce, as well as from a teaching and learning viewpoint. In addition to skills and knowledge, demonstrator engagement needs to be addressed, and it is argued that establishing a learning culture in the teaching labs is an effective and appropriate way to create such wide-spread demonstrator engagement. As the Higher Education Standards Framework becomes fully implemented, the issue of improving student outcomes through harnessing the power of the laboratory as a unique learning environment becomes more pressing. A cohesive learning culture, with appropriate structures and procedures in place to enable that culture, has a critical place in achieving this outcome. Such a culture becomes a framework for learning where money spent becomes an investment yielding benefits and value rather than a cost.

Section 5 deals with findings collected from Australian universities concerning demonstrator development. These findings give a picture of how demonstrator development is conducted in Australia and show how some first year coordinators have instituted elements of collective learning in their science labs.

learning laboratory/ies
professional learning
undergraduate science education higher education
collective learning
inquiry laboratories
engagement
professional learning
undergraduates
engagement
demonstrators
science
continuous improvement
undergraduates
science teaching and learning
team culture
demonstator
professional workforce
engagement
feedback graduate teaching assistants

undergraduate science education
selection
graduate teaching assistants
inquiry
selection
team culture
science teaching and learning
laboratory
higher education
feedback
graduate teaching assistants
team culture
inquiry learning
continuous improvement
higher education
selection

5 The Findings

The literature review showed how much of the science literature portrayed demonstrator competency development in somewhat narrow terms of teaching and learning. It was argued that other issues need to be resolved in order to promote demonstrator engagement and foster a collective learning culture in the science lab.

In this section, the findings from the empirical part of the study are presented. The findings are presented on a thematic basis and include the results from the survey, interviews, and a web search. These findings are based on the questions that focused the study and on themes that emerged during the data analysis. The findings are organised in the following sections, which are based on the initial questions that focused the study:

+ Who are the demonstrators?
+ How do demonstrators learn?
+ What are the benefits of demonstrating?
+ Other issues that impact on demonstrator performance.
+ Towards collective learning.
+ Conclusions

The findings show that Australian universities have embraced many of the recommendations that are to be found in the science education literature. In addition, several coordinators are promoting emergent collective learning cultures.

5.1 Who are the demonstrators?

The composition of demonstrators as a theme in the research emerged from the data. Although the composition of demonstrators, in terms of experience, did not directly form part of the research questions, a question was included in the survey concerning the background of demonstrators to ascertain their prior knowledge and experience. As questionnaire and interview data were collected, it became apparent that diversity in the demonstrators' science experience and life experience yielded considerable benefits in the science lab.

In terms of a quantitative depiction, the responses to the survey showed that majority of demonstrators were recruited from the ranks of PhD students, and, to a lesser extent, honours students (see Figure 2).

As Figure 2 illustrates, the lower the percentage of PhD students, the more diverse the backgrounds of demonstrators. In the 71 – 90% and 91-100% ranges, the demonstrators are overwhelmingly drawn from the ranks of PhD students, with the only extra groups represented being that of academics and honours students.

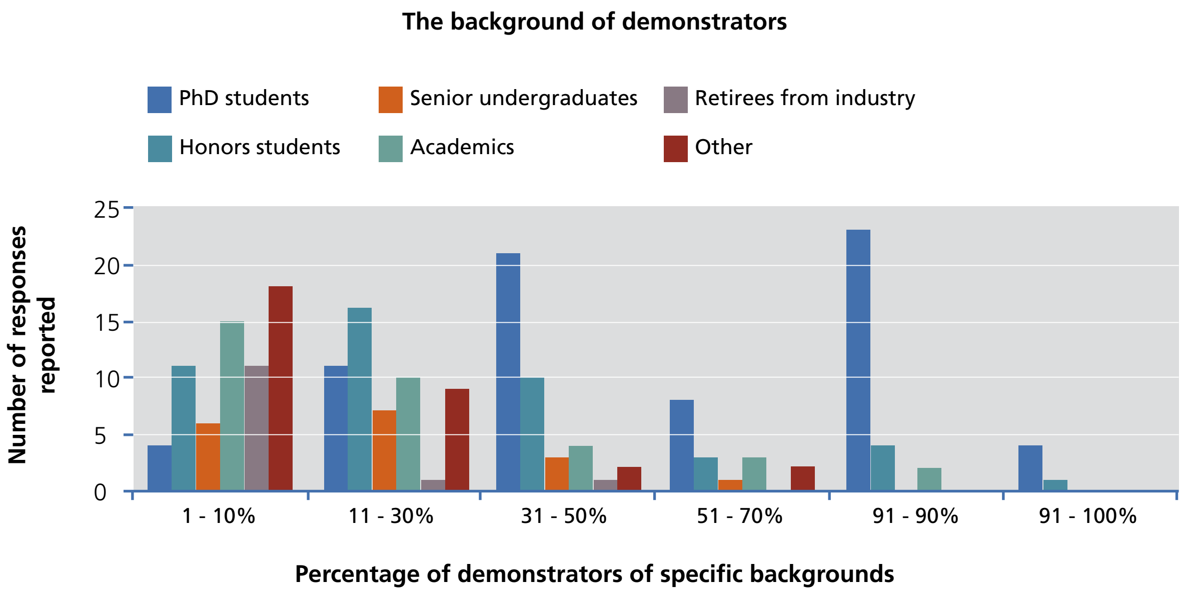


Figure 2: The background of science demonstrators

The *Other* backgrounds reported by respondents were overwhelmingly graduates, most often PhD graduates, and to a lesser extent, Masters students. It is speculated that these graduates may be sessional teachers, entering academia or looking for other jobs.

There were only six responses that gave indications of demonstrators with an external focus that were not included in Retirees from industry. These responses were:

+ Industry people;
+ Researchers from academia and industry;
+ Varied: ex-teachers, changing careers;
+ Medical practitioners, chiropractor;
+ Teachers; and
+ Foreign medical.

Although the survey results shows a prevalence of PhD students employed as demonstrators, extending the experience level of the demonstrator pool has been shown to be beneficial.

The people we have coming in as teaching associates who have more life experience, a bit older, they've got a couple of kids at home. ... because they've got more life experience, they usually, mostly have better communication skills. They're more patient. They're often used to dealing with kids of the same age. And so, yeah, I think there is a deficiency in probably the ability of these newly completed or currently doing PhD students to kind of impart the same or teaching the same way or the same quality Coordinator

Despite the low incidence of externally-recruited demonstrators, there were advantages to their inclusion in the laboratories cited by various participants during interviews. One demonstrator, for example, noted an advantage of a diverse workforce when teachers were part of the demonstrator group:

For first year demonstrators I noticed, which is different because now I'm doing second year, first year you have some post-graduate students but you also have people like me who have worked and now just want to do something on a part-time basis and you have school teachers as well. Yeah, school teachers. And they probably have masters and all that but they are school teachers, yeah. And it was really good because they can actually bring in the point of what students know in year 12 and coming into first year. Demonstrator

Several coordinators deliberately recruited demonstrators with more life experience, which was not only beneficial for students. It was seen that more inexperienced demonstrators valued and learned from the insights that the more experienced demonstrators could bring.

Because a lot of the demonstrators come to oldies like me and quietly whisper, "Can you help us here?" and I usually can. And that's part of the exhilaration too … And the postgrad students have worked in a fairly narrow field. They're all pretty good, but they don't have the breadth of experience. So it's good to have that mix.
Demonstrator

The practice of hiring people other than students does not seem to appear in the relevant literature, however there are some obvious benefits in doing so. In a previous study (see Rice et al., 2009) a lab manager noted that hiring industry people meant that students could find out how relevant certain procedures were in the science professions. It is certainly likely that some externally hired demonstrators could be hired continuously for a period of years, providing continuity and a valuable “memory” in regard to lab operations.

For students, demonstrating enables the development of various competencies, and it would be detrimental if they were excluded from the labs. The inclusion of some other demonstrators with the needed generic skills who are more experienced in science, however, would enable the student-demonstrators to benefit from first hand knowledge of other science domains, bring expertise into the labs to benefit enrolled students, and provide continuity of knowledge over time.

For new demonstrators hired, no matter how experienced, the specialised nature of teaching laboratories means that learning and development is required to enable them to perform competently.

5.2 How do demonstrators learn?

The development of demonstrators is seen as a significant issue for effective teaching labs (Rice et al., 2009). The type of learning opportunities that are available to the demonstrators will strongly affect their capability to facilitate different forms of learning (Kirkup et al., 2008; Luft et al., 2004). In this section, the purposes that shape demonstrator learning, and the formal and informal learning opportunities are explored. This section also examines demonstrators’ responses to their learning opportunities.

5.2.1 The purposes that shape demonstrator learning

The purposes of the demonstrator learning activities that were encountered in the interviews included enabling demonstrators to:

+ guide students in the conduct of experiments and lab work;
+ answer questions from students concerning their learning experience in the labs;
+ act as role models for students;
+ act as advocates for the unit, the course, the disciple and as representatives of the given academic unit;
+ encourage interactive engaging learning in the labs;
+ monitor health and safety in the labs;
+ mark assignments and lab reports; and
+ treat all students in a fair and equitable manner.

wThe questionnaires gave similar answers. The questionnaire answers were grouped into the following categories, with the number of responses shown in brackets:

+ Developing teaching and learning competency (36), including the subgroups, Improving the student experience (15) and Establishing attitudes (5)
+ Equipping the demonstrator (24)
+ Ensuring consistency in teaching (15),
+ Maintaining Occupational Health and Safety (13).

Other classifications were: Training for administration (6) Developing for long term career needs (6), and Inducting into culture (3). The numbers of responses for each type of rationale are shown in Figure 3[1].

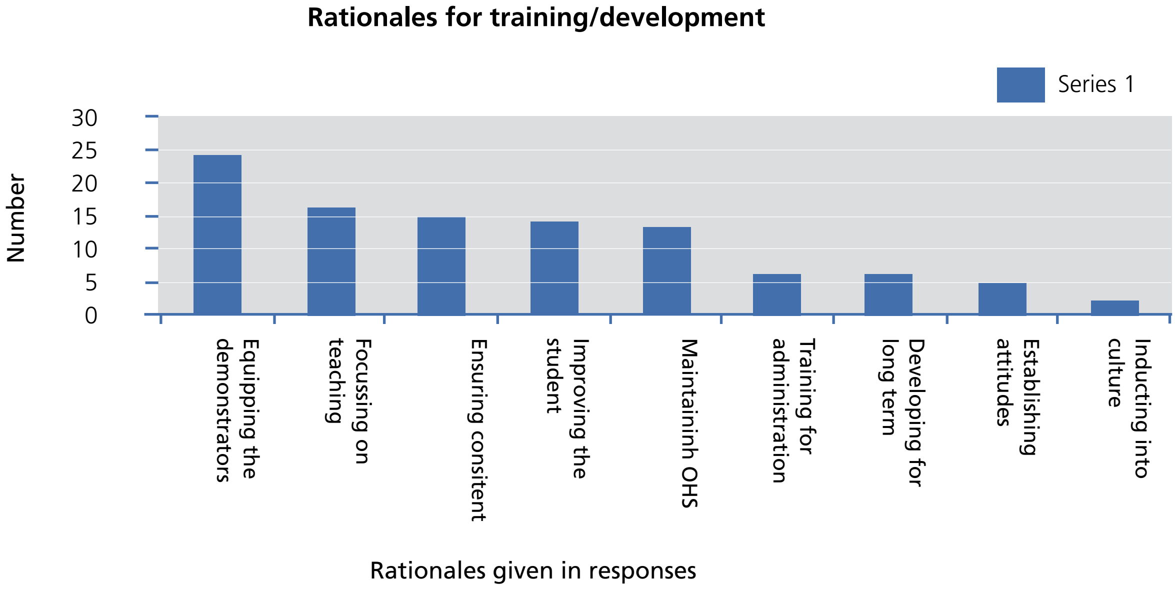


Figure 3 above: Rationales for Development from questionnaire respondents[1]

Further explanation of the data within each category is shown below. Significant variations among disciplines will be noted.

Developing teaching and learning

Many of the responses above included rationales classified as Focusing on teaching and learning. These rationales recognised the importance of an understanding and capability with regard to pedagogy and assessment in teaching laboratories. This indicates that a focus of teaching and learning has gained and/or is gaining in prominence in Australian teaching laboratories.

1 This chart does not give classifications that were mentioned only once.

These responses generally underlined that successful demonstrating was more than knowing the experiments. It was reported that demonstrators needed understanding of the theory of teaching and practice of teaching and learning, to help students understand and learn. One response that encapsulated these responses was:

enable …tutors and demonstrators to more effectively, efficiently and confidently help their students learn

In one case, there seemed some recognition of teaching science as a field of teaching theory:

The rationale is to improve the quality of the lab teaching by improving the LD understanding of lea[r]ning science.

and one case, this understanding was more specialised:

'best practice' in demonstrating/teaching anatomy using cadavers and to understand basic rules (as determined by the Anatomy Act) on the use of cadavers

Improving the student experience

Improving the student experience classified responses, which, although involving teaching and learning issues, explicitly referred to demonstrator development as a way to have an impact on the students. The focus of these responses, therefore, was on the student, rather than on the demonstrators. The responses ranged from providing an effective learning environment for the students to providing conflict resolution in the labs.

One response stated a need to deal with professional attributes to improve student outcomes:

It requires very little time dedicated to return excellent learning outcomes in students. I specifically target the demonstrators' understanding of generic professional attributes, which leads to a far more effective contextualization of learning activities.

Establishing attitudes

These five responses strongly implied that more than skills and knowledge were needed by the demonstrators. These responses ranged from giving the demonstrators confidence to desiring that the activities be undertaken in a "professional, yet enthusiastic manner", and:

encourag[ing demonstrators] to improvise within the framework of the lab notes and experimental design

Equipping the demonstrator

The responses classified as Equipping the demonstrator involved improving the demonstrators' knowledge of teaching and learning or how to deal with students. The distinction of these responses was that they were explicitly involved with providing the demonstrator with sufficient knowledge, skills and attributes, in areas where the respondent thought important, to succeed in the teaching laboratory. In the words of one respondent, the rationale underlying training/development is to 'ensure demonstrators are capable of doing the job'.

Ensuring consistency in teaching

Consistency was deemed important in a number of responses, particularly consistency in marking assessments. Of the 15 responses concerning consistency in teaching, 10 responses specifically mentioned consistency in marking as a rationale for training/development of demonstrators.

Maintaining Occupational Health and Safety

Safety and Occupational Health and Safety procedures was an issue in terms of 13 responses. One respondent noted that ‘OH&S understanding has obvious outcomes’. These outcomes seem encapsulated in another response, giving two aspects of this issue, namely ‘Ensuring safety, and satisfying bureaucratic requirements in this regard’.

Training for administration

Six responses noted the need for adherence to requirements of the university on the part of the administrators. One testy response was:

To try to show uni complies with some ill-defined and nebulous “quality” concept in order to comply with federal “policies” hurled at the uni. annually.

Developing for long term career needs

Six respondents explicitly pointed to the opportunity for longer term career development in terms of their demonstrator experience. One response indicated the seriousness of this issue:

T*he rationale is that demonstrators and tutors are at the early stages of a career in tertiary teaching and hence require both on-site training and especially professional development from that perspective. We take this extremely seriously, both as an institution (basis of the devleopment of the devleopment [sic] modules that are conducted at Faculty and planned at institutional level) and as a School.*

Another response, setting out a range of reasons for demonstrator development noted two reasons relating to career development:

many post-graduate students repeatedly express the desire to gain experience as teachers … moving into higher levels of responsibility is usually undertaken by those students who desire a career in teaching.

Does a focus on the longer-term career needs of the demonstrators conflict with the needs of the student? Not according to this respondent:

Demonstrating/tutoring is part of the academic and professional development of postgraduate studetns. The training and development also improves the quality of both the student experience and their learning.

Inducting into culture

Only four responses indicated any need to ensure that the demonstrators were inducted into the school or department culture. These responses included:

… demonstrators will grow in appreciation of the School's values

Rationale is to (re)acquaint demonstrators with… the philosophy of practical teaching in this dept.

make them realise that they are a valuable member of our first year teaching team.

One response, however, indicated a need to improve relationships between lecturers and demonstrators.

The purposes for providing learning opportunities to demonstrators are consistent among interviews and questionnaires. Obviously people being interviewed can furnish much more detail than those answering a questionnaire. Desired attitudinal change was more prevalent in the interviews, however, than in the questionnaires. Only five respondents to the questionnaires noted explicitly the need for demonstrators to acquire attitudes that were appropriate to the job, although some respondents did mention "confidence" that were classified in other ways.

The lack of explicit recognition by the majority of respondents of the importance of fostering positive and relevant attitudes in terms of the demonstrators argues for the need of a conscious focus on more than knowledge and skills acquisition by the demonstrators. Demonstrators need to be engaged, willing to learn and ready to excel in the lab.

5.2.2 The learning opportunities for demonstrators: formal learning spaces

Formal learning spaces are those physical, emotional and virtual spaces where organised learning takes place. First year science coordinators indicated in the questionnaire responses that the majority of formal training and development activities take place as shown in Table 1.

Provision of training and development	Number of responses
a) By the faculty/department	32
b) By a central training and development unit	6
c) Both a) & b)	19
Total	**57**

The responses to the questionnaires can be compared by a web search, which was followed up by email queries, to give a picture of formal learning available to demonstrators only in centralised units in universities, such as provided by Human Resource Development units:

Findings	T&L for demonstrators offered by centralised units	T&L for sessionals offered by centralised units
Yes	11	36
No	20	1
Unknown	8	2
Total	**39**	**39**

Table 2: Centralised training and development for demonstrators in Australian universities

This table illustrates that specialised demonstrator training and development at the university level is not yet wide-spread across universities, although more generalised opportunities exist. These activities generally covered generic teaching issues, particularly teaching in small groups, and procedural issues such as how to claim payment.

It may well occur, however, that a central training development unit may employ former science academics, or second them specifically for demonstrator training, or that some science faculties and departments may have scientists who, for various reasons, have further generic qualifications in teaching, learning and education.

During the web search, a small number of generic materials were also found to be available, as shown in Table 1.

Available from:	Resource	Available from
Deakin University	Teaching in laboratory settings	http://www.deakin.edu.au/itl/pd/tl-modules/teaching-approach/prac-labs/index.php
University of Wollongong	Skills for Laboratory Demonstrators	http://www.uow.edu.au/cedir/ult/UOW053288.html

Table 3: Available demonstrator learning marerials

In addition, a small number of demonstrator handbooks/resources provided by Faculties were publicly available.

In terms of face to face activity, the common sites of demonstrator learning opportunities communicated in the interviews were as follows:

+ university or faculty induction;
+ unit introduction;
+ prelab preparation; and
+ in some cases, a unit debrief.

University or Faculty induction

The significance of where and who provides the development for demonstrators seem to be based on the following assumptions:

+ a central training and development department will mainly have capabilities relating to generic teaching and learning; and
+ a science department and faculty will mainly have capabilities relating to disciplinary and science knowledge, and some teaching and learning capabilities specific to science and the discipline.

Each of the science coordinators interviewed acknowledged that some form of centralised training and development for demonstrators was available, although the degree of centralisation differed. In one case, for example, staff members from a central unit contributed to faculty activities.

The science coordinators that were interviewed had differing views in terms of the value of the contribution of the centralised facilities. One coordinator pointed out that university politics can get in the way of effective centralised teaching for demonstrators:

They hold these training courses, but they're designed for people giving small group tutorials in … [social sciences]; they're not designed for laboratory demonstrators. So we've been engaged in this death match with them about letting - about them creating a laboratory demonstrators' course, which we have designed and given to them and they still send people out who then ignore our design. So we revolted and there's a lot of in-fighting about that, which we're slowly winning, but only because [of a certain political advantage]. But it is incredibly hard to get useful resources out of these guys.
Co-ordinator

From the demonstrators' point of view, generalised sessions offered by a university stand in danger of being irrelevant to the specialised needs of the demonstrator, as shown in this quotation;

No it was a university, it wasn't even science specific. It was everyone from every other school, so it was a very uninformative, from my point of view. It just didn't apply to us, the situation of a demonstrator in a lab conducting an experiment and dealing with students, you know who are unruly or just.... a lot of them you would find a lot of reaction is people who can't understand the material and they just can't deal with it and they are.... just faces in their hands and they just go blank, completely... they can't even start. Demonstrator

On the other hand, another demonstrator found centralised sessions very helpful:

S*o they happen to have this training for how you interact with students from various backgrounds and how do you build that trust and everything, which was good. The first day was like a workshop. I went there with some more seasoned demonstrators and it was good because we had the discussion on how would you actually treat a student's essay if English is not that good, not up to par and how do you build up your confidence. And it was good in the sense that, well at least for me, because I actually come from a multi-cultural background anyway, but it's good to see the other side of it to see how students actually perceive the person teaching them. So that was the first formalised training that I had and this was even before teaching. It was helping the class.* Demonstrator

From the university and faculty's perspective, centralised competency development lowers the cost and is more efficient in communicating generic issues to the demonstrators (and others). Centralised training and development can be useful for demonstrators provided the demonstrators see the relevance to their practice. Then faculty and departmental resources can be used to focus on discipline- , unit- and lab-specific issues.

One coordinator outlined part of an induction session for demonstrators in the laboratory:

We talk about safety issues, specific location issues, what to do in the event of this, this or this. Where all the risks assessments are kept. Where all the MSDS Material Safety Data Sheets are kept because if we're audited and any of the Work Safe people ask, the demonstrators need to know where all of these particular things are kept. Coordinator

The same coordinator also mentioned a faculty induction where participants were introduced to the notion of building their teaching portfolio. The location of the induction in the faculty, however, does not guarantee student satisfaction:

Well there wasn't really any preparation for the first session because the first session was just a welcome to [university], here are the rules, here are our safety sort of things. They told us that we were going to go into a class and do something like that, but I was, I actually tried to do a bit more preparation so I sat in on another class that was being run by an experienced demonstrator that was before mine, just to see what he was doing. I took some notes on how he was acting and how he was giving out tasks and things like that because I didn't feel confident enough just to go in straight away and know what to do because I didn't really know what I'd be doing. I don't think I was told to do that and I wasn't paid to do that but I just decided that that would be a good thing and I checked with that other demonstrator and he said that would be fine. So I felt like I was thrown in the deep in a bit. I think a few of the other demonstrators felt the same way as well, but we've got used to it and it's fine now. I just think at first we didn't know what to expect. Demonstrator

Subject-specific learning

A significant part of the demonstrator learning is the pre-lab sessions, where demonstrators have the opportunity to be briefed on the lab activities for that week. For many demonstrators, this is their opportunity to catch up on scientific knowledge that they have forgotten or never learned. One demonstrator noted the need for such preparation:

I told [coordinator], "You know, I've never dissected ...[an animal]. Mice, [...], yes. [an animal] ..., no." So basically I tried it out and what was good is that they do realise that nobody can be experienced in every single field. So this dissection of [an animal], during that one hour meeting … they actually put an animal there. You can try it. So we actually have first hand experience before going through those things. So that was good in that sense … So, when it comes to [scientific field] I'm happy but when it comes to all this dissection and everything, it's new. It's new. But because of that prep session, so that was all right. Demonstrator

This same demonstrator noted the advantage of sharing experience in preparatory sessions where a large number of demonstrators where present:

So it was very good sharing our experience every time in that one group. Because when you demonstrate a class, I think there's only about six demonstrators per shot, but during these prep sessions it's all from the different days, so I think there will be probably 20 of us and everybody's sort of not shy to tell them the experience, even if it's something they did wrong it doesn't matter. But it was good in that sense.

Some puzzling discrepancies occurred when data collected was compared from coordinators and demonstrators in the same unit. In one case the coordinator described a fairly comprehensive program of centralised learning activities and pre-lab sessions and a new demonstrator claimed that they received very little support:

I*nterviewer - What happened between you getting accepted and you stepping into the lab?*
Demonstrator: Um, nothing, really. Yeah. It was quite interesting. So you get given the manual. So I'd read the prac that we were doing, but then you just show up. …. They have like six demonstrators in three different groups and they have like a supervising demonstrator … and the assistant. I've always been the assistant. Yeah. So then I just met my supervising demonstrator in the prac started. So it kind of went from there. Yeah. It was interesting. [laughs]

Although there may be various reasons for the discrepancy, it is clear that there is a lack of communication in terms of feedback mechanisms concerning the effectiveness of demonstrator development in this case.

5.2.3 Grading

A challenge in higher education teaching and learning is to provide fair and consistent marking and grading of students' work. In the interviews conducted, there seemed to be several strategies to ensure consistency. Three linked strategies were found in the labs, which were to: a) implement the use of marking guides; b) teach the demonstrators how to use them; and c) have moderation sessions. Several coordinators implemented one or more of these strategies.

Well, I think, pretty strenuous effort's made to produce consistency. … Apart from that one lab, I don't mark, so in that one lab, we're given a sheet of pretty strong guidelines as to how to deal with each question. You should give one mark for the neatness of the drawing. It's broken down. One mark for the neatness of the drawing. One mark if they've put the proper labels on it, etc., etc. So it's pretty objective. Yeah, yeah. And it's also scrutinised. I've had some feedback. I goofed a couple of times, because I'm just not used to marking when I goofed a couple of times. Added up wrong or something like that. And you get to hear about it pretty quickly so you lift your game and next time it doesn't happen. Demonstrator

At another university, the resources were not there to spend on grading consistency:

It's common sense, it's absolutely a no-brainer, and costs far more than we can afford. It probably doesn't cost all that much when you think about it, but somehow we just - I would actually spend the money on it. I would do something to make it possible, but I don't actually run the budgets, I just advocate how they should be spent.

Despite a lack of funds, this coordinator put a high value on grading and spent a considerable amount of time with new demonstrators to teach them how to use a rubric that he devised. He strongly believed that effective feedback was important to the first year students.

…whereas 40% just means your work is rubbish and it's really important that they [students] get this feedback, because they don't get it in Year 12, they don't get it in Year 10. Coordinator

5.2.4 The learning opportunities for demonstrators: informal learning

Learning by doing, informal learning and communities of practice are constructs that were created to foreground the learning that takes place as part of doing the job. For demonstrators, this learning can be facilitated by the composition of the demonstrator workforce and the structure of work. In a previous section, it was argued that selecting a diverse demonstrator workforce can improve the informal learning in the first year science lab. In addition, coordinators that were interviewed noted that the use of the following strategies also helped learning among the demonstrators:

+ allocate demonstrators to specific benches or groups of students, so that shy or less proficient demonstrators could not hide away from student queries;
+ pair new demonstrators with more experienced demonstrators;
+ arrange for new demonstrators to observe experienced demonstrators;
+ encourage demonstrators to share experience by encouraging group gatherings; and
+ schedule moderation discussions relating to student assessment tasks. In one case, the coordinator participated in these discussions and together the coordinator and demonstrator developed and shaped group expectations concerning assessment standards, which in turn facilitated the emergence of a group culture (see section 5.5).

In addition to the resources provided by the coordinators, in some units, groups of demonstrators would meet outside the labs and informally share ideas and experience, as one demonstrator noted:

Yes, there's usually about eight people each morning, different people, but have coffee at nine thirty every morning and we talk about pracs quite a lot and just all the different scenarios and the confusing parts and things. So yes we do talk about it quite bit.

These gatherings usually involved the PhD students, although in the case of one lab, the 'external' demonstrators did arrange lunches together.

One demonstrator thought that having the option to attend lectures would be helpful.

I mean unfortunately a lot of my knowledge is prac specific because of course, if you don't lose the information and you learn a lot of it doing a four year uni degree, you tend to lose it and so all of the research that I have done is very prac specific, all of the revision and I can't really step outside the box because I don't attend lectures. I would like to actually be given the option, you know, or the bosses to say 'you can attend the lectures, there is no problem whatsoever, feel free to, no cost or any you know, inducement, just if you need to go, go.' I would have liked that refresher personally, the time on the other hand to do it is probably not there, but I would have liked the option. Demonstrator

The data shows that demonstrators across Australia have a range of learning resources. In various labs, the purpose of demonstrator development exceeds simple direction to students in terms of the experiments. Some coordinators wish their demonstrators to be role models and advocates, as well as embrace elements of a teaching role. For many respondents, however, learning about demonstrating is about acquiring knowledge and skills, particularly in terms of teaching and learning. Learning opportunities are offered by centralised departments and faculties, although there are few publicly available electronic resources. In the interviews, demonstrators generally had a range of views about the effectiveness of learning opportunities offered. Some demonstrators felt unprepared for their work in the lab, others were grateful for formal sessions, while some made their own opportunities for learning. But demonstrators also learnt from each other, in groups or pairs. In some cases this informal learning was engineered by the coordinator, in other cases, the learning was due to emergent social groupings. Demonstrator learning is a complex and multi-layered affair – formal learning opportunities are only part of the picture.

5.3 What are the benefits of demonstrating?

Demonstrators were asked about the benefits of demonstrating in terms of increasing their learning as scientists and as people. Overwhelmingly, particularly from postgraduate students, demonstrating was held to increase their confidence and skills in communication. There was also considered to be some benefit in terms of science knowledge. There was wide spread agreement that demonstrating was useful experience for a range of career paths.

5.3.1 The generic skills of communication

As mentioned previously, there was far more agreement on how demonstrating helped demonstrators talk about their research in particular, and about science to people in general:

Well I think a big part of a career in science is public speaking. So you always have to get up and tell people what your're researching and what you're doing. And I've found ever since I have been demonstrating I have increased confidence in my public speaking abilities. So for example the end of last year I had to get up and give a talk and I was absolutely terrified to do that in front of the whole physics faculty. And since then I had to give a talk at the end of last semester on what I'd been working on and when I got up I was a bit nervous, once I got up and started speaking I was completely comfortable and fine even though I could see all these academics looking at me who probably know a lot more than I do, what I was talking about. And after I'd actually done that a few people had commented on how relaxed I looked as I was talking. So I think that definitely has been a big benefit for me.
I guess it helps as well when, I'll be applying to do a PHD next year, possibly overseas and they often want demonstrators or people who've got some experience doing some teaching because then I guess that's something extra you can bring to their university. You're able to teach their undergraduate students, so I think that's a bit of a benefit as well. Demonstrator

One coordinator noted the importance of skills learned in demonstrating for PhD students:

I am so sick of hearing that "no, I can't demonstrate because I have to get my research done and I have to get my PhD done" and it is not a priority and even lab leaders, their supervisors are telling them they are not allowed to demonstrate… then I have another conversation with other academics, lab leaders, PhD supervisors who said "I am so distraught that my students can't articulate anything about their research and they can't stand up and give a powerpoint presentation. How can they be PhD students and not be able communicate anything about their findings". And I am, like, they need to teach, it teaches you so many different things. Coordinator

Demonstrators expressed their belief that demonstrating would help them communicate more effectively in general, as in this case below.

It's helps a lot with me communicating with other people because that's one of my major weaknesses and something I've been trying to improve on for the last couple of years very hard on and it's quite helpful to get the experience like that so the main reason why I chose to demonstrate was for the experience not for the money and it helps - and also helping, it helps me in freely explaining things to the students because I use to only be able to explain things one way but of course if they don't get that you need to come in from another way and it's helped a lot, me to develop my skills that way. Demonstrator

5.3.2 Knowing science

One demonstrator was able to come up with an example of how demonstrating had helped her in her research:

… actually I can think of an example of how it has helped. I had to write a literature review for a project I'm working on in our last semester, and there was one area that I think you would need, it was more of a basic understanding of physics. So what I'm doing my thesis on is, it's [topic] So it's, one part of the thesis I had to discuss what is the evidence for [topic]. And one thing was a simple sort of first year concept which I think I probably didn't understand myself on a very deep level when I was a first year student, but I had to teach the students that a few weeks beforehand and I found I could write a lot better on that section given I had been doing the demonstrating. So it did overlap a little bit. Even though it was a basic concept, it was a basic concept that I needed to explain something that was at a higher level. So it helped me in that sense. Demonstrator

Other students acknowledged that demonstrating helped them revise basic science, but did not believe that it helped in terms of PhD research:

I *guess it's probably a good revision of some of the basic concepts that you kind of forget about, after doing an undergraduate degree, and Honours and having a break for a while, which is what I did. Um, I can't think of any specific examples. But I guess it's probably reinforced some of the, you know, building blocks you kind of learn in first year. It's just a good reminder of some of those sort of concepts.[Interviewer – is it useful for you in your PhD?] Probably not specifically. Yeah. And the stuff I've been doing is quite different to it.* Demonstrator

A chemistry coordinator believed that the demonstrating experience was 'brilliant' for PhD and honours students as it is 'pretty important to have a broad chemistry thing going on'.

5.3.3 Preparing for a career

When so many demonstrators are students, a relevant question is how the demonstrating experience helps them to prepare for future careers. The emphasis on communication skills was noted universally by the demonstrators in interviews, but some demonstrators saw a broader value to the experience, for example:

But I'm not a natural teacher, so I'm probably not going to go into the teaching side of things. But I think it's been really useful and it's also nice to enthuse people and you might be sitting at your computer and it's really boring and you're doing it and you feel like you're not getting anywhere and then you go into the class and go hey science is cool and you sort of talk yourself into it. Demonstrator

I think I have seen a couple of demonstrators who have moved to teaching line, just having this experience, and they could realise that yes it's helping us in learning things and we can explain. It's a nice interaction and I can make it as a career. Two of them actually were doing research, and then they have opted that in research, because obviously getting a teaching position is not that very easy, so they have opted to go for education degree and go for school and all. And having this experience, one at least I know who is teaching in our school and she said that she could establish a sort of small lab and based on the design of the experiments and what they were doing here. So it's definitely helped her in a way to use it in her own career. Demonstrator

A coordinator named three career benefits of demonstrating, namely:

+ public speaking;
+ communicating science; and
+ professionalism.

Public speaking and communication has been discussed above. In terms of professionalism, the coordinator pointed out:

They may have never worked before, um or they may have worked in Maccas or Big W. This is a professional environment and we have very high standards … this might be their first job in the field. Coordinator

One demonstrator, however believed that from demonstrating to teaching was a linear pathway, which was not always desirable:

I would not be here otherwise because I can't find work and demonstrating is not a job. It is not a proper job, it is a stepping stone, a teaching role that you learn whether maybe you want to go into the education sector, a lot of people, a lot of demonstrators that are doing the Diploma of Education. I know two who have done it and say they are completely refused to ever go into teaching, they completely hated it and there are two I know doing it now and who knows if they will go into it or not. There is no guarantee. Demonstrator

Apart from the dissenting demonstrator above, the other demonstrators interviewed saw demonstrating as positive experience for careers. Where the demonstrators were older, such as retirees, they had the view that demonstrating was a positive career experience for the younger demonstrators. Although most of the demonstrators seemed to be engaged and generally enthusiastic about their role, the issues of pay and conditions were cited as having a potentially negative impact on engagement.

5.4 Other issues that impact on demonstrator performance

Demonstrating is a casual job, where the employment contract sets out given hours of work for set rates of pay. Section 4.3.1 set out the issues involved in engagement with regard to casual employees, particularly sessional academics. In interviewing demonstrators and coordinators, a fairly frequent reference was made to demonstrators who were "only in it for the money", although, probably because the participants were self-selecting, the demonstrators interviewed generally deplored the attitude. One coordinator noted:

The PhD students… for them, it's more about the money, in a lot of cases, and they see it as a chore and an annoyance in their routine as, as a member of the school, rather than something that they want to do.
Coordinator

An issue that arises in science teaching labs is the concept of just what is a fair amount of time and effort for the money received. In the labs that were the sites of the interviews, demonstrators were generally paid for pre-lab preparation, the actual teaching pracs and the marking. One academic noted that:

… just to encourage them to read the prac book, we have the prelab and we'll go through the prac and talk to them about those activities. So we run those anyway, and we'll continue to run those ,… and we pay them to turn up to that because it's training.

This academic believed the money well spent:

They need to walk in there, even if they're not familiar with the subject material, even though it was years ago that they did first year, they need to be confident when they're dealing with the students.

For younger less experienced demonstrators, the implications of an employment contract became concrete as academics made clear their expectations. One academic notes:

I expect the demonstrators to do their marking immediately following the lab. So they get paid for four hours, three hours' worth of face time, one hour work of marking. They do their marking on the computers in the lab. If they don't, then I get grumpy. I don't sign their pay sheets until they've marked. "I haven't done my marking yet." I'm sorry, not acceptable.

There is some evidence that science faculties are paying demonstrators for time taken in terms of pre-labs and training. One demonstrator stated that s/he had only just starting receiving payment for a one hour pre-lab preparation session:

Yes they wouldn't pay us two years before that, of course, you had to take a whole day like my daughter is in crèche for the whole day and for me to come to a morning meeting and it was just... and a lot of people drive for long distances and not to even get compensated for one measly hour, and they were compulsory. I just had to mention that because it was completely unfair.

One coordinator argued that a major change in terms of demonstrator development for that unit was that 'they're paid for whatever they have to do now … there is recognition that in the past, they were exploited'. The rationale for the change, according to the coordinator, was that 'we want these people to be better equipped, better teachers and better recognized as the quality of their teaching as well'.

Despite better payment, other needs of demonstrators in a casualised workforce can be unmet by the university:

I guess I should be just fortunate enough to have the work that I have but it is not enough and I can't buy a home on this income and sessional teaching. I worked for four months of the year in total, the whole year and unfortunately a lot of people rely on just that income as a supplementary income for their families and I found that I wasn't offered anywhere near enough... I was offered three sessions and I needed four. I could do four, why aren't I getting four sessions a week to teach when I can do them, because they hired two extra demonstrators when they couldn't even give the existing demonstrators enough work and that I think, needs to be looked at, seriously; to deny work to your existing staff. Demonstrator

Conversely, one coordinator who did try to accommodate the working load needs of the demonstrator pool, particularly the experienced demonstrators, noted that he was unable to pay demonstrators for all the work that they did, which caused ‘grumbles’. This situation also meant that he felt unable to impose any more work on them.

An issue that arises is the underlying assumptions toward demonstrators. Do universities see demonstrators as a critical part of their science teaching workforce, or are demonstrators simply PhD students who act as comparatively cheap labour? An allied issue is the underpinning assumption towards demonstrator engagement. Is engagement an issue in which the actions of the faculty play a role? The question of how much investment should be provided to secure a competent demonstrator workforce must be answered in a substantial way before the cost of demonstrator wages can be turned into an investment through a collective learning approach.

5.5 Towards collective learning

Three elements of collective learning were described in the interviews. These elements were feedback loops, emerging cultures and commitment to continuous improvement.

Feedback loops are an important learning/improvement mechanism for any system. In terms of teaching laboratories, two feedback loops were seen to exist. One feedback loop consisted of feedback to demonstrators on their performance in the lab. The other feedback loop consisted of feedback from the demonstrators to the teaching coordinators concerning the activities, equipment and set up of the labs.

5.5.1 Feedback to demonstrators

Whether the demonstrators gained feedback from which they could learn depended on the individual coordinators. One coordinator noted that:

… we tell them, we give them feedback on their teaching, because many of them, all of them, will put it down on their CV, and they want to know how it is going, whether it’s good, bad or indifferent. Coordinator

One university had a formal survey that demonstrators could opt to have administered to students, and according to the coordinator quite a few of the demonstrators to have.

Some demonstrators noted that they received little feedback from their performance, and in fact, when one academic was queried about feedback, their answers indicated that feedback was something that students gave demonstrators, rather than the academics themselves. Although it is useful for demonstrators to receive feedback from students, the usual mechanism for such feedback was from unit evaluations or the specialist survey mentioned above. The problem with feedback proffered at the end of the semester is that the demonstrator does not get the chance to act on the feedback until the next semester, provided that the demonstrator is, in fact, employed in the next semester.

5.5.2 Feedback on the lab session

A strong feature of teaching labs was the receptivity of the coordinators, from the perspective of both coordinators and students interviewed to feedback from the demonstrators. Information on experiments that work and do not work, mistakes in the lab manuals and other aspects of lab teaching are the subjects of potential improvement as the demonstrators work through the lab sessions:

I think the best satisfaction of the program in first year is that we are very collegial, we encourage feedback from them about the pracs. We, many of the pracs are modified as a consequence of feedback from demonstrators. Now, we value their opinion. I always tell them, constantly tell them to let me know if something is going on, so that we can improve the quality of the learning experience of students. It sounds pretty trite to say that, but their opinions are valued. They're not going to be criticised. I recognise that I don't, we don't always get things right.

Coordinator

An issue with implementing the feedback was the strength of the system that caused the feedback to be implemented. It was fairly common that the coordinators would wait until the end of the year and then call for suggestions for improvement then. One coordinator had a strong commitment to continuous improvement, although he did not label his practice in this way. He would occasionally conduct a prac to get the perspectives of the demonstrators. Through this, and other communications, the coordinator was continuously informed of needed changes, and made alterations to the master versions of manuals and other documentation immediately. By incorporating the changes so quickly, ideas and corrections were not forgotten.

5.5.3 Creating a culture

A culture is created as patterns of behaviour become discernible in groups. Schein (1985) succinctly defined culture as 'the way we do things around here'. Interviews with coordinators and demonstrators indicated that, particularly where a coordinator had been a coordinator for some time, cultures emerged. Pay is the extrinsic reward for demonstrating, but there are intrinsic rewards as well, such as mixing with congenial people, working in a congenial atmosphere and feeling part of a special group of people. Much of the enjoyment that demonstrators experience will result from the coordinator and the culture that the coordinator encourages. In the interviews, there were two aspects of culture discernible, one where the demonstrators were part of a team, and the other, more pervasive, related to continual improvement.

Team culture

In two labs in particular, a team culture was noticeable. This seemed to be a way of working with which both coordinators were comfortable. In one case, a demonstrator noted that:

He's [The coordinator] like just the nicest person around to work with and he so much values everybody's input. Because I went to this [event] or whatever, this big university and I met this new lady right, so I was talking, talking, talking and he walks by and I said, "That's my boss." He was like taken aback, "[Name], I'm not your boss. We work together." And he was like so nice. I was like, "But you're the one that decides that I get paid.

You're the boss." And he was like, no. It's very nice comradery, like, we work together you know, for the betterment of the studies. Demonstrator

The other coordinator noted that s/he took pains to encourage the demonstrators to think of themselves as part of a team. Moderating grades, for example, was treated as an opportunity for banter and engagement.

Part of a team culture is to feel included, part of a group. In one university, a demonstrator who was not a PhD student felt frustrated and excluded when s/he could not obtain keys to the laboratory and was refused any place to stow her belongings. Where demonstrators are not otherwise part of the university structure, clearly basic procedures enabling these demonstrators to function need to be instituted in order for the team environment to be experienced by all demonstrators.

Continual improvement

A commitment to continual improvement was evident in terms of the unit coordinators interviewed. One unit coordinator was undertaking a structural reorganisation of the demonstrating arrangements in the next year to encourage a more team-based approach and an inquiry-based learning experience for students. Another coordinator looked forward to using wikis and Moodle to encourage demonstrators to communicate with each other. For each coordinator, planning to strengthen the way demonstrators interacted with students in the labs was considered to be part of their role.

The findings depicted in this section show that in some laboratories, due to the efforts of the coordinators, that a learning culture was emerging through the structures relating to feedback, continuous improvement and team cultures.

5.6 Conclusions

The challenges facing undergraduate laboratories in science higher education are increasing. The Higher Education Standards Framework is likely to lead to a more stringent quality regime, national curriculum standards in secondary education will affect the expectations of school leavers undertaking a science degree, and the removal of student caps will add pressure on university infrastructure.

In response to these challenges, however, labs are evolving. In terms of demonstrator development, Australian science faculties are responding in ways that have been promoted in the science education literature, and demonstrators are now instructed in pedagogy, student engagement, maintaining safe laboratories and assessing students' work. The focus of much of the demonstrator learning was to prepare the demonstrators to cope in the lab in terms of present demands. It is suggested that although this development strategy is a definite improvement on doing little or no training, it is a strategy that positions the development as a cost – when the demonstrator leaves, their knowledge leaves with them and new demonstrators have to be brought up to the required standard.

The next stage for demonstrator development can be discerned in the practice of some labs in which interviews took place. In these labs, learning was optimised in collective ways. New knowledge was "imported" through the careful recruitment and selection of science professionals who had more life experience than the majority of current demonstrators. Some coordinators encouraged gatherings of demonstrators, both formal and informal, where knowledge could be shared and generated, creating new practice in the lab. Continuous improvement was actively encouraged by actively seeking out feedback from demonstrators and immediately embedding improvements in lab manuals and lab practice.

Further improvements to the labs can be fostered through processes of collective learning and promoting a learning culture, shown in the recommendations in the next section. In particular, such a workplace culture facilitates and sustains the realisation of the potential of teaching laboratories to foster inquiry-based learning, develop graduate capabilities, and to identify and address the diversity of student backgrounds and aspirations. Such a focus requires more than formal and informal professional learning provided to individuals, and certainly more than relying on a pre-semester workshop and prelab sessions. The human resource practices related to recruiting, selection, feedback and working conditions must be also considered as a foundation for collective learning.

This focus on fostering collective learning among the demonstrators and other lab staff will make learning more sustainable, improve the experience in the labs sessions and turn the teaching lab into a learning lab.

learning laboratory/ies
professional learning
undergraduate science education
higher education
collective learning
inquiry
laboratories
engagement
professional learning
undergraduates
engagement
demonstrators
science
continuous improvement
undergraduates
science teaching and learning
team culture
demonstator
professional workforce
engagement
feedback
graduate teaching assistants
science teaching and learning
laboratory
higher education
feedback
graduate teaching assistants
team culture
inquiry learning
continuous improvement
higher education
selection
selection
team culture
undergraduate science education
selection
graduate teaching assistants
inquiry

6 Recommendations

Drawing on the findings and the literature review,
the following conclusions and recommendations are proposed.

6.1 Recommendations

Demonstrator recruitment and selection

The role of demonstrator is often seen as a rite of passage for PhD and honours students. The inclusion of others in the demonstrator pool can benefit the demonstrator group as a whole, and the enrolled students. People who are employed in industry, retirees and carers looking for part-time work can add a valuable dimension to the teaching lab. For the demonstrators, the breadth of experience can add both knowledge and reassurance to inexperienced, young demonstrators, particularly where mentoring is encouraged. For students, the inclusion of demonstrators from a broader range of experience illustrates the diverse pathways that a science degree engenders.

1. Groups of demonstrators should encompass a wider range of experience than university science research. Faculties should consider policies for including, where appropriate, experienced science professionals to provide leadership and expertise to the demonstrator group, as well as a link to the more diverse backgrounds and aspirations of students.

Demonstrator competency building

In universities, the structural unit for strategizing is usually the faculty. First year science subjects, however, have elements of a strategic entity. Such subjects have diversified staff, different sites of activity, and structures. Instead of treating first year science subjects as an activity, faculties could usefully treat such subjects as a strategic entities which require formal structures, processes and a (learning) culture that enable the achievement of a vision for the subject. The induction of demonstrators into a collective learning environment not only will improve the competency of individual demonstrators, but makes the competency building sustainable over time.

2. An explicit vision for the teaching laboratories should be articulated that provides focus for demonstrator development as well as teaching and learning for students.
3. Demonstrator development should be planned within a framework focused by the vision, which could include:
   - formal professional learning sessions that are linked to lab practice
   - pre-lab briefing sessions
   - formal and/or informal mentoring during the semester
   - promotion of a learning culture where demonstrators share ideas and knowledge, and where new knowledge is embedded in the documents and practice of the lab
   - debriefing or "lessons learned" session at the end of the semester.
4. Laboratory program coordinators should provide feedback (both positive and developmental) to demonstrators at regular intervals and encourage feedback from demonstrators.
5. Student feedback mechanisms on demonstrator performance should be established

Demonstrator working conditions

The performance of demonstrators is not dependent solely on the provision of teaching and learning activities. Demonstrators need to feel engagement with the aims of the subject, the activities of the teaching laboratories and that their work is of value. Engagement is difficult to achieve if the working conditions such as pay and facilities are not considered "fair", and/or respectful of the demonstrators.

6. Science faculties should review the pay arrangements for demonstrators to promote fair payment for effort and time spent in demonstrator-related activities to encourage learning cultures in the laboratories.
7. Science faculties should review working conditions for demonstrators, particularly demonstrators who are not students of the university, to ensure that these demonstrators have the resources to perform their work

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8 Appendices

8.1 The empirical research

This project employed a mixed method approach where three methods were used to collect the data, namely:

+ survey
+ interviews
+ documentary analysis of university websites.
+ Survey

8.1.1 Survey

The preparation of the survey took account of two somewhat conflicting objectives. The survey had to be comprehensive enough to elicit useful data, but imposing as little burden as possible on the respondents in terms of time needed to assemble and report the requested data. Several academics trialed the survey, and the survey was made available to science academics through the web-based software SurveyMonkey.

After it was judged that sufficient responses had been received[2], data was downloaded from SurveyMonkey into an Excel spreadsheet. In this format, the data requiring closed and numerical responses has been sorted, counted and calculated using Excel functionality. A copy of the original download has been retained and is used as a check to ensure accuracy of the adjusted data. In manipulating and adjusting the data, protocols were created and used to prevent confusion. Where responses 'skipped' questions, there seemed no point in discarding the other information supplied, and the rest of the response was used in the data analysis.

Sixty-eight potentially useable responses had been received, including two by email.

Of these, several responses were found to have related to second year subjects, which were not within the parameters of this study. In addition, although the survey asked for information at a subject level, several respondents:

+ combined several subjects in one response, or
+ prepared a response to account for all faculty or all disciplinary first teaching.

2 Reports were provided to the ACDS on response rates after each stage of followup.

The number of subjects that were included in sixty-eight responses is shown in Table 4[3].

Disciplines	Number of subjects reported
Biology	23
Chemistry	19
Physics	20
Other	14
Faculty response	1
Total	77

Table 4: Number of subjects in the study after adjustment of data

8.1.2 Interviews

The interviews took place with six academics who coordinated first year science units in Australian universities. Five of these coordinators were chosen according to data provided in the sur vey. Other coordinators were contacted but either declined or failed to reply. One further coordinator was approached on the basis of external recognition of lab teaching.

In addition, a call went out to the demonstrators of those units, of which fifteen in total agreed to be interviewed. The demonstrators were paid with a $50 gift voucher for their time.

The interviews were guided with semi-structured questions, and analysed using NVivo qualitative analysis software, focused by the research questions, and also using a grounded approach to develop further themes.

8.1.3 Documentary analysis of websites

The websites of Australian universities were searched to ascertain the level of centralised development activities for demonstrators. Where websites were not clear about the development offered, a followup email was issued. This work resulted in a table available in the Findings.

8.1.4 Ethical clearance

This research involved human subjects and thus received ethical clearance from the Monash University Human Research Ethics Committee, see approval number MUHREC: CF11/0702 - 2011000153

3 These figures do not include the faculty or whole of first year responses.

Questionnaire

8.2 Questionnaire

Thank you for taking the time to answer this questionnaire for the Australian Council of Deans of Science research project The state of demonstrator development in Australian universities.

The questionnaire deals with the first year subject/course that you coordinate. Your answers will be treated as confidential. The questionnaire should take you no more than 20 minutes.

1. **Name of University:**

2. **Discipline:**

◯ Physics ◯ Biology ◯ Chemistry ◯ Other

3. **Name of subject:**

4. **Please indicate the background of the demonstrators employed in 2009 by clicking on the relevant fields.**

% of demonstrators	1 - 10	11 - 30	31 - 50	51 - 70	71 - 90	91 – 100
PhD students	◯	◯	◯	◯	◯	◯
Honours students	◯	◯	◯	◯	◯	◯
Senior undergraduates	◯	◯	◯	◯	◯	◯
Academics	◯	◯	◯	◯	◯	◯
Retirees from industry	◯	◯	◯	◯	◯	◯
Other	◯	◯	◯	◯	◯	◯

5. How many demonstrators were employed in this topic in 2009? ☐

6. Is any form of formal or informal training and development provided by your department or any other department or body?

No ◯ [send participant to question 7]

Yes ◯ [send participant to question 8]

7. Training and/or development is not provided because:

____

____

In this study, "training" is defined as activities that occur that enable people to perform particular tasks, for example, the Occupational Health and Safety issues for a particular laboratory, while "development" is defined as a process of enabling people to grow into a career, for example, conflict resolution skills.

8. What is the nature of the training activities provided for demonstrators?

____

____

____

____

9. Is this training provided by:

a. your department ◯

b. a central training department ◯

c. both a and b above ◯

10. What is the nature of the development activities for demonstrators?

____

____

____

____

11. Is this training provided by:

    a. your department ◯
    b. a central training department ◯
    c. both a and b above ◯

12. What are the rationale and outcomes achieved by current training and development?

13. Informal training and development activities can be powerful learning experiences for demonstrators. Are there any other activities provided by your department to support demonstrators in their role?

14. Do you give permission for an interview of no more than 50 minutes about demonstrator development related to the subject that you coordinate if required? You can withdraw this permission, and such a withdrawal will remain confidential.

    Yes ◯
    No ◯

Many thanks for completing this questionnaire!