Supply, demand and approaches to employment by people with postgraduate research qualifications in science and mathematics:

Consultation Report

Report to the Australian Government Department of Education, Employment and Workplace Relations

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Australian Council for Educational Research

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Executive Summary

This report is part of a wider research project examining issues of supply, demand and employment opportunities for people with research degree qualifications (Doctor of Philosophy (PhD) and Masters) in the mathematics and science fields in Australia. The research aims to identify key factors influencing supply and demand and examine the views of various stakeholders in relation to these factors. The project comprises three main stages – a literature review and data analysis, consultations with stakeholders and case studies of organisations with good employment practice.

This report presents findings from the consultation stage of the project. It is based on interviews and group discussions with a wide range of people and peak bodies closely involved in the training, employment and promotion of scientists and mathematicians in Australia. Consultation participants included employers from the private and public sector; university academics; employer, university and discipline stakeholder groups; post doctoral researchers; and postgraduate mathematics and science students. The participants were from a range of geographic locations across Australia and a broad spectrum of the disciplines and sub-disciplines that constitute the science and mathematics fields.

In total, more than 120 people, representing 37 different groups and employers, and most universities in Australia were involved in the consultation process.

Key Findings

- The general consensus appears to be that Australian science and mathematics PhDs are as good as those available in any other part of the world.

- In general, employers (especially those in the private sector) of mathematicians and scientists do not specifically seek employees with a PhD or Masters qualification. Instead, they are most interested in Bachelor and Honours level graduates. This situation appears to be at odds with other parts of the world.
• Universities are finding it increasingly hard to attract high quality PhD candidates in the mathematics and science disciplines. This is due to a strong graduate employment market, the lack of emphasis on these degrees in industry (due to declining investment in Research and Development (R&D), very low stipends for PhD candidates and declining numbers of students in school and at the undergraduate level studying in these fields.

• Those who are studying or have recently completed a PhD in science or mathematics are passionate about research, but see that most employment opportunities for them are outside Australia.

• The university sector in Australia is likely to have problems in replacing the imminent retirements unless the profession can be made more attractive. Finding ways to address issues related to the post doctoral ‘treadmill’, providing greater security of tenure, and balancing teaching, research and administrative expectations of academics are all issues that need to be addressed if more young researchers are to be attracted to academic careers.

• Increasing demand for high level research qualifications in these fields is contingent on increasing the levels of research and development undertaken in Australia. This in turn depends on the priorities of government and industry.

• There is a need for much greater university-industry collaboration in the science and mathematics areas. This would have the potential to increase industry awareness of the skills these qualifications can offer, and alert universities to the types of graduates that employers need.

• Future demand is likely to exist for people with qualifications in mathematics and science due to the fact that people with these skills are needed to solve issues of climate change, to deal with sustainability of resources, to sustain Australia’s mining capabilities, to predict and prepare for the future through the creation of scientific models, and to invent and maintain new technologies.
• In particular, there is a strong need for scientists with multidisciplinary capabilities, particularly capabilities that include strong quantitative skills combined with knowledge in another field (for example, statistics and biology).

• In order to improve industry engagement and increase employment supply to the university sector, the profile of science and mathematics need to be raised. This will involve allocating better resources to those groups involved in promoting science within schools and among the wider community.

In addition to these findings from the consultation process, three key ideas emerged consistently. These ideas were aimed at providing solutions to some of the issues noted above. For a strong and sustainable future in mathematics and sciences to be realised, consultation subjects emphasised the following solutions (embedded in education):

• Renewed efforts to improve participation in and quality of science provision in schools, with focus initially on attracting qualified and motivated teachers.

• Education provision in universities (especially at the postgraduate level) needs to be more applied and curricula need to be developed in closer collaboration with both private industry and the public sector.

• Employers need to be educated about the value of people with higher degree research (HDR) qualifications and the importance of these people in establishing a strong reputation of innovation and expertise for their enterprise and more broadly for Australia.
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<tr>
<td>ACCI</td>
<td>Australian Chamber of Commerce and Industry</td>
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<td>ACDS</td>
<td>Australian Council of Deans of Science</td>
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<td>ACER</td>
<td>Australian Council for Educational Research</td>
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<td>AiG</td>
<td>Australian Industry Group</td>
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<td>APA</td>
<td>Australian Postgraduate Award</td>
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<tr>
<td>APESMA</td>
<td>Association of Professional Engineers, Scientists and Managers</td>
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<tr>
<td>CRC</td>
<td>Cooperative Research Centre</td>
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<tr>
<td>CRCA</td>
<td>Cooperative Research Centres Association</td>
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<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation</td>
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<td>DEEWR</td>
<td>Department of Education, Employment and Workplace Relations</td>
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<td>DEST</td>
<td>Department of Education, Science and Training (former federal department)</td>
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<tr>
<td>DIAC</td>
<td>Department of Immigration and Citizenship</td>
</tr>
<tr>
<td>DIISR</td>
<td>Department of Innovation, Industry, Science and Research</td>
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<tr>
<td>GCA</td>
<td>Graduate Careers Australia</td>
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<td>GDS</td>
<td>Graduate Destinations Survey</td>
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<td>FASTS</td>
<td>Federation of Australian Scientific and Technological Societies</td>
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<tr>
<td>HDR</td>
<td>Higher Degree Research</td>
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<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>NAGCAS</td>
<td>National Association of Graduate Careers Advisory Services</td>
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<tr>
<td>NSW</td>
<td>New South Wales</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>PhD</td>
<td>Doctor of Philosophy</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<td>--------------------------------------------------</td>
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<tr>
<td>SMEs</td>
<td>Small and Medium Enterprises</td>
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<tr>
<td>STEM</td>
<td>Science, technology, engineering and mathematics</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RTS</td>
<td>Research Training Scheme</td>
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<td>UA</td>
<td>Universities Australia</td>
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<td>UK</td>
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<td>United States of America</td>
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Note

This report is one of four which make up a project examining the supply, demand and employment opportunities for graduates with higher degree research qualifications in the science and mathematics fields in Australia. Each report is intended to stand alone as an independent piece of research. However, in order to gain an overall perspective of the factors influencing supply and demand for this group it is important to consider all the reports in this project. In addition, the report findings highlighted here are based on information available at the time. These findings can be expected to vary with changing circumstances.

The four reports comprising the project are: 1) Literature Review And Data Analysis, 2) Consultation Report, 3) Case Study Report and 4) Final Report. These are available on the DEEWR website and can be accessed at:

Acknowledgements

The authors of this report would like to thank colleagues at ACER for the support and assistance provided during this research project, in particular Dr Hamish Coates and Dr Phillip McKenzie. We also acknowledge the invaluable advice and comment provided by DEEWR and the project Reference Group that has helped to frame this project and facilitate links with many of those involved in the consultation. Most importantly, we offer sincere thanks to the numerous groups and individuals who took part in the interviews and discussions that are the basis for this report.
1 Introduction

This is the second report in a series of four in this project that examine issues of supply, demand and employment opportunities for people with research degree qualifications in the mathematics and science fields in Australia.

This report details the findings of the consultation phase of this project. It is an accompaniment to the first report in this project, which explored national and international literature relating to these issues and undertook an analysis of numerous data sets to investigate some key issues relating to higher degree qualifications and areas of interest in this project.

The second phase of this research project involved gathering information from stakeholders related to issues surrounding the demand, supply and employment outcomes for people with science and mathematics HDR qualifications in Australia. The aim of this phase is to build on the findings of the Literature Review and Data Analysis Report in order to create a better understanding of the issues facing employers, universities and individuals with an interest in these issues. This phase provides an up-to-date analysis of the experiences and practices of a range of key groups and individuals on the issues of demand and supply in these areas of expertise in Australia.

The scope and direction of the consultation phase of this research project has been guided primarily by findings and outcomes stemming from the research undertaken in the first stage of the project. The first report revealed a number of key themes and issues that have been explored further in the consultations. The key findings of the literature review and data analysis included:

- Australian output of HDR graduates in the science and mathematics fields is growing at a rate faster than many other comparable nations. However, the growth in graduates in these fields in Australia is not as large as the growth in other fields of education.

- Despite growth in numbers in Australia and internationally, there still appears to be unmet demand for people with these qualifications. Some of the literature (for
example, FASTS 2008; Mason, 1999) argued that demand was high because employers were not satisfied with the quality of existing graduates.

- Australia experienced a net inflow of science professionals between 2002 and 2007 due to its skilled migration program.

- Those with PhD and Masters qualifications in mathematics and science in Australia have high levels of employment and are predominantly working in professional occupations. Many are employed in the university sector, although there are substantial differences in occupation depending on the specific discipline of expertise. In general there appears to be a relatively good job-skills match for people with these qualifications in Australia.

- Demand is hard to measure and current data available in Australia only allows for an indication of the extent to which demand exists in each of the disciplines within the science and mathematics area (Edwards & Smith, 2008). From the available data, there appears to have been growing demand in the science professions over the past five years (Edwards & Smith, 2008, pp. 77-79). However, the extent to which this demand is for HDR qualified people is unclear.

- The age profile of the workforce of people with higher degree qualifications in science and mathematics in Australia shows that this group is older than the rest of the professional workforce. However, there is a relatively good ‘stock’ of younger people with these qualifications.

- Within the academic workforce there is a similar issue with the age structure. While there are relatively robust numbers of younger academics in the mathematics and science fields within universities, retaining these people for long enough to help fill positions vacated by large numbers of ‘baby boomers’ may be difficult due to declining availability of tenured positions and an increasing trend towards short-term contracts.

This report begins with an overview of the participants and discussion of the method and approach taken with the consultations (Chapter 2). It is followed by a broad discussion of the key findings from the consultations (Chapter 3). The subsequent three chapters provide a detailed and more targeted discussion of the findings.
stemming from this report. Each of these chapters relates to a main sector/group involved in the consultation process. The chapters cover views from the university sector (Chapter 4), employers (Chapter 5), and early-career researchers and current postgraduate students (Chapter 6). Each chapter is also divided into sub-sections to cover a range of key issues covered in the consultations.

This research is being undertaken by a team from the Australian Council for Educational Research (ACER). The project is funded by the Department of Education, Employment and Workplace Relations (DEEWR) and directed by the Skills Analysis section of the Research Analysis and Evaluation Group. A Reference Group has been formed to advise and guide the direction of the project. Members of the Reference Group are listed in Appendix A.

The next report in this project will examine case studies of organisations with good employment practice for this group, and the fourth, and final, report will provide a summary and synthesis of the first three research reports.
2 Research Methodology

The consultation process in this research covered a wide range of people and groups closely involved in the training, employment and promotion of scientists and mathematicians in Australia. It must be highlighted that this consultation phase was not intended to constitute a representative sample of stakeholders in this area. Nonetheless, the consultations gained insight from groups and individuals who represented a range of employers from the private and public sector and a number of universities across Australia covering a broad spectrum of the disciplines and sub-disciplines that constitute the science and mathematics fields.

2.1 Consultation participants

Groups and individuals were selected for involvement in the consultation by the ACER team in collaboration with DEEWR and the project Reference Group. Contact was made with all groups listed in the proposal for this stage of the research and the vast majority were subsequently involved in consultations. In addition to the groups and employers listed in the proposal document, some other groups and employers were contacted on the recommendation of consultation participants.

Initially the consultations focused on peak representative bodies of university and employer groups. The views of smaller, discipline-specific groups and recruitment firms were explored next, and the final stage concerned the views of individual employers, students, early career researchers and academics. In total, more than 120 individuals were involved in the consultation process, representing 37 groups or employers and most universities in Australia. Appendix B includes a list of the groups and employers involved in the consultation.

2.2 Consultation approach

There were two main methods employed in the consultation process: individual interviews and group discussions. Consultations were carried out as semi-structured interviews, with key questions and issues raised by the researchers and specifics of the discussion guided by the area of expertise of the interviewee or group. The majority of interviews were carried out via telephone primarily because of the geographical location of participants and due to the constraints of time and convenience of this technology for participants.
Many of the consultations undertaken involved individuals speaking with one or both of the main researchers. However, the ACER team also undertook a number of larger group interviews with key stakeholder groups. In particular, larger group discussions were carried out with Universities Australia (UA), the Cooperative Research Centres Association (CRCA), the Australian Council of Deans of Science (ACDS), the Federation of Australian Scientific and Technological Societies (FASTS), the Australian Academy of Science, Innovative Research Universities Australia (IRUA), Geoscience Australia, the Australian Mathematical Sciences Institute, and the Science Research and Development Park at the Bundoora campus of La Trobe University (Melbourne). In addition, a focus group discussion was undertaken with Post Doctoral candidates at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Clayton (Melbourne) site. Individual interviews were generally of half an hour in length, while group discussions were an hour.

Consultation participants were contacted via telephone and email, and a number of the large groups involved in the consultation were provided with a document outlining the project and the consultation phase. This document can be found in Appendix B.

As noted above, the broad issues covered in the consultations were established during the first stage of this research project through the Literature Review and Data Analysis Report. Following the earlier research, the ACER team compiled a list of key issues to be explored in the consultations. This list was distributed among the Reference Group and was amended following feedback. A table outlining the main broad issues covered and indicating the target groups for each issue is displayed in Appendix D.
3 Key Findings: Perceptions of demand, supply and employment opportunities

3.1 Introduction

The key findings from stakeholder consultations are discussed in this chapter which incorporates the views of the main groups and sectors involved in the consultations. Detailed discussion of the views among individual sectors is presented in the following three chapters.

3.2 Key findings

Overall, the story emanating from these consultations is complex and contingent on a number of factors, in particular discipline type and geographical location. However, there were common themes that emerged throughout the consultations. These themes are discussed here.

In general, the feedback from employers, especially private sector employers, was that the PhD or Masters by Research qualification in the mathematics and science fields is not particularly sought after by Australian industry. There was a common view among private industry expressing the desire for good quality undergraduates (especially honours graduates) rather than those with higher qualifications. The public sector employers involved in the discussions generally had a greater recognition of the value of HDR qualifications.

Similarly, academics and university stakeholder groups generally indicated that there was little or no premium given to the PhD in Australia and although their graduates were having little trouble finding jobs, the financial reward for the additional study undertaken was not substantial. Academics and others emphasised the notion that this lack of appreciation of the PhD by industry in Australia was not common in other parts of the world and as a result, the potential for Australia to lose its best scientists overseas was acute.

In between are the students and early-career researchers themselves. This group appears to be relatively ‘tuned in’ to the apparent indifference of private enterprise to higher degrees in the science and mathematics fields. Nonetheless, many believe that
there are opportunities for them within the academic sphere, in public research bodies and within the private sector – as long as they can prove themselves to be adaptable.

Therefore, the overall picture of demand for postgraduates with research degrees in the science and mathematics fields is seen differently from the perspectives of each of the three key sectors identified in this report. In the present situation, it appears that from an industry perspective, the only need for PhD qualified persons is within universities – operating as training facilitators to ‘pump out’ more undergraduates. From the universities point of view, there is a vision that if better links with industry in Australia are formed, recognition of the value of PhDs in the mathematics and sciences will increase and so will demand. And, if this does not happen, many academics and science peak bodies contend that Australian industry will suffer in a highly competitive global market where most of the competition is utilising PhD qualified people. Among students and recent graduates themselves, there is a hint of optimism about the future and a general confidence that their skills are needed. However, this optimism and confidence is accompanied by an element of caution.
4 The University Sector

4.1 Introduction

In this chapter the findings relating to the consultations with universities are discussed. The consultation process involved a large number of university academics, Deans of science faculties, and university and discipline peak bodies. Appendix C lists these institutions and peak bodies.

Academics and university representative bodies were keen to emphasise that there are substantial differences among the science disciplines when it comes to discussing issues of demand, employment, training and quality of people with higher degree qualifications in the mathematics and science fields. While most of the comments from the people in this sector were general in nature, some discipline-specific issues emerged which are discussed below.

4.2 Demand and employment opportunities

Among academics and others involved in the university sector, there appear to be two key elements in discussions of demand in respect to HDR graduates. One is demand among undergraduate students for positions in HDR (especially PhD) programs. The other is demand among employers within Australia for people with a HDR qualification. Each of these issues is treated separately in the discussion below.

4.2.1 Demand for HDR programs among students

Incentives

Academics from all universities involved in the consultations and across all disciplines expressed substantial difficulty in recruiting undergraduate students into research training programs in the mathematics and science disciplines. In general, there is a feeling that the incentives to undertake a PhD in Australia are not sufficient. Scholarships ranging between $20,000 and $30,000 (tax free) per annum are being offered throughout Australia, with different top-up schemes existing to raise the level to the $30,000 mark. Academics from a number of universities, including some of the larger and more prestigious in Australia, mentioned having to compromise on previous levels of expectation of quality in order to fill scholarships (and not have to
return funding) in recent years. In particular, issues in funding industry-based scholarships PhD scholarships in universities are most acute.

The reason given for this low demand is that currently there is such a strong graduate employment market in Australia that people finishing their undergraduate or honours degrees are finding lucrative jobs easily and are not seeing any reason to pursue a higher degree. As articulated in one discussion, there is a pattern whereby in good economic times with high growth and high employment it is difficult to recruit good undergraduates into research degrees, and in the reverse situation undergraduates are more likely to go on to postgraduate enrolment.

At present it appears that most disciplines have recruitment difficulties. Areas that struggle to recruit research degree students include statistics, where graduate demand is very high, salaries are excellent and the best undergraduates are focused on work rather than further study; and chemistry, where workforce demand is high and salaries have been increasing.

The education pipeline

The issue relating to transition to higher degrees is also seen by academics and stakeholder groups as one that can be traced to the declining participation in science at the school level. Many groups noted that there are currently low levels of participation in the senior levels of secondary school in the mathematics and science disciplines, and that this is leading to fewer prospective undergraduate students and, in turn, a reduction in the flow into postgraduate qualifications.

Partly as a result of the lower demand among students for places in science and mathematics PhD and Masters programs, universities are enrolling a growing proportion of international HDR students in their faculties. There was some concern expressed that this reflected poorly on the overall domestic training situation, because many postgraduate international students do not remain in Australia following completion of their degree.

4.2.2 Demand for HDR qualifications among employers

In accord with the figures shown in the Literature Review and Data Analysis Report (Edwards & Smith, 2008, pp. 52-55), academics noted that very few of their
Completing PhD and Masters by Research students had trouble finding employment. This simple fact contributed to a general optimism about the necessity for people with these qualifications. The types of jobs taken by people with HDR qualifications ranged widely across the science and mathematics fields. Many academics indicated that their students were undertaking work utilising skills they had gained during their study. A few suggested that the opportunities within niche areas of specialisation (for example, in pure mathematics) were limited, but that graduates who could see the adaptability of their skills had been able to find good jobs. In general it was agreed that students who had completed theses with an ‘applied’ edge to them found it easiest to gain employment, especially outside the university sphere. Academics and university peak groups perceived that there was employment demand in the public, private and university sectors for most HDR graduates.

**Perceptions of industry demand**

However, quelling the general optimism were some key elements identified as problematic in the demand dynamics for scientists and mathematicians with HDR qualifications. In particular, the consistent theme enunciated by university sector groups that private industry in Australia was desperate for science undergraduates but relatively ambivalent about postgraduates with research degrees. Many academics believed that Australian industry does not understand how to utilise the research skills of PhD graduates and therefore have an over-reliance on undergraduates. The view was expressed that this lack of appreciation of the value of a PhD could be the result of the general absence of higher degree qualifications in industry management.

This situation was contrasted starkly with industry demand in other countries. The experiences of one academic in the area of mathematical statistics provide an example of the feeling among many academics. This professor holds academic positions in both Australia and California. He has found that the skills his PhD graduates have are invaluable for a range of different jobs across a variety of industries, and among the disciplines in the science and mathematics areas, statistics expertise is relatively well recognised by private enterprise. However, the employment destinations of his students in Australia were notably different to those in the US. Of his completing PhD students in California, more than 95 per cent enter employment in private industry, while in Australia the figure is between 60 and 70 per cent. An example raised by
academics that highlights the differences in employers’ appreciation of a PhD in Australia is the pharmaceutical industry, where companies in Australia are focused on undergraduates, but in Asia, the US, the UK and Europe, PhD qualifications are viewed with a premium by these companies and their research and development areas.

The declining research and development (R&D) capabilities of companies based in Australia also appears to be contributing to problems in the recognition of a PhD degree in private industry in Australia. It was mentioned both in university peak group discussions and individual interviews that large companies have moved their R&D divisions out of Australia in the past few decades and that as a result, opportunities for HDR graduates have been reduced. An open letter written in mid-2003 to the then Minister for Education, Brendan Nelson by the head of the biometrics development arm of Roche Products (Australia), himself a former Australian academic, was provided by one of the consultation participants as an example of the issues facing both industry and the university sector. The letter details the demise of a number of multinational biometric development sites in Australia – originally established as bases for the Asia Pacific Region because of a reputation of ‘excellent educational institutions and a stable political system’. The main problem facing these companies was a substantial decline in availability of qualified people from Australian universities. The letter argued that if companies had to continue to recruit from other countries, they would relocate.

*Ideas for increasing demand*

Some academics argued that if there was any intention to increase demand for PhDs in the science and mathematics areas, the present focus of the Australian Government on Small and Medium Enterprises (SMEs) was misguided, a view that was reinforced in an interview with representatives from SMEs. The contention among the academic groups was that SMEs constitute only a small market in the provision of research-intensive jobs and therefore focusing on their capabilities would not have a substantial overall impact on demand or opportunities for those with HDR qualifications. Academics pointed out that the vast majority of industry jobs for PhD graduates are in the R&D areas of large multinational companies, so investment in attracting large companies to base their R&D centres in Australia is more likely to stimulate industry demand and opportunities for high quality research capabilities in these fields.
While such policy suggestions were relatively common among academics in these consultations, very few of those working in universities had common contact with industry. In general, it appeared to be that strong links between industry and university departments in Australia are relatively rare. While there were some clear exceptions to this, there was a general acceptance by senior academics in science faculties that the level of contact and collaboration between industry and universities is minimal. It was believed that if links could be established, the recognition of the value of a higher degree in the mathematics and science fields within industry would be increased.

4.2.3 Academic profession – demand and opportunities

Within the university sector itself, there were a number of different issues relating to demand in the academic profession that were raised by academics and peak bodies. The main concerns in this regard were fostering a new generation of academics to replace imminent retirees, finding ways to address issues related to the post doctoral ‘treadmill’ and providing greater security of tenure, and balancing teaching and research capabilities of academics.

Decreasing desirability of academia

Among the academics spoken to during the consultations, there was a consistent message emphasising the growing workload expectations of academics. In many cases, the profession was painted as particularly undesirable due to intense competition for research funding, large teaching burden, increasing administrative duties and, for many, lack of tenured opportunities. In this light, the lure of an academic career for the current crop of PhD students appears to be relatively uninviting.

As a result, the concern among senior academics in the mathematics and science faculties across Australia is that there will be a shortage of new academics to fill the positions of the expected large numbers of retirements over the coming decade. The age profile figures for the academic profession explored in the Literature Review and Data Analysis Report showed that there are currently sufficient numbers of early and mid-career academics in the science and mathematics fields to replace those coming to the end of their careers (Edwards & Smith, 2008, p. 85). But numerous academics
warned that assuming there would be a smooth transition over the next decade was misguided because growing demands on academics and the lack of mid-career tenured opportunities was likely to lead to an increasing exodus from the academic sphere for mid-career as well as later career academics in the near future.

*The ‘Post Doctoral Treadmill’*

One of the key issues facing science faculties in retaining staff during their early and mid-careers is the fact that the number of tenured positions is decreasing. The data analysis in the first report in this project highlighted this trend and the consultation phase confirmed what the statistics suggested. A number of academics referred to the ‘post doc treadmill’ issue, whereby researchers in the sciences have found themselves stuck in post doctoral contract after post doctoral contract, always chasing new grants and never getting time to properly establish their research profile, nor having the opportunity to gain teaching experience. Some academics pointed out that for some of these researchers, this is what they are best at and other positions might not suit their style of work. However, for the majority of academics, the ‘post doc treadmill’ is something that is not of benefit.

This is not to say that post doctoral positions are out of favour among academics – they are considered a key phase of the research career of scientists and mathematicians. What the university sector is not keen on is the fact that post doctoral positions are morphing from something one undertook in their early career to a position that scientists commonly find themselves in well into the middle of their careers. The concern is that once in this cycle of post doctoral positions, many researchers find it hard to gain a tenured posting.

In this regard, there was some fear among academics involved in the consultations that the Australian Government’s Federation Fellowships/Australian Laureate Fellowships and Future Fellowships may be further extending the ‘treadmill’ pathway further up the ranks of academia. These Fellowships, allocated by the Australian Research Council, provide funding and support for senior academics in Australia for a
set amount of time, to work on research projects of national significance.\(^1\) It is argued that while these schemes are useful, there is no guarantee of job security or a tenured position for a researcher at the completion of the fellowship. Another issue raised in regard to these schemes is that they were creating a large amount of ‘churn’ in the system, with the same people moving from one scheme to another, therefore raising questions about the ability of some schemes to attract new talent.

To counteract the issues mentioned above, many universities in Australia are now offering opportunities to post doctoral and grant-based researchers who bring research projects (and therefore money) to them. A common practice that appears to be emerging is for universities to promise an academic from outside the university bringing a lucrative and high profile Australian Research Council (ARC) grant or Fellowship to the university, a tenured position at the completion of the funding. However as this tends to attract only those academics considered to be the best in their fields, only a small number of academic positions are affected and it certainly does not extend ‘across the board’.

Senior academics in science and mathematics faculties across Australia indicate that this sort of offer works in a university’s favour in a number of ways. First, it attracts immediate research funding, via the research grant held by the new appointee. Second, it attracts high profile academics to the department. And third, it provides the university with the opportunity to fill a tenured position ‘in the future’ – i.e. not immediately. This ‘buying time’ benefit is seen as particularly crucial due to the impending retirements of senior academics. It allows the university to plan ahead for these retirements and have a ‘tried and tested’ academic assume the position of those at the end of their career. However, it does require universities to have an effective workforce planning strategy.

Changing nature of academic work

Another issue raised in relation to the career opportunities within universities for those with research degrees in the mathematics and sciences is that the expectations of

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academics have grown substantially in recent times. Today, there is much emphasis placed on attracting research funding while at the same time a need for academics to teach undergraduates and supervise postgraduates, and keep up-to-date with a range of administrative requirements, particularly reporting on performance. Due to the increasing difficulty in balancing these pressures, many academics involved in the consultations indicated that the academic career path is not one they would recommend to young researchers.

Areas of demand

Within the academic sphere, there appear to be a number of areas with high demand for staff. In particular, a number of people mentioned the lack of senior statisticians in Australian universities – positions for a Chair in Statistics have remained vacant for a number of years in some universities across Australia. Other areas where there was mention of high demand for academics were water management, ecological sustainability, biostatistics, and applied mathematics.

Among the more visionary academics involved in the consultations, there was a strong sense that the future for science would be forged by those who had multidisciplinary capabilities – particularly those with expertise in a quantitative field that was supplemented by proficiency in another science discipline. Biostatistics is an example of such multidisciplinary capabilities (the melding of biology and statistics) that are seen as important for the future.

4.3 Training and quality issues

Among the groups and individuals from the university sector consulted during this phase of the project, a number of different opinions emerged in relation to the role of the PhD program in universities and the extent to which the needs of industry should dictate the curriculum and course offerings within institutions. On issues of quality, the general consensus was that Australian science and mathematics PhDs are as good as those available in any other part of the world. However, there were some hints of concern among academics that any reduction in quality in the future would damage the fine reputation that Australia currently possesses. Particular issues in regard to training and quality are explored in the sections below.
4.3.1 Training

Australian academics in the science and mathematics fields are extremely proud of the reputation that Australian PhDs have on a global scale. The composition of the PhD program in Australia is seen as its strong point. A number of groups mentioned that one of the reasons for the high international regard for Australian-trained PhDs in the mathematics and sciences was because graduates of these programs were much more independent than those from other parts of the world. One academic argued that European PhD graduates appear to have a ‘great depth of knowledge’ about their topic, but are not as competent at applying this knowledge and thinking independently about problems.

PhD programs in the science and mathematics areas in Australia also tend to be relatively diverse. Many students undertake a traditional type of candidature, working throughout their research within the university in which they are enrolled. But others have very different experiences, linking with industry, Cooperative Research Centres (CRCs), or government bodies such as the CSIRO to undertake their research work.

Despite the range of opportunities and the diversity of PhD programs in Australia, as discussed earlier, academics are frustrated by the lack of recognition for these skills within Australian industry. In order to resolve this issue, some academics feel that university PhD programs should be altered to emphasise some of the key ‘generic skills’ that they believe industry demands from graduates. These skills include teamwork, communication, project management and budgeting. It was suggested in some groups that specific courses should be run to improve skills in these areas. In order to facilitate the additional time that such programs entail, some thought that there would be merit in increasing the length of candidature for the PhD in Australia from three to three-and-a-half or four years.

However, such views were not universal among academics and university representatives. Many argued that the fundamental role of universities was to promote scholarly research, based on critical thinking, rather than to provide training with a specific vocational emphasis. Therefore, according to these academics, pandering to the expectations of industry should not be a core focus of PhD programs. Those expressing this opinion also pointed out that if universities changed their program every time industry jumped on a new idea, the training situation in Australia would be
disastrous. Others noted that university PhD programs already included a number of seminars and programs that offered advice and help on a range of issues such as thesis-writing, intellectual property issues and project management, and that teamwork skills were becoming more of a focus among science departments, with joint projects and laboratory teams increasing over recent years. The strong view held by those expressing these opinions was that industry expectations were unrealistic and that there was need for industry to recognise that it too had a role in nurturing high quality, industry-savvy science and mathematics professionals in Australia.

A separate issue relating to PhD programs in Australia raised by a number of senior academics was that the current Research Training Scheme (RTS) – which provides block grants to universities to enable them to support their research students – does not necessarily encourage good scholarship. The key reason given for this was that under the RTS, the bulk of government funding for PhD places is not provided to universities until after successful completion of candidature. It was argued that this means universities focus more on getting students complete their degrees as quickly as possible and less on ensuring the highest possible quality. According to some academics, the existence of this funding arrangement also means that there is less capacity for PhD students to become involved in industry placements, because often this involves part-time candidature and therefore a longer wait for funding.

Some states offer other funding incentives to encourage universities and PhD students to become more closely involved in applied projects, particularly within areas of interest to government. For example, Queensland’s ‘Growing the Smart State’ program\(^2\) has been tailored to fit closely with the state government’s policy priorities and was mentioned by some academics as a good alternative funding source for students and supervisors.

In addition, the recently released Interim Report relating to the Federal Inquiry into research training and research workforce issues in Australian universities (House of Representatives Standing Committee on Industry Science and Innovation, 2008) recommends increasing the stipend for scholarships by 50 per cent (Recommendation

12) and indexing them with the Consumer Price Index in future (Recommendation 13) as well as increasing the length of a PhD from three to three and a half years (with the option of two six month extensions) to allow a greater range of skills to be developed during candidature (Recommendation 11).

4.3.2 Quality

Among university groups and individual academics, the issue of whether there were any crises in Australian PhD programs regarding quality was tackled differently. In general, the differences in opinion occurred between individual disciplines that comprise the science and mathematics fields. Academics in the physics and biochemistry fields in particular were strong in relaying that their experience in these fields suggested that quality was high and consistent across Australia. Others argued that quality is high across the board because of high expectations set by academics and the fact that around half of all PhD examiners are from international institutions.

However, there were a number of voices within the university sector who claimed there is substantial variation in quality across Australian universities in the mathematics and sciences. These academics were keen to point out that such variation is inevitable due to massive differences in resources across the universities. It was argued that those universities with larger science faculties and greater resources often produced better PhD candidates because of the facilities available to students in laboratories, students’ access to high quality supervisors, and because in larger laboratories there was greater opportunity to work collaboratively with other students and staff.

In general, most concerns relating to quality within the university sector related to communication skills. Academics noted that written and verbal communication issues are most common among international students – many of whom are from non-English speaking backgrounds. Given that there has been rapid growth in international science and mathematics PhD students in Australia in recent years, there was some concern that any escalation of this problem could damage the international reputation of Australian PhDs.

However, such concern was not limited to international students. There was also considerable concern among academics about the communication skills of domestic
students. One academic saw the communication issue as related closely to personality rather than domestic or international student status, suggesting that bright students switch on and learn to communicate regardless of background.

Another ‘quality’ issue alluded to in the consultations with academics and university peak groups was that, due to the lack of demand for PhD scholarships, some universities were now accepting students that they might have rejected a decade ago. This suggests that quality might be declining in science and mathematics PhDs in Australia. However, in a somewhat paradoxical outcome, when this issue was raised, there was little suggestion that this situation was resulting in an overall decline in quality.

4.4 Future directions

Academics, peak bodies and representative groups in the university sector had a number of suggestions regarding the ways in which the training situation could be improved in Australia. These suggestions include greater industry collaboration, improved recognition of the importance of scientists, increased engagement in mathematics and science in schools, and areas that are likely to be in high demand in the future.

Increasing industry-university links

Many of the academics and members of university groups that were involved in the consultations were acutely aware of the disconnect between industry and the academic sphere. Few had comprehensive experience in industry and a surprisingly small number were involved in grant projects, joint supervision arrangements or any collaboration with enterprises operating commercially in their fields of expertise. It was acknowledged by most of these academics that improved links with industry would be helpful in two ways. First, it would raise the profile of PhD qualifications within the private sector. Second, it would strengthen PhD programs and improve understanding of the role of universities in training provision.

Academics believed that raising the profile of a PhD to those outside the university sector would be helpful in improving the recognition of the wide skill-sets that PhD completers possess. According to a number of academics, many of the core skills involved in completing a PhD were not understood and therefore not valued by
industry. By creating better links with industry, through collaboration on research programs and more informal avenues, many academics believed that they would be able to demonstrate to industry ways in which the skills of PhD graduates could be effectively nurtured and utilised across a range of roles.

Greater industry-university collaboration was also seen as a way of establishing an understanding between both groups about the role of the university in fostering young talent. As noted earlier, many academics were concerned that industry expected graduates to be able to step straight into a role without any further training or support. It was argued that by increasing links with industry, the key facets of the PhD program would be better understood by employers. By doing this, the extent to which universities could improve training in particular skills and the corresponding role of industry in providing additional work-based training could be more effectively established.

*Raising the profile of science and mathematics*

In addition to improving industry engagement, academics and peak groups were keen to emphasise the increasing need for science and mathematics fields to have a higher profile in the wider community. Many key peak bodies in the individual disciplines are already closely involved in encouraging community participation in science events. However, most emphasised that more resources were needed to heighten public awareness of the key roles that scientists and mathematicians play in shaping the future of Australia.

Clearly, one key way of improving the profile of these fields is clearly the extent to which science and mathematics is taught and promoted in schools. It was emphasised on numerous occasions that any discussion relating to improved provision of HDR qualifications is heavily contingent on the engagement and encouragement of student participation in these disciplines within schools. Improving teacher quality – especially ensuring that those who teach in the mathematics and sciences have formal training in these fields – was seen as a key foundation on which growth of the sciences should be built.

It was argued by academics that the science and mathematics fields in general required a boost in training numbers in order to maintain the number of quality
postgraduate students and continue to provide innovative capabilities to the Australian economy. However, some specific sub-disciplines that are likely to provide invaluable skills for the future, but at the same time were seen as needing additional training provision, were mentioned in numerous interviews. One is applied mathematics and the other biostatistics. Both of these areas rely on highly developed quantitative skills and are seen to be of crucial importance in a huge range of industries and occupations within Australia’s knowledge-based economy. There was substantial emphasis on these two particular areas because of the wide application that people with these skills are able to provide and because of the modelling skills, and application of these skills in planning for, and predicting future outcomes on issues such as climate change, ecosystems and the sustainability of different industries.
5 Employers

5.1 Introduction

The discussions and main findings from the consultations with employers and employer groups are detailed in this chapter. The employers canvassed in this consultation were from a range of industries and geographic locations across Australia and comprised representatives from both the public and private sectors. The discussion below is based on individual and group interviews with peak bodies, specific employers and specialist science recruitment firms. The consultation also canvassed the views and experiences of members of the National Association of Graduate Careers Advisory Services, who provide university-based career advice for students and have substantial contact with employers and industry. The groups and individual employers included in the consultation are listed in Appendix C.

5.2 Demand and employment opportunities

There was some notable variation in approaches and opinions about hiring PhD and Masters by Research graduates among employers and groups involved in the discussions. In general, there were differences between the public and private sector employers. In the first part of this section – demand and employment opportunities – the discussion has been segmented so as to highlight the differences in the general approaches of the two sectors.

Overall, the story emanating from employers (especially those in private industry) is relatively uniform. The general thrust of the discussion below is that while there are employment opportunities for those with PhDs in these fields, Australian industry is not specifically seeking people with such qualifications. Apart from the large government employers, particularly the CSIRO, there seems to be a preference for undergraduate or honours qualifications in the science and mathematics areas.

5.2.1 Private sector

Among private sector employers in the relevant industries, there is currently substantial demand for people with qualifications and experience in the science and mathematics fields. Competition for quality candidates is high and poaching of good talent common. However, the overwhelming view provided by employers, recruiters
and stakeholder groups in this sector is that qualifications required for the jobs available in these fields are undergraduate and honours degrees – not Masters or PhD.

The key reason given for the focus on undergraduate qualifications is that there was a perception that these graduates were more easily moulded to a company’s specific needs, whereas PhD graduates were seen as more narrowly focused and generally less adaptable to employer requirements. Essentially the message from private sector employers seemed to be that three or four years of employment in private enterprise following an undergraduate science degree was much more likely to produce an innovative, commercially aware employee, than the same amount of time spent undertaking a PhD at university.

The main exception to this view came from employers who had established close links with universities. In particular, the industry partners of CRCs, which collaborate on PhD projects and linkage grants with universities and industry, appeared to be substantially more enthusiastic about the skills and development opportunities that people with higher degrees in the mathematics and science fields could offer their businesses.

There was some indication during these consultations (especially among recruitment company interviewees) that the ambivalence of private industry to a PhD has grown in recent years. Those who have been in the industry for a number of decades indicated that there has been substantial movement of industry R&D facilities offshore since the early 1990s and that this has had a dramatic impact on demand for the PhD qualification. Such issues were also raised in the university sector discussion.

An interview with Johnson & Johnson Research highlighted that this issue is likely to become more pertinent in periods of economic downturn, such as that being experienced currently. In August 2008, it was announced that the Johnson & Johnson Research facility in Sydney would be shut. The main research carried out by this company will now be concentrated in its overseas bases. Rare within private industry in Australia, this facility had been an avid employer of higher degree qualified scientists and was involved in joint university and industry collaborative projects.

Among large companies employing maths and science graduates (mainly undergraduates), the common theme expressed was if they wanted more complex
research undertaken, they would outsource it to universities or the CSIRO. One representative explained that this was the approach his company was taking in the Asian region, rather than investing in ‘bricks and mortar’ to create R&D laboratories. He noted that this policy was different to the company’s approach in the US and UK, where they had R&D facilities ‘the size of university campuses’ employing hundreds of researchers.

The general ambivalence of private industry in Australia towards research degrees and training is also highlighted in the recent House of Representatives Inquiry into research training and research workforce issues in Australian universities (House of Representatives Standing Committee on Industry Science and Innovation, 2008). Among 105 public submissions to the inquiry, none were lodged by a private company.

Regardless of the ambivalence towards the qualification itself, there are still employment opportunities in private industry for people with PhD and Masters qualifications in the mathematics and science fields. In many cases these jobs are more lucrative than those available in the public sector and within universities, but often they are not PhD-specific and therefore HDR graduates are no better placed than those with undergraduate degrees and industry experience when applying for these positions.

Employers and recruiters indicated there were relatively large numbers of people with PhD qualifications trying to make a transition from the academic/university workforce into the private sector. This move is considered a big step because switching from university to private industry is often seen as a ‘one-way street’; publication and grant profiles are not maintained in private industry, so going back into academe is often not an option. The main reason given to recruiters for the decision to shift career paths seems to be to find greater job security. However, contract provisions in private enterprise also tend to be short term, so this can often be a disappointing realisation. Another problem those trying to make this transition find is that they are over-qualified for the positions being offered. In general, academics who make a successful transition to the private sphere are those who have extra ‘get up and go’ and who have had some exposure to industry during their academic career.
The private sector market in the mathematics and sciences is seen to be particularly volatile by those who operate within it. Small and medium enterprises in particular hire few people (and very few PhDs) and employment relies on winning competitive projects and grants. These industries are seen to be at the mercy of the market and companies ‘come and go’ without warning. One recruiter noted the recent demise of a number of small and medium biotechnology companies in Australia, which suffered substantially due to economic downturns and market instability. Another representative in the industry emphasised the limited opportunities for businesses in the scientific industry in Australia, which means that the market can become crowded very quickly on the back of the latest ‘fad’. In addition, the size of the Australian market is ‘minnowed’ by the might of world powers such as the USA, Japan, China and Europe, so gaining widespread recognition for driving innovation is a difficult task for Australian enterprises.

According to private employers, currently there are a number of particular areas of demand in Australia. The qualifications of interest to the mining industry include geology, geophysics, geochemistry, geomatics as well as skills related to the petroleum industry (e.g. basin analysis and petrology). In addition, there is widespread need for chemists, microbiologists, geneticists, biotechnology specialists and those who can adapt their skills to medical research (such as physicists who have radiology capabilities). Numerous other occupations are also in demand, a number of which were discussed in the university sector section above.

However, as already stated, from the point of view of people with HDR qualifications, the problem with this demand is that it is substantially focused on undergraduate and honours degree qualified people.

5.2.2 Public sector

Among public sector employers involved in the consultations, there was generally a greater recognition of the value of a PhD or Masters qualification. However, this did not always translate into the provision of more HDR-specific positions among these employers.

The CSIRO is clearly one of the most enthusiastic supporters and employers of PhD graduates in the mathematics and sciences in Australia. A large proportion of its 6,000
strong workforce has PhD qualifications, and each of its many divisions run specific post doctoral programs and sponsor PhD students. The CSIRO managers interviewed for this project were some of the few among employers who were concerned about the lack of PhD qualified people in Australia. This is because the CSIRO is currently experiencing difficulty in hiring people with PhD degrees in mathematics, statistics, biotheematics, ecogenomics, materials science, hydrology and almost any field related to the mining industry.

One of the problems that managers in the public sector face is competing with the private sector and universities for the best scientists. One manager believed that in many instances the public sector was the third choice for employment, with the lucrative private sector first and university academic life second. Others in the public sector were also aware of this. To counter-balance these issues, they used other factors about public sector employment, such as conditions, opportunity to diversify and passion for research, as key lures for attracting people.

In order to find qualified people to fill positions in the public sector, managers indicated that they had been forced to search overseas to find people with the right mix of qualifications and talent. In recruiting qualified talent from overseas, some employers took a broad brush approach, posting job advertisements on key science career internet sites (a strategy that resulted in many applications, but often few genuine candidates), while other organisations approached international recruitment in a more targeted fashion – knowing in which universities and regions they were likely to find suitable graduates and informally approaching staff in these institutions to enquire about potential new talent.

5.3 Training and quality issues

Employers (regardless of sector) generally indicated that the quality of graduates in the mathematics and science fields from Australian universities was equal to world standards. However, there were still considerable concerns expressed by employers about the level of skills that people completing their postgraduate research degrees possess. The core concern among employers, employer groups and recruitment firms was that communication skills were below expectations.
Concerns about communication deficiencies in graduates were spread across written and verbal skills. There were numerous concerns about the communication skills of international students who had undertaken their research training in Australia and perhaps more strongly in relation to migrants who had come to Australia with a PhD from elsewhere. However, similar to the academic group, concerns in relation to communication skills were not limited to those from non-English speaking backgrounds. There was disappointment expressed by some employers and employer groups about the written communication skills of domestic graduates as well.

5.3.1 Desirable Skills

Employers of all sectors and company sizes were consistent in identifying the key skills they looked for when hiring PhD (and lower qualified) graduates. The core group of skills required are: flexibility, adaptability, communication, teamwork and commercial acumen. Many employers, especially those in the private sector, indicated that within the PhD program there was little emphasis placed on any of these core skills. Within the private sector, it was often said that the university was a ‘cloistered environment’ and that PhD graduates had very specific skills that led to ‘narrow thinking’ and an inability to solve problems outside their specific sub-disciplinary area.

Public sector organisations were also aware of these issues, but were more likely to have set in place programs to improve these skills among their employees. For example, the CSIRO has programs for post doctoral and early career researchers that are tailored to improve writing, presentation, networking, teamwork, leadership, negotiation and risk management skills. According to recruiters, while good practice in this regard does exist in private enterprise, professional development is becoming less common. This is mainly because once trained, employees are often poached by rival companies, thus making any investment in human capital commercially unviable.

While generic skills are highly desirable and continually mentioned by employers, there was also a sense that graduates who had the knowledge and ability to tap into multiple areas of science were more likely to be seen as desirable by employers. Therefore, as indicated by some academics, a multidisciplinary approach to the sciences through PhD and Masters programs (and indeed in undergraduate levels as
well) is likely to create graduates with a wider range of skills that are seen as useful to employers.

5.4 Future directions

In general, due to the underwhelming enthusiasm for HDR qualifications in the science and mathematics fields by many employers, the future of PhD qualifications in Australia could be potentially under threat. However, inspiration for a resurgence in recognition of the value that a PhD qualified person can offer a company can be taken from the esteem in which such qualifications appear to be held among employers elsewhere in the world. Below is summary of the views of industry and employer groups in relation to the future needs of Australia in terms of skilled scientists and mathematicians.

5.4.1 Future demand

Although many private sector employers did not show any genuine interest in hiring people with PhD qualifications, many of them were acutely aware of the need for such people within universities and public research institutions. From their point of view the core need for such qualified people was to train the future waves of undergraduates in science and mathematics that industry is clamouring for. In addition to this, there was some recognition that research driven by universities and large public sector organisations, such as the CSIRO, was useful in raising Australia’s international research profile – and a good profile would attract international investment in private industry.

Academics with close ties to industry, who perceive that there has been a decline in private R&D in Australia over the past few decades, insisted that the future of a thriving economy with a thirst for HDR qualified people should be based on proactively setting research priorities in Australian universities which would build a core of experts in particular areas. In other words, rather than react to industry priorities (which is problematic given the length of time it takes to complete a higher degree), it is better to identify potential core needs in the future and build skills in these areas. It was argued this would attract investment in Australian universities and industry, and promote job growth and increased demand for HDR qualifications.
5.4.2 Collaboration with universities

While it was not commonly articulated (especially among private sector employers), it appears that (as in the university sector discussion), a critical future direction should be related to increasing the interaction between industry and universities at the postgraduate training level. Those public and private employers that have established relationships with universities appear to have a much greater appreciation of the way in which the skills of a PhD graduate can be utilised outside the university setting.

The CRC initiative appears to be a good example of the way in which industry can be engaged with universities and people with HDR skills. In addition, the Australian Mathematical Sciences Institute has introduced an internship program for PhD students over the past few years, which links them with an industry partner. This arrangement provides incentives for industry in terms of giving an employer access to high level expertise and incentives for university supervisors and students in the form of experience in industry and a financial contribution. This is based on a successful internship model now used widely in Canada. Both these different approaches appear to be effective in alerting industry to the usefulness of highly qualified scientists and in providing future employment opportunities for young researchers.

6 Postgraduate students and early career researchers

6.1 Introduction

The final group engaged in the consultation phase consisted of those studying for or recently qualified with a higher degree across a number of disciplines in the mathematics and science fields. In this stage, interviews were carried out with post doctoral researchers and postgraduate candidates across universities in Australia. This chapter highlights the main themes that resonated from these interviews.

Many postgraduate students targeted in this study were involved in university life as student representatives. These postgraduates spoke about their own personal choices as well as the experiences of other postgraduates at their institution and other institutions in Australia who they had come in contact with in their student representative role. Other postgraduates involved in the consultation were more focused on their own personal pathway.

In addition to postgraduates, early career researchers from the CSIRO, the Sustainable Minerals Institute, Roche Pharmaceuticals and CRC for Polymers were engaged to speak about their career decisions and training experiences. Members of these groups were asked to speak not just about their current roles, but also about choices and alternative pathways they felt were available to them at the completion of their PhD. These groups were also asked about the extent of demand they see within private industry for people with their skills and qualifications.

The students involved in the consultations were generally engaged in training for a variety of reasons – not all vocational in emphasis. The early career researchers had all chosen research-based work after graduation and generally expressed an enthusiasm and drive to undertake meaningful scientific research throughout their careers. In general, those involved in the consultations were aware of the dynamics of the employment market for their particular disciplines. Their experiences and understanding in relation to demand, quality and future directions are set out below.

6.2 Demand and employment opportunities

The views expressed by university academics, employers and stakeholder groups regarding the demand for people with HDR qualifications in the mathematics and
science areas were generally well recognised by postgraduates and early career researchers. Overall, postgraduates and post doctorates were careful to emphasise that there were different factors influencing the various individual disciplines in the science and mathematics fields and therefore it was difficult to make generalisations.

6.2.1 Choosing to undertake a PhD

Among current students, there was not an overwhelming feeling of confidence that a PhD pathway was the best option for them to take. Those who have a passion for research and are determined to follow the academic pathway seem to be more certain about their choice than others – even if they are not entirely confident about opportunities available in the academic sphere. A number of students interviewed spoke about the experiences of friends and other former students they knew who had looked back on completion of a PhD and regretted the time they had spent (‘wasted’). Those who had experienced such conversations said it was often the graduates who had entered private industry who spoke in this way. These graduates tended to find their specific skills were not needed and that they might have been better off with three or four years of additional career experience than with a ‘Doctor – Dr.’ at the front of their name.

Following this same theme, postgraduate students in very high demand areas found it hard to ignore the lure of job opportunities that were available on completion of their undergraduate qualifications. For example, a chemistry student, who had offers from large companies such as BHP and Alcoa at the end of her honours year, but had decided to pursue a postgraduate degree, expressed being constantly torn between the ‘clear career path’ of industry and the unsure opportunities in academic research.

6.2.2 Employment pathways

In regards to industry work following graduation from a PhD, post doctoral researchers involved in the consultations took a relatively negative position. Many of these early career researchers saw entering private industry as ‘selling out’, because of the lack of ‘real’ research that is undertaken in such enterprises in Australia. According to these researchers, most of the jobs available for scientists in private industry involved repetitive experiments or ‘custom research’ and no real innovation. They argued that most of the real research that private enterprise funded in Australia was outsourced to the CSIRO or university research centres.
While there was some uncertainty about employment prospects among students interviewed, most students expressed general confidence in the PhD process and the likelihood of gaining employment on graduation. Among some there was an air of confidence that if you had the ability to ‘be proactive in presenting yourself to employers’ then there would be good opportunities available. However, there was recognition among those with this view that not all of their fellow students possessed the same attitude. With this feeling was a fear that there was potential for disappointment among those science students whose focus was too narrow or not ‘applied’.

PhD students involved in the consultations had chosen different directions to follow on completion of their degree. Some had found that their goals had changed during their candidature. For instance, one student had gone from being certain that she wanted to follow an academic career path, to deciding to focus her attention on job prospects that might become available within industry. The reason expressed for this change in direction was that once in the university research environment she had discovered that the academic career was ‘competitive, hard work and contingent on short contracts’. While this student realised that ‘it’s not the PhD that will get me a job in industry’, she was determined that the research she was undertaking would make a difference as long as her experience was presented in an employer-friendly way. Another student had recognised a niche in his field, specifically sought out a supervisor in Australia considered to be a world expert, and was determined that an academic research career would be available to him on completion.

Among post doctoral researchers, the ambition and drive to undertake research following their PhD was strong. Most had begun their PhD with this outcome in mind and some had harboured this goal even before university. There was also contentment among these researchers about their current positions, and most indicated that they would be happy to continue in their situation for as long as possible. When the possibility of an academic career was suggested, very few showed any interest, claiming that it was a competitive occupation and very difficult to establish yourself. The demands of teaching and administration were also mentioned as deterrents for working in the university sector. Given the current concern about potential shortfalls
of academics as a result of the impending retirement of baby boomer academics, this outcome has the potential to exacerbate this problem.

### 6.3 Training, quality and incentives

#### 6.3.1 Scholarship deficiencies

The most overwhelming issue relating to training provision articulated by postgraduate candidates and early career researchers was the ‘appalling’ level of support provided by scholarships available in Australia. All the students and most post doctoral researchers were quick to point out that at $20,007\(^4\), the base level of the Australian Postgraduate Award (APA) scholarship was below the poverty line. As a result, postgraduate students felt they were making significant financial sacrifice to undertake their degree. There was mention of ‘top-up’ scholarships (offered by individual institutions, by the CSIRO or other organisations such as CRCs), which had made life easier for some students, but for the majority the basic scholarship was the best option available. Those who had made the transition into their research degree straight from their undergraduate studies were particularly conscious of the Higher Education Contribution Scheme (HECS) debt they had accumulated that was not being paid off while they continued to study.

Despite the fact that current and recently completed students had made sacrifices necessary to commit to a higher degree, there was unanimous feeling among those involved in the consultations that the financial incentives to undertake a science or mathematics PhD in Australia were not great enough. It is clear from these discussions that some substantial improvements in the PhD stipend are necessary if universities are to be in a position to attract the best young undergraduates into research degrees. As mentioned earlier, a key recommendation of a recent parliamentary inquiry into research training in Australia is to increase the APA stipend substantially (House of Representatives Standing Committee on Industry Science and Innovation, 2008).

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6.3.2 Support at university during study

In relation to support during studies, students and early career researchers had different experiences. The most positive feedback in relation to academic and pastoral care support during study came from those students who had worked in a faculty that had a number of postgraduate students and had encouraged interaction between students and supervisors. This formation of a collegial atmosphere seemed to help motivation and inspire students to produce their best work. Another key element in the training process mentioned by these groups was the importance of a quality supervisor. Those with supervisors who they viewed as being top quality experts in their fields tended to show more confidence in the employment opportunities available to them following completion of their qualification.

Another crucial issue in regard to support within the university, related to the availability of funding for students to be able to run their experiments. In order to conduct experiments many of those undertaking research in the mathematics and science fields require access to equipment and technology that is not necessarily available in their institution or even in Australia. Therefore, funding to write research applications and funding to travel to specific sites to conduct experiments is commonly required. A number of students and post doctoral researchers noted that funding available for such things was minimal, meaning that the quality of a research project could be compromised.

In this context, it was suggested by some post doctoral researchers that universities need to pay extra attention to pre-planning for their PhD candidates. Pre-planning would help identify the equipment and expertise that a new student would need to undertake their research and accordingly create a realistic budget for the research. This would help to solve many of the funding problems faced by PhD students when they come to organising the experimental stage of their research.

Lack of resources was a common theme mentioned by current and former students who had less than positive experiences in their candidature. This resource issue included funding as noted above, as well as departmental problems such as a faculty being too small, not fostering relationships and issues relating to bad supervision. Those students who felt isolated during their studies were described by one academic as ‘orphaned students’.
6.3.3 Quality

Students and recent graduates did not generally feel in a position to comment widely about issues relating to the actual quality of PhD candidates in their fields. However, one broad issue relating to quality and ‘work readiness’ that was raised revolved around the social side of the PhD program. A number of students noted that the work undertaken during a PhD does not really prepare them for the social aspects of the ‘real world’. The concern expressed among these students was that within the closed environment of the university, academics did not interact outside their narrow sphere and lacked the social skills and perspective that is required by younger people negotiating the labour market. Therefore, the way in which some academics supervise and advise can often miss the wider contextual viewpoint that students should be aware of. This issue, while not expressed by all those involved, appears to be a genuine concern.

6.4 Future directions

Discussion of ‘the future’ with students and early career researchers involved speaking about individual pathways rather than the big picture ‘future’ that was the focus of discussions with the academic, employer and stakeholder groups.

In general, each student interviewed was relatively optimistic about their future opportunities. Many saw potential in their specific fields of research, while others believed that postgraduate experience would equip them with a range of skills that they could utilise both in their area of expertise and in other fields.

Post doctoral researchers were slightly less optimistic about their future. Many of them saw the early years following completion of a PhD as a difficult pathway with no clear destination. In general, they were keen to remain in research positions, and were acutely aware of the need to ‘keep an eye out’ for future opportunities. However, given that many of them did not have any interest in industry and were put off by academia, the opportunities in Australia for the future appeared relatively limited to research institutes and public sector organisations such as the CSIRO. As a result, both PhD students and post doctoral researchers believed the best and widest range of future opportunities for them existed outside of Australia.
In relation to the wider context, the main message coming from this group was that the incentives for undertaking HDR study in Australia were far too small. As mentioned above students and early career researchers believed that unless scholarships and bursaries were increased, fewer people would choose this pathway.
7 Conclusion

This report has explored in detail the opinions and experiences of numerous groups and individuals in relation to the employment and training of people with HDR qualifications in the science and mathematics field in Australia. This chapter emphasises some of the key findings detailed in this report.

Throughout the discussions with academics, employers, stakeholder groups, peak representative bodies, early career researchers and students, there was a clear message that the issues facing the science and mathematics fields in Australia were discipline specific and did not necessarily relate throughout the broad area covered in this project. This is an important point and the general context of this report needs to be interpreted with this in mind. However, at a broad level, there were a number of key themes that were raised by people across a spectrum of disciplines and positions. These themes, as articulated throughout the consultations, are reiterated below.

First, it is clear that Australia has an important role to play in scientific innovation and providing solutions to a vast range of problems facing the planet now and into the future, including environmental sustainability, climate change and development of new technologies. Without a strong university sector and diverse industry, the ability of Australia to embrace this role will be compromised. In this context, the importance of highly trained, well-equipped, intelligent higher degree research graduates is vital.

The general consensus is that Australian science and mathematics PhDs are as good as those available in any other part of the world. However, currently in Australia appreciation of research degrees is generally poor in private enterprise. Within the mathematics and science fields, the Australian situation appears to be at odds with other parts of the world. University leaders and employers who embrace research degree graduates believe that a PhD qualification in particular offers a substantial premium and should be treated as such.

Perhaps a key reason why the recognition of this premium is low in Australia is that, apart from some notable exceptions, there is a general lack of interaction between universities and private industry. Improving links through cooperative grants,
industry-based PhD candidature and joint problem solving ventures could help to improve the image of a PhD. In addition, incentives for employers to sponsor PhD students and universities to agree to industry placements as well as encourage candidates to build relevant skills could also benefit both sectors.

Of crucial importance to the ongoing supply of high quality students in PhD programs in Australia is renewed attention to the incentives offered to students to undertake such qualifications. With the most common scholarship for students currently below the poverty line and a graduate employment market that is booming, some may say that it is surprising there are any Australian students taking up HDR places at university.

Another issue for universities that is of importance is the need to foster a new generation of academics to replace the retiring baby boomer generation. Finding ways to address issues related to the post doctoral ‘treadmill’, providing greater security of tenure, and balancing teaching, research and administrative expectations of academics are all issues that need to be addressed if more young researchers are to be attracted to academic careers.

Overall, in order to improve industry engagement and increase employment supply to the university sector, there is a need to bolster the profile of the science and mathematics fields in the wider community. While there is currently effort on the part of many groups to achieve this, key peak bodies emphasised that more resources were needed to heighten public awareness of the key roles that scientists and mathematicians play in shaping the future of Australia.

The key to a thriving innovation-driven economy in Australia, with a strong foundation in the mathematics and science fields, appears to be embedded in education. Consultation participants emphasised a number of areas that need to be addressed to ensure a strong and sustainable future for these disciplines. These are as follows:

- Renewed efforts to improve the participation and quality of science provision in schools, with a focus on attracting more qualified teachers and lifting the status of those in the profession.
• Education provision in universities (especially at the postgraduate level) needs to be more applied and curricula need to be developed in closer collaboration with both private industry and the public sector.

• Employers need to be educated about the value that people with HDR qualifications can offer and how important these people can be in establishing a strong platform for innovation and productivity in Australia.
References


Appendix A: List of Project Reference Group Members

Chair:
Ms Jane Smith, Research Analysis and Evaluation, DEEWR

Executive Officer:
Dr Anne Rozario, Research Analysis and Evaluation, DEEWR

Members:
Mr Jason Coutts, Higher Education Group, DEEWR
Mr Michael Teece, Higher Education Group, DEEWR
Ms Anne McConnell, Higher Education Group, DEEWR
Ms Nerida Coulter, Research Analysis and Evaluation Group, DEEWR
Ms Sharyn Sturgeon, Innovation Analysis Branch, DIISR
Ms Kate Taylor, Science Strategy and Investment Group, CSIRO
Prof Rob Norris, Australian Council of Deans of Science
Dr Alex Maroya, Universities Australia
Mr Peter Canavan, Australian Industry Group

ACER Research Team:
Dr Daniel Edwards, Project Director, Senior Research Fellow, ACER
Prof Fred Smith, Consultant
Dr Hamish Coates, Principal Research Fellow, ACER
Appendix B: Example of key group consultation request form

Below is an example of the wording used for the information pamphlet provided to groups involved in the large consultations.

RESEARCH INTO DEMAND FOR AND EMPLOYMENT OF MATHS AND SCIENCE POSTGRADUATES
CONSULTATION REQUEST

The Australian Council for Educational Research (ACER) is currently undertaking new research for the Federal Department of Education, Employment and Workplace Relations (DEEWR). The research is examining demand for postgraduates with mathematics and science skills.

As part of this research we are seeking to collect the ideas and experiences of individuals and groups who have a keen interest in this subject.

What the project involves
As you are no doubt aware, Australia’s productivity and success in a competitive global marketplace increasingly relies on critical science, technology, engineering and mathematics skills. DEEWR has already conducted some research around these broad skills issues, much of it focused on supply-side questions.

The research now underway is looking specifically at demand for higher degree-qualified scientists and mathematicians in Australia, i.e. those with a PhD or Masters by Research qualification. Among this group, this project also has a particular focus on demand for academics with these qualifications to help understand issues around this vital part of the university workforce.

A key part of the project involves consultation with stakeholders including representative/peak bodies, universities, employers, postgraduates and others about their experiences and ideas in training, recruiting and working with these people.

The researchers are investigating broad questions such as:

- What types of jobs require post-graduate qualifications in science and mathematics?
• How hard – or easy – is it to find postgrads with the right skills for jobs in demand?
• How ‘work ready’ are these postgraduates on graduation from university?
• How has the employment situation for people with these qualifications changed over the past decade?
• What challenges might employers face in hiring such people in the future?
• What issues are universities facing in relation to recruiting undergraduates into postgraduate training, and postgraduates into academic positions?

The consultation process
ACER is currently gathering information for the project. The XXXX has been invited to participate in the consultation process. Your involvement is most appreciated. If you have any questions before or after the discussion organised by the XXXX for this project, please contact the ACER Project Director:

Dr Daniel Edwards
p.
e.edwardsd@acer.edu.au
Appendix C: List of groups and employers involved in the consultations

The list below provides an overview of the peak bodies, employers and industries which participated in the consultations. Individual names have not been included in this list. The list is primarily divided into sections that match the sections used in discussion of the outcomes of the consultations. However, an additional heading in the list below has been included to cover peak bodies that represent members from a number of sectors.

The university sector

Universities Australia

The Group of Eight (Go8)

Innovative Research Universities Australia (IRUA)

Australian Council of Deans of Science (ACDS)

Deans of Science, or their representatives, from all 37 universities that are members of the ACDS

Other academics from:

- Monash University
- University of Melbourne
- University of Technology, Sydney
- Curtin University
- Griffith University
- Deakin University
- Wollongong University
- Queensland University of Technology
- University of Newcastle
- James Cook University
- Murdoch University
- University of Queensland
Employers and employer groups

Australian Bureau of Statistics (ABS)

Geoscience Australia

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

Australian Chamber of Commerce and Industry (ACCI)

The Association of Professional Engineers, Scientists and Managers (APESMA)

Minerals Council of Australia

The Australian Industry Group (AiG)

Cooperative Research Centre for Polymers

Automotive Cooperative Research Centre

Kelly Scientific

Science People

ChemSkill

Qiagen

Roche Products (Australia)

Johnson & Johnson Research

Science Research and Development Park, La Trobe University

Aviation Data Systems

Australian Consulting Engineers Association

Pfizer Australia
Baker IDI Heart and Diabetes Institute

*Early-career researchers and current postgraduate students*

Council of Australian Postgraduate Associations

Students and student representatives from:

- LaTrobe University
- University of Western Australia
- Macquarie University
- University of Tasmania
- University of New South Wales
- RMIT University
- University of Queensland

CSIRO

The Sustainable Minerals Institute

CRC Polymers

*Other peak bodies*

Cooperative Research Centres Association (CRCA)

Federation of Australian Scientific and Technological Societies (FASTS)

Australian Academy of Science

Australian Institute of Physics
Australian Institute of Biology
Australian Society for Biochemistry and Molecular Biology
Australian Mathematical Society
Australian Mathematical Sciences Institute
Mathematics Education Research Group of Australasia
Australian Institute of Agricultural Science and Technology
Association of Australian Medical Researcher Institutes
Australian Research Council
National Association of Graduate Careers Advisory Services
## Appendix D: Broad issues covered in the consultations

<table>
<thead>
<tr>
<th>Broad Issues (each to be tailored differently to suit consultation group – an ‘X’ indicates that the issue will be covered with the specified group)</th>
<th>Key representative bodies</th>
<th>Recruitment firms</th>
<th>Universities and uni research centres</th>
<th>Employers</th>
<th>Postgraduates &amp; ECRs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptions of the range of employment undertaken by postgraduates in the science and mathematics fields (i.e. the types of jobs that they do)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent of under-utilisation of skills among these postgraduates in their employment.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent of lack of skills in these postgraduates immediately following completion of their degree.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Broad perceptions of the extent to which these skills are required in Australia.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perceptions of how supply, demand and employment situations of these postgraduates have changed in the past two decades.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Industry-specific issues with supply of and demand for postgraduates – e.g. within the academic profession, ideas relating to ageing workforce, tenure problems etc.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Indications of growth markets or emerging industries within these fields.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perceptions of the quality of postgraduates – with specific questions about which (if any) skills they are lacking. This will include focus on communication skills (English language skills, written and spoken), technical skills, teamwork skills and other ‘soft' skills.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perceptions of the extent to which ‘generic’ skills should be included in university curriculum.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ideas about the extent to which employers expectations of these postgraduates are unrealistic.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
### Table continued.

<table>
<thead>
<tr>
<th>Issues that the postgraduates themselves present to these organisations in relation to their job searching, university training and employment outcomes.</th>
<th>Key representative bodies</th>
<th>Recruitment firms</th>
<th>Universities and uni research centres</th>
<th>Employers</th>
<th>Postgraduates &amp; ECRs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information about particular employers (small, medium and large) who are successful in employing postgraduates or have particular innovation in these fields.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent to which postgraduates with skills in science and mathematics are taking up employment in other fields.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Volumes of demand for employment of postgraduates by specific fields.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Strategies used by employers to advertise positions in these areas.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent of unfilled jobs requiring people with these skills.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Issues in relation to the perceived idea of the ageing academic workforce and how current supply will facilitate demand.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent of interest among the best undergraduates in considering a higher degree.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Recruitment procedures undertaken for new positions and filling old positions at universities and industry.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perception of issues relating to short-term contracts as opposed to tenured positions at universities.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent to which bright young academics are leaving the higher education sector.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Issues with funding positions for young academics.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Recruitment difficulties by particular disciplines/areas.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Table continued.</td>
<td>Key representative bodies</td>
<td>Recruitment firms</td>
<td>Universities and uni research centres</td>
<td>Employers</td>
<td>Postgraduates &amp; ECRs</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
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<td>----------------------</td>
</tr>
<tr>
<td>Perceived work readiness of graduates and the extent to which these organisations are willing to fund further training programs for individuals.</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Issues with the nature of postgraduates that may have occurred over the past five years or so that could be related to ‘Gen X’ or ‘Gen Y’ issues.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Difficulties in financing positions for young researchers in these fields.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>The extent to which poaching of the best talent occurs.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Perceptions of the differences in quality (if any) between international and domestic postgraduates from Australian universities.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>