

Introduction

For many PhD graduates entering the employment market with recent research training under their belt, a career in research and higher education would seem to be the obvious choice. After all, that is the kind of work they have been trained to do. However, with the steep rise in PhD graduations in recent years, and growing demand within the private and public sectors for innovative capability, universities are no longer the only career option. Some evidence seems to point to a problematic job market for PhD graduates and difficulties in securing employment after graduation.¹ However, there is significant demand in the private and public sector for people with deep knowledge and sound research and analytical skills. If there is a gap that needs bridging, it could be a lack of understanding on the part of employers outside academia of the value of engaging a PhD scholar or graduate to meet these needs.

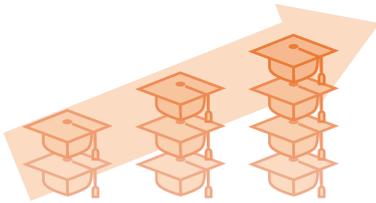
With the steep rise in PhD graduations and growing demand within the private and public sectors for innovative capability, universities are no longer the main career option

In this collaborative project between the Australian Mathematical Sciences Institute (AMSI) and CSIRO Data61's student-employer matching platform, Ribit.net, we illuminate current engagement between industry and research graduates. We have investigated which sectors within the Australian workforce employ PhD holders, and what the career ambitions of current PhD students are. Our focus is on PhD graduates already working, or having the ambition to work outside of academia: What sectors are the most research and innovation intensive and employ the most PhDs? Who are the top PhD recruiters among Australian businesses? What, if any, are the differences between PhD graduates from various fields of study?

This analysis is a first step in a broader campaign to:

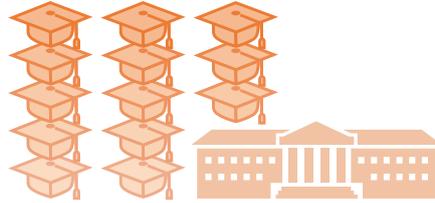
- Encourage Australian businesses (big and small) to expand their capability, innovative capability and global competitiveness through hiring PhD scholars and graduates;
- Promote further engagement between industry and the research sector in Australia in a bid to increase our productivity in a fast-changing world.

Key findings



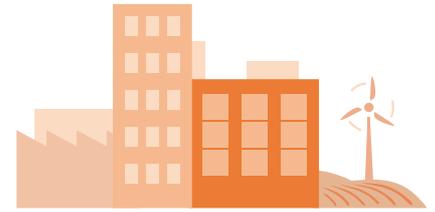
Annual PhD completions have more than doubled in the last two decades

As with most other OECD countries, the number of PhD completions in Australia has grown dramatically, from under 4,000 per annum in the year 2000, to around 10,000 per annum today.



There are many more PhD graduates than academic jobs available

There are not enough jobs for all PhD graduates in academia. The total number of PhD graduates has outnumbered the number of academic jobs available in Australia since the mid-1990s and the gap has widened ever since.



PhD graduates are increasingly finding jobs outside academia

A growing percentage of PhD graduates are finding employment in businesses, government and the non-profit sector. 19 out of the 20 largest ASX listed companies now have PhD graduates among their senior executive teams.



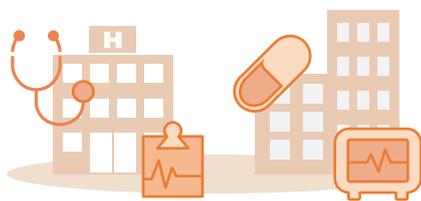
About 51% of PhD students hope to enter business or the public sector

Just over half of current Australian PhD students (51 percent) responding to our national survey hope to leave academia and work in business or the public sector once they graduate.



Top business PhD employers are finance and resources & energy sectors

The Australian business sectors that employ the most PhDs are banking, finance and insurance, followed by mining, oil and energy and the medical and pharmaceutical industry.



Public and private health & medical sectors employ the most PhDs

In the public sector, the main area of PhD employment is hospitals and health care, while in the business sector the medical and pharmaceutical industry ranks third. Together these sectors employ the most PhD degree holders outside of academia.



Australia's existing growth sectors lead PhD employment

Many PhD employers are aligned with the nation's growth sectors related to medicine, pharmaceuticals, advanced manufacturing, mining and finance as well as emerging industries such as environmental services and media technology and services.



Innovation is key to future opportunity

There are significant opportunities ahead for PhDs to work with young, global startups and innovative Australian high-growth employers.

Project approach

This project reports from a range of data sources. In the section “PhD graduation in numbers”, we bring together some national and international statistics on PhD graduations. “The value of research training” section describes some of the literature and data on the value of a PhD degree to students themselves, and the skills PhD graduates bring to the workforce. Our project adds to the existing knowledge with a new national survey of PhD students at Australian universities as well as analysis of the employment patterns of PhD graduates in Australia as revealed through LinkedIn profiles.

LinkedIn is a global professional networking platform, which was launched in 2003 and has since then amassed more than 600 million users worldwide. In Australia alone, 10 million members out of a total workforce of 12.6 million people², had a profile on LinkedIn as of October 2018. It is therefore a valuable source of data on indicative trends in talent and qualifications on a national level.

Where do Australia's PhD graduates work?

Using LinkedIn, we completed a tally of all employers in Australia with PhD-qualified employees, classified by industry. A total sample of 67,826 Australians indicated in their profile they have a PhD qualification.

According to the 2016 ABS census, there were 135,277 doctorate degree holders in Australia in 2016, of which 103,016 were employed at the time.³ The 67,826 PhD holders with LinkedIn profiles therefore cover at least about half of all people in Australia with a research doctorate. This is a solid basis on which to further investigate where PhD graduates tend to find employment.

Everyone with a LinkedIn profile may choose one – and only one – industry in which they work. PhD cohorts by industry are therefore mutually exclusive and can

be aggregated at a country wide scale. For each of the 147 separate industries listed in LinkedIn, we recorded the total number of employees with a PhD as well as the top 15 employers of PhDs in that industry. Counts of PhDs were re-tallied by employer. This is to account for the fact that different employees from the same employer might self-classify as belonging to different industries (they might choose either banking, or finance for instance). Employees working at universities sometimes self-classify as belonging to an industry aligned to their field of research or work rather than with “research” or “higher education”.

According to the 2016 ABS census, 50 per cent of the employed doctorate holders in 2016 were working in tertiary education and research.⁴ From our analysis of LinkedIn, we found that about 52 per cent of people in Australia on LinkedIn and with PhD degrees work in the research and higher education sector. The remaining 48 per cent work in business (around 23 per cent) and the public sector comprising government and non-government organisations (around 24 per cent). These ratios were cross-validated with a random sample of 167 PhD graduates in Australia that were individually hand coded as either working in academia, industry or public/health sector and the results were consistent, with 51 per cent of the sample working in academia.

By summing up the PhD counts of each employer in the top 15 in each industry we can provide a good indication of both the main areas in the public and business sector that employ PhD graduates, as well as a list of the top employers in each sector.

Where do current PhD students want to work?

The second part of the project – examining the career ambitions of current PhD students – was carried out through a national survey of PhD students. The survey asked students to nominate their field of research, their place of study and their

10 million+
LinkedIn members
in Australia⁵

This represents
around **8** out of **10**
working Australians

Around **70,000**
Australians with
PhD qualifications
on LinkedIn

preferred sector of employment. A total of 446 responses were received from PhD candidates from 32 universities in all states around Australia as well as a handful of expats studying at overseas universities. All disciplines including business, science, arts and health were represented in the survey with students working in over 100 different fields from accounting to zoology.

Students were also asked to name their top two “ideal” employers. Many students stopped short of specifying companies, instead preferring to give a broad indication of the sector and kind of employment they are interested in.

Case histories

Throughout this report you will find some examples of PhD research expertise applied within industry. These case studies illustrate the appetite of PhD students to engage with organisations outside the academic sector, and the value they have added to these organisations by bringing their research talents to short term projects. The source of these stories is the APR.Intern (formerly AMSI Intern) program.

TOP 50 PhD EMPLOYERS IN BUSINESS (500+ STAFF)

 BANKING, FINANCIAL SERVICES & INSURANCE	 MINING, OIL & ENERGY
Australia and New Zealand Bank Commonwealth Bank of Australia Macquarie National Australia Bank Suncorp Westpac	Alcoa Corporation BHP Chevron Origin Energy Rio Tinto Shell Woodside Energy WorleyParsons
 COMPUTER SOFTWARE & INFORMATION TECHNOLOGY	 MANAGEMENT CONSULTING & ACCOUNTING
Amazon Web Services Atlassian Google IBM	Boston Consulting Group Deloitte EY KPMG McKinsey & Company PwC
 ENGINEERING	 OTHER INDUSTRIES & SERVICES
AECOM GHD SMEC Aurecon	Australian Broadcasting Corporation Boeing Coles Golder
 LAW & LEGAL SERVICES	 TELECOMMUNICATIONS
Davies Collison Cave FB Rice	NBN Co. Telstra Corporation
 MEDICAL & PHARMACEUTICAL	 UTILITIES
AbbVie AstraZeneca Cochlear CSL GSK Novartis Pfizer ResMed Sanofi Seqirus	Australian Energy Market Operator Melbourne Water Sydney Water Western Power

“My PhD taught me to develop myself and my thoughts with much greater rigour. It also created a life-long curiosity to understand and acquire as much knowledge as possible. My thesis touched much of the scientific and engineering basis of the mining, oil and gas industries. This has served me well in a corporate world struggling with cultural and technological transformation. It has helped me with critical, information-based high-quality decisions throughout my career – and made me into the leader I think I am today.”



Dr Andrew Mackenzie
CEO, BHP
 PhD in Organic Chemistry

Figure 1 Trends in PhD completions and academic workforce in Australia 1948–2018 (Per annum and cumulative)⁶

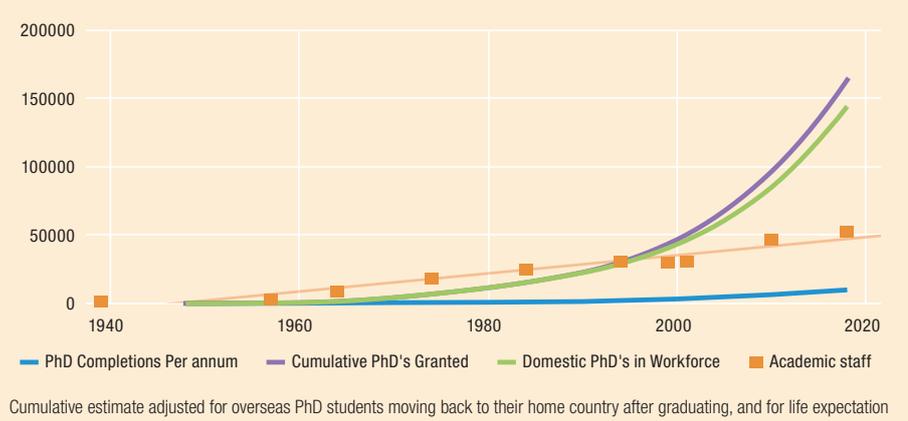
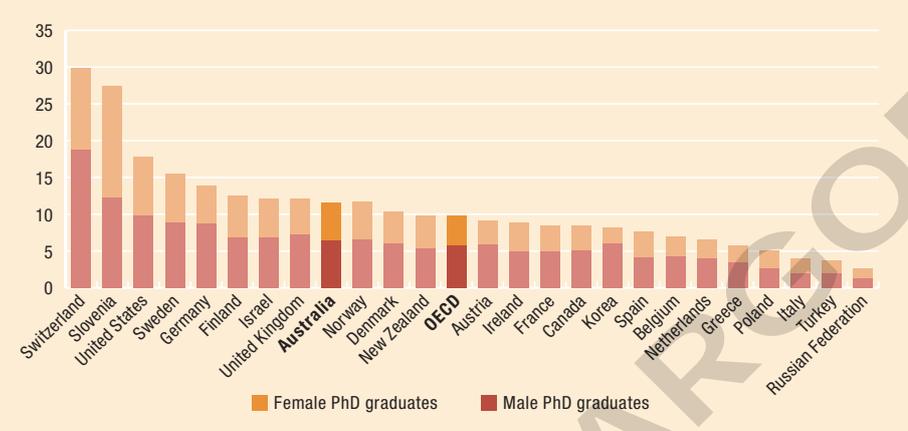


Figure 2 Proportion of PhD graduations in the OECD (per 1,000 people of working age)⁷



Background PhD graduation in numbers

According to ABS Census data, there were 116,096 residents with a PhD degree in 2011, and 135,277 in 2016 – an increase of more than 19,000 over a period of five years.⁸ The number of PhD graduations has been steadily rising for a number of years. Since 2000 the PhD graduation rate increased from about 1.3 per cent to 2 per cent of all graduations in 2012. In absolute numbers, the number of people graduating with a doctorate in research has more than doubled in this century, from 3,933 in 2001 to 9,054 in 2017.⁹

Figure 1 combines long-term trends in PhD completions, cumulative estimates of the number of PhD holders in the community, and trends in academic staff numbers over the last 50 years.¹⁰ It provides a simplified but revealing account of the

transformation that has taken place, away from the traditional destiny of the aspiring academic scholar: the university. The PhD completions per annum (the blue line) show a steady increase, in particular from the 1980s onwards. The size of the academic workforce (the yellow line) also shows an upward trend over a long period of time. The purple line represents a cumulative count of PhDs granted annually, and the green line an estimate of the growth of domestic PhD holders in the Australian workforce. Note that this cumulative estimate is adjusted for overseas PhD students moving back to their home country after graduating, and for life expectation.

The combination of the long-term trends, in particular the exponential growth of the PhD workforce and the steady, but much

more modest growth in the academic workforce reveals how sometime in the 1990s the academic workforce became unable to absorb the number of PhD graduates. Since that time, an ever-increasing proportion of PhD graduates has had to find employment elsewhere.

According to 2016 census data, the top industry destinations of PhD graduates were tertiary education (41.9 per cent), followed by professional, scientific and technical services (13 per cent), medical and other health care services (7.1 per cent) and public administration (6.2 per cent).¹¹ However, these figures do not tell us how the PhD graduates are divided over the private, public and academic sector. They also do not give us an idea of the possible differences between PhD graduates from different fields of study. These are areas where our investigation of LinkedIn data gives fresh insights.

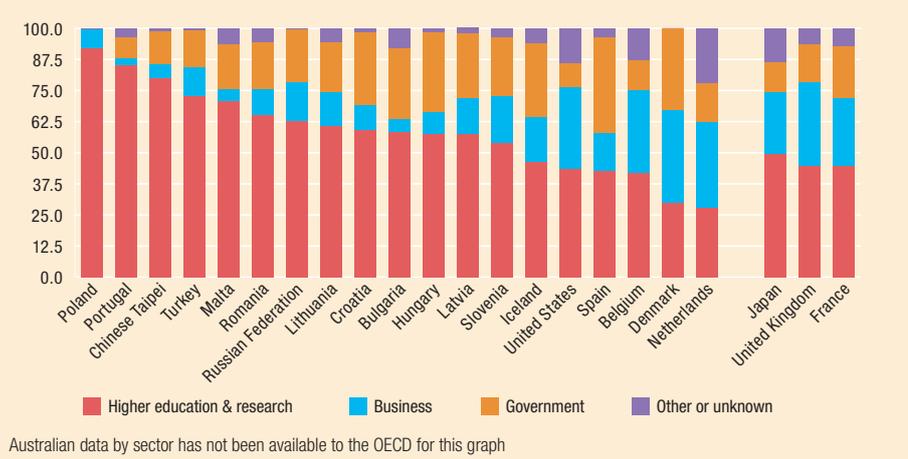
How does Australia compare internationally?

The Australian PhD graduation rate (1.17 per cent of the working population) is slightly over the OECD average of 0.99 per cent of the working population. However, it is lower compared to the USA (about 1.78 per cent), Germany (1.38 per cent) and the United Kingdom (1.21 per cent).¹²

PhD graduation rates are rising across the OECD: new doctorate graduations grew from 158,000 in 2000 to 247,000 in 2012. They have also grown as a proportion of all degree completions. The OECD average was 1 per cent in 2000, growing to about 1.65 per cent in 2012.¹³

Data from the OECD reveals that PhD employment by sector varies considerably. In countries such as Poland and Portugal the overwhelming majority of graduates work in the higher education sector. However, in other countries, such as The Netherlands, Belgium, Denmark, the United Kingdom and the United States, more than half of doctorate holders work outside of academia – in business or government.¹⁴

Figure 3 Which sectors employ PhD graduates by percentage (OECD 2009)¹⁶



Australian data by sector has not been available to the OECD for this graph

Figure 4 A growing share of PhD graduates in the United States are being employed outside academia¹⁷

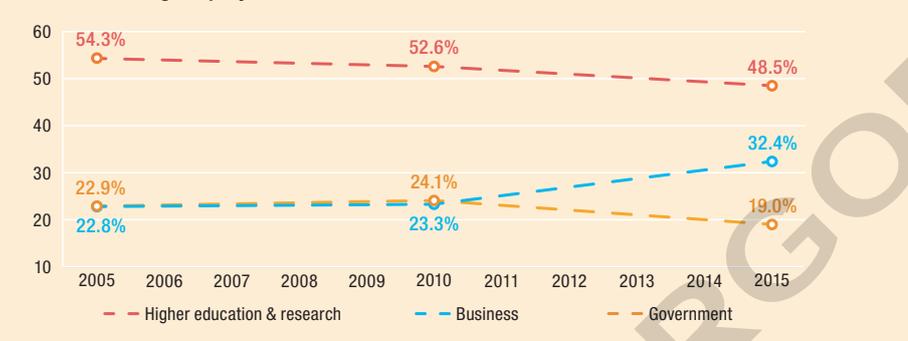
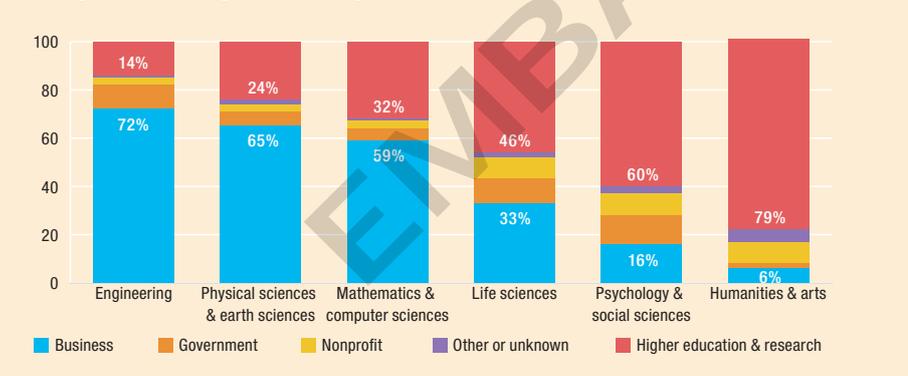


Figure 5 Most United States STEM PhD graduates work in industry, humanities graduates stay in academia¹⁸



Australian data by sector has not been available to the OECD.

A 2017 survey by the European Science Foundation among “early career” doctorate holders at nine European organisations in The Netherlands, Germany, Romania, Croatia, Luxembourg, Austria and France found that 62 per cent of respondents worked in academia, but that 39 per cent of those working in a research role were planning to change to a non-research career.¹⁵

In the United States, PhD graduates working outside academia have started to outnumber those remaining in the academic sector in the last decade. Data show that the percentages of PhD graduates employed in research and higher education and the public sector have been in steady decline. Fewer than half of all United States PhD graduates now work at universities.

The data from the United States also provides a glimpse of the differences in career destinations between PhD holders

“The promotion of an independence of thought and an understanding of the value of persistence that comes from doing a PhD has helped meaningfully in my business career, even though that career has been in an industry different from my original studies.”



Dr Brett Cairns
CEO, Magellan Financial Group
PhD in Chemical Engineering

from various areas of study. Where most psychologists and social scientists with a PhD overwhelmingly tend to stay on in an academic job, most engineers, computer scientists, and other scientists in science, technology, engineering and mathematics (STEM) areas move on to jobs in industry.

The analysis of the LinkedIn data sheds some light on the career destinations of Australian PhD graduates – including differences between doctorate holders coming from different areas of study.

Research outcomes

PhD employers in Australia: Summary of the project results

Where do our PhD graduates work?

Our exploration of LinkedIn data shows that a considerable proportion – 48 per cent – of doctorate holders are employed in the private and public sectors. While this proportion is not quite as high as in the United States or some other countries, it represents a substantial number of PhD graduates. Based on the reported years of experience of employees on LinkedIn, we estimate that over the last ten years, on average more than 2,500 doctorate holders per year have entered the public and private sectors. Given the growth of PhD graduations, this number will likely increase every year. For example, based on the 2017 number of domestic PhD graduates (5,525)¹⁹, as many as 2,652 new graduates entering the job market in 2017/2018 might have ended up in business, public or non-profit sectors.

Business sectors that attract PhD graduates

In the private sector, certain industries stand out for engaging and employing research-trained recruits. Topping the areas of employment are the banking, finance and insurance industries, followed

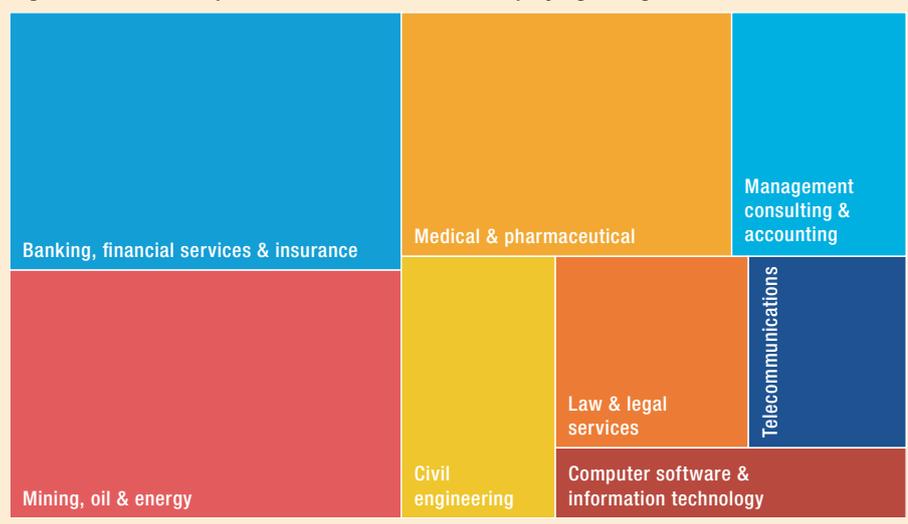
by mining, oil and energy. The medical and pharmaceutical industry also employ very significant numbers of PhD graduates.

The index of top 50 PhD employers in the business sector contains some of the largest companies in Australia, such as the “Big Four” banks and large mining entities. Many are Australian branches of multinational companies with thousands of employees both here and overseas. The LinkedIn data also shows that the overwhelming majority of PhD graduates (more than 70 per cent) work for very large employers (including universities) that employ more than 500 staff. This leaves just under a third of PhD graduates working for small (1–19), medium (20–199) or larger organisations with 200–500 staff.

In the public sector, various levels of state and federal government dominate as PhD employers. Within federal government specialist, knowledge-intensive agencies such as the Australian Bureau of Statistics, Geoscience Australia and the Bureau of Meteorology have a high percentage of PhD graduates.²⁰ The hospital and health care sector is likewise a prominent employer of researchers. In fact, combined with its

“I work in high tech, financial services and capital markets environments, which are predominantly male oriented. As a woman in leadership, having a PhD has enabled me to demonstrate immediate credibility in these sectors. It has stood me in excellent stead with regard to analysing and synthesising disparate information in order to make predictions about emerging technology trends. The PhD is powerfully useful, but well beyond the way I originally thought.”

Figure 6 Business Top 100: The main industries employing PhD graduates in Australia²¹



Dr Catriona Wallace
CEO and founder, Flamingo AI
PhD in Organisational Behavior
Human Technology Interaction

Figure 7 Spread of PhD employment by size of employer²²

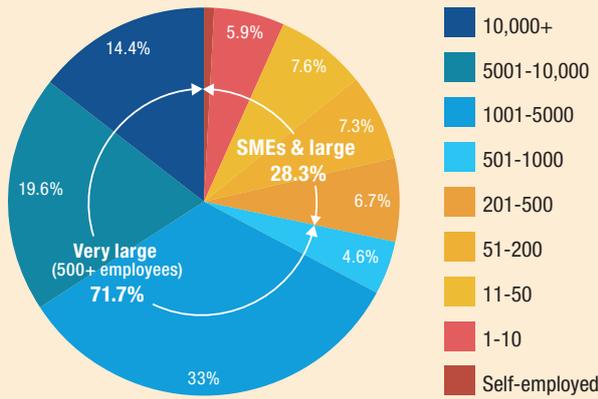


Figure 8 Government, health, defence and not-for-profit top 100: main sectors employing PhD graduates²³

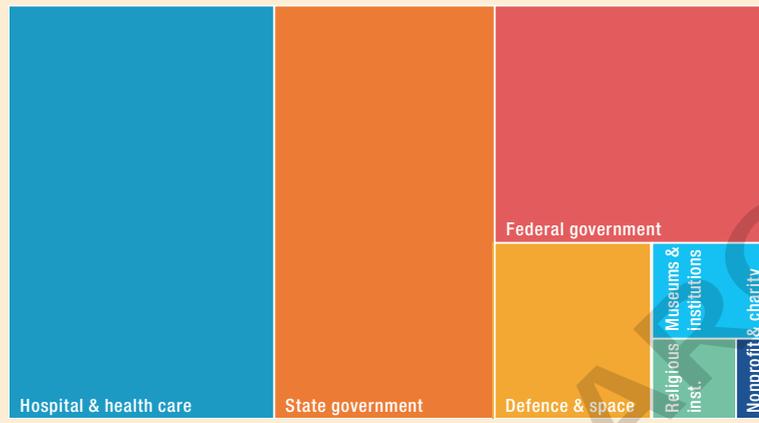
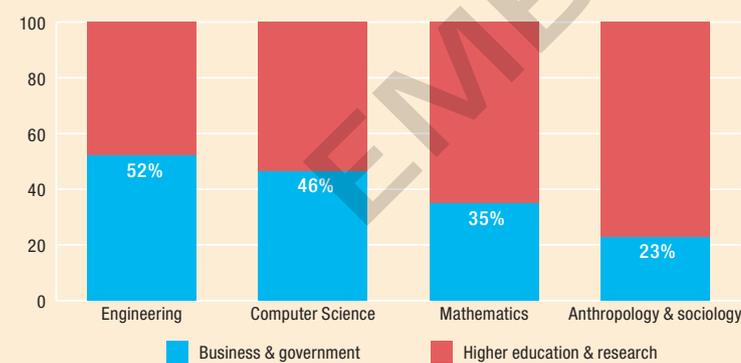


Figure 9 Australian PhD employment by sector and field of study²⁴



counterpart in the private sector, the medical and pharmaceutical industry, the combined public and private medical and health-related industries are the most PhD-heavy all around.

In light of the substantial differences in career outcomes of PhD graduates from different areas of study in the United States (see “PhD graduation in numbers” in this report), we were not surprised to find similar results in Australia. In Australia for example, we can see from our analysis of LinkedIn data that sociologists and anthropologists overwhelmingly remain in academic jobs. On the other hand, the majority of engineers end up moving out of research and higher education into industry.

Fostering long-term collaboration between research & industry

A PhD internship with CSL has influenced the way the global therapeutics company identifies new drugs and improves treatments for a range of conditions. Dr Milica Ng first started at CSL in 2013 as a PhD intern, after catching the eye of CSL with her skill set across mathematics, computing and engineering.



From intern to department head in five years, Milica now leads the Data Science team at CSL and is taking on her own PhD interns, cultivating her team and supporting the company’s capacity to develop and deliver innovative biotherapies that save lives, and help people with life-threatening medical conditions live full lives.

Milica and her team are working alongside biomedical researchers leveraging bioinformatics, biostatistics, high-throughput image analytics, systems modelling and artificial intelligence approaches to support identification of new therapeutic targets and confirm effectiveness of existing therapies. Milica has thrived in this ever-changing landscape, driven by the challenge of rapidly advancing research technologies and the need to work with increasing volumes of data.

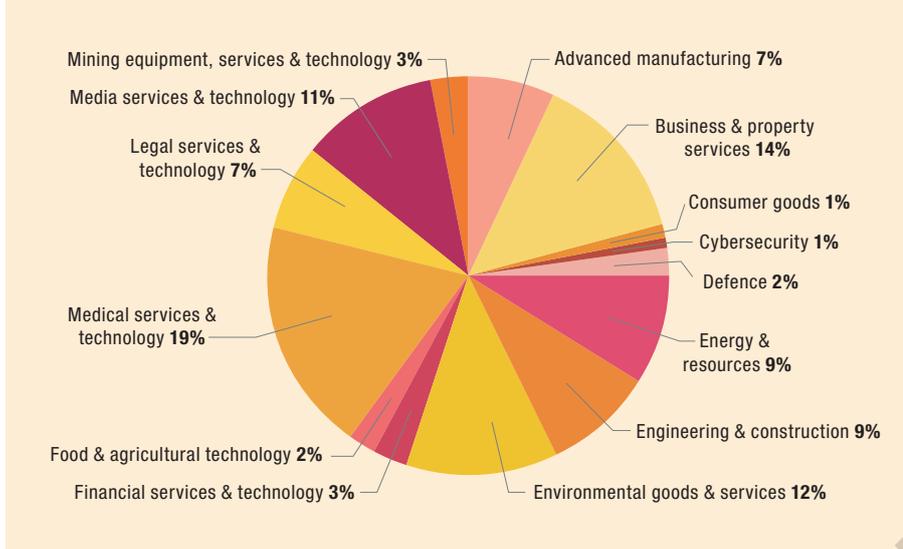
“I definitely enjoy the dynamic nature of the field. It is exciting to see the role of mathematical and other quantitative sciences evolve in medical and biological research with the rapid development of measuring platforms and technologies.”

Dr Milica Ng, CSL Head of Data Science

Now with experience on the other side of the fence, Milica is an advocate for on-going engagement of PhD interns.

Research outcomes

Figure 10: Spread of PhD employment in Australian businesses with less than 500 staff²⁷



“The PhD has taught me how to finish what I started and taught me persistence, which I use on a daily basis in my job”



Dr Silvia Pfeiffer
CEO & Co-Founder, Coviu
PhD in Computer Science

PhD employment in companies with less than 500 staff

Employment of PhD degree holders is not limited to Australia’s largest employers. Almost a third of PhD holders are employed in organisations with less than 500 staff. Our exploration of PhD employers in the business sector with under 500 employees reveals an interesting cohort of innovative and high growth companies across a range of industries. Many of these companies are Australian-owned but have a global focus—together the top 100 of these employers employ over 500 PhD graduates. This gives an indication of the innovative drive of the industries in which these businesses operate and their openness to adding analytical and research capacity to their business.

Interestingly, many of the sectors in which these companies operate align with the existing Industry Growth Centres which have been established as an initiative of the Department of Industry, Innovation and Science in six industry sectors: Advanced Manufacturing, Cyber Security, Food and Agribusiness, Medical Technologies and Pharmaceuticals and Oil, Gas and Energy Resources.²⁵ However, some other sectors are also revealed as areas of innovation, such as environmental goods and

services, media technology and services, as well as small and medium enterprises in engineering and construction and business and property services.

Many of the companies in this list are developing software products to transform their industries. For example, Down Under Geosolutions’ software is used by the oil and gas industry worldwide; Canva—valued at over \$1 billion last year—is transforming graphic design worldwide via its online design software, and SafetyCulture is providing airlines,

mining and many other industries with mobile safety inspection software.

Note also that many of the companies we have listed are serving global customers—in media technology and services for example, Appen is providing voice technology infrastructure services to technology companies around the world; Melbourne-based Redbubble runs one of the world’s largest online marketplaces for independent designers; Rokt, based in Sydney, is now one of the world’s leading marketing technology companies.

There is significant demand in the private and public sector for people with deep knowledge and sound research & analytical skills

Figure 11: Where do Australia's current PhD students want to work?²⁸

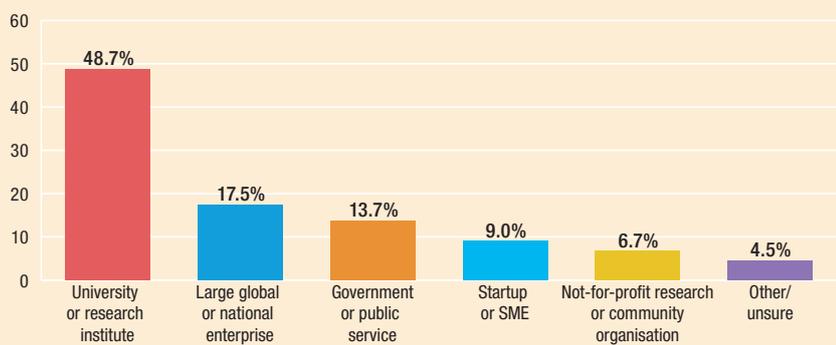
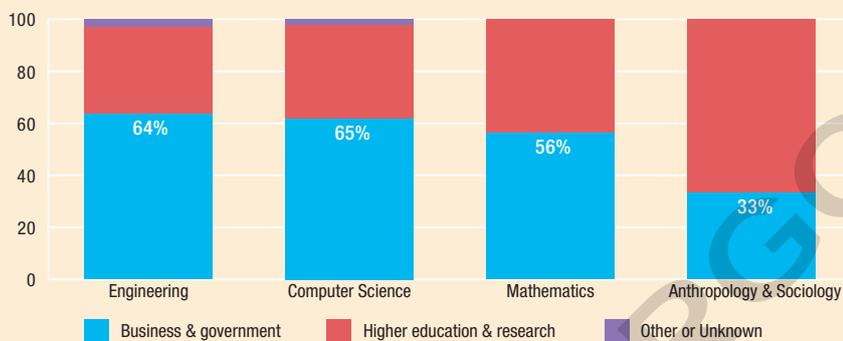


Figure 12: Career aspirations of Australian PhD students by discipline²⁹



Where do our PhD students want to work?

The survey among PhD students reveals that many recognise and see the value in pursuing careers outside of academia. Just over half of survey respondents aspire to work in business, government and related sectors. For 26.5 per cent of students their ideal employment is in a private sector enterprise, while 13.7 per cent prefer to work for government and 6.7 per cent in the not-for-profit sector. These results also align with the results from a biannual survey among doctoral students performed by *Nature*. In the latest *Nature* survey conducted in 2016 among 5,700 doctoral students worldwide, 22 per cent of students preferred to work in industry, 9 per cent in a medical profession, and 9 per cent in government.²⁶

When we compare the career aspirations of PhD students in engineering, computer science, mathematics and anthropology

& sociology with the actual employment destinations of PhD graduates on LinkedIn, we see similarities between the two. According to survey responses, the participating students in STEM-related areas tended to have the highest interest in working outside academia. Given the low number of responses included in this graph (from 33 engineering, 42 computer science, 16 mathematical sciences and 6 anthropology and sociology students respectively) we cannot draw any firm conclusions. However, the similarity between career aspirations and career outcomes does pose some interesting questions that fall outside the scope of this report: How do career aspirations and outcomes influence each other? Are these results an indication that PhD students will be able to find employment in any sector they choose? Or are their career aspirations informed by their expectations about where they will be able to find work after graduating?

“A PhD is an endeavour in itself and curious minds embarking on the journey of getting one have certainly gone through a truly transformational experience. Planning and executing a project as large as a doctorate requires skills similar to the ones that modern industry needs: innovation, agility, desire to be relevant and keep up with state-of-the-art if not to define it!”



Dr Anastasia Volkova
CEO & Co-Founder, Flurosat
PhD in Aeronautical Engineering

The value of research training

Employers each have their own reasons to employ researchers—their motivations might vary depending on their sector or industry. For the academic sector, advancing knowledge through research is their main purpose. They need to attract talented researchers with the ability to communicate effectively to contribute to their local and international profile and reputation. On the other hand, businesses and other organisations outside of the academic sector will have very different motives to employ researchers. Companies in the private sector are probably more interested in hiring researchers to develop and improve products, processes or services, and create a competitive edge through innovation. For government agencies, hiring researchers is a way to access specialist knowledge and skills.³⁰

When asked what type of skills employers find important in researchers, the answers will vary across types of employers as well. For instance, some businesses might put special value on problem solving, working collaboratively and organisational skills, while government agencies might look for communication and self-management skills.³¹ In short, there is no one particular set of skills or attributes that all employers are looking for.

Employees who have undergone the rigorous research training leading to a PhD can be regarded as highly skilled in their field. Generally speaking, Australian organisations who already employ PhD graduates appreciate what they offer and are highly satisfied. Employers rate postgraduate research graduates considerably higher than others when it comes to adaptability, technical skills and employability. The only skill area where PhD holders are rated—only slightly—lower than undergraduates is in collaborative skills.³²

The manager: *“When I say that [the PhD graduate] can do everything, I mean that if there is something he does not know how to do, it is not an obstacle...he will find solutions to the things he cannot do.”³³*

What is the added value that PhD graduates bring to their careers? Besides a good grounding in a specific area of expertise, the day-to-day experience of completing a research project delivers profound, life-enhancing opportunities for personal growth that go far beyond the particular project. PhD students have to learn to work independently. This requires discipline, rigor and autonomy. Through this process—which can be hard and stressful³⁴—they become different from other students. The skills they receive by working through the challenges they face become part of who

Informing & leading new product development



Interest in underground fuel storage has recently skyrocketed, thanks to growing environmental concerns and regulation. To investigate fuel loss during storage at service stations, wetstock management specialists, **Environmental Monitoring Solutions (EMS)**, collaborated with **La Trobe University** PhD student, Roshan Kumar, on a tailored internship. As part of the five-month project facilitated by APR.Intern, Roshan was given the opportunity to apply his technical skills to a real-life challenge, working with EMS to inform and lead new product development.

“Roshan’s project not only achieved its aim of identifying influences of known fuel system losses, but uncovered new information leading directly to broader benefits in terms of environmental impact.”

Erica Scott, EMS Operations Manager

With the guidance of his Academic Mentor, La Trobe University Head of Mathematics and Statistics, Associate Professor Luke Prendergast, Roshan utilised machine learning and software development skills to design data-driven algorithms.

“The internship provided me with an opportunity to hone my programming skills and learn new concepts, while attempting to manage the complexities of real-world situations. It was a great transition from the academic environment, which makes the education experience more wholesome.”

Roshan Kumar, PhD Intern at EMS

Following the project’s success, EMS employed Roshan in a newly created, full-time position.

TOP PhD EMPLOYERS (<500 STAFF)

 ADVANCED MANUFACTURING	 FINANCIAL SERVICES & TECHNOLOGY
ANCA Motion ATSE Balance Utility Solutions	Carbon Revolution Q-CTRL Silanna
 BUSINESS & PROPERTY SERVICES	 FOOD & AGRICULTURAL TECHNOLOGY
Australian Institute of Business Country Garden Australia daisee Data Analysis Australia McKinsey & Company NAATI Noetic Group Nous Group	Consilium Technology Coogee Chemicals
 CONSUMER GOODS	 LEGAL SERVICES & TECHNOLOGY
McPherson's Consumer Products	Colin Biggers & Paisley Doogue + George FPA Patent Attorneys Griffith Hack
 CYBERSECURITY & DEFENCE	 MEDIA SERVICES & TECHNOLOGY
AVT Australia QinetiQ Australia	Appen Australian Marketing Institute Canva Cordite Publishing Inc. Memjet Technology Predictive Analytics Group
 ENERGY & RESOURCES	 MEDICAL SERVICES & TECHNOLOGY
AMOG Consulting APD Engineering Beach Energy Core Resources CRU CSA Global	4Dx Limited Acrux AGRF Ausvet Bionics Institute Compumedics Ego Pharmaceuticals Epichem Genetic Signatures IDT Australia In Vitro Technologies
 ENGINEERING & CONSTRUCTION	Jurox LifeFlight Australia Microba Nanosonics Novotech Pharmaxis ProScribe Saluda Medical Starpharma TetraQ The Animal Referral Hospital
ACOR Consultants ACSES Engineers CMW Geosciences Douglas Partners EIC Activities FSG Geotechnics & Foundations	Klohn Crippen Berger Martens & Associates pitt&sherry PSM Taylor Thomson Whitting
 ENVIRONMENTAL GOODS & SERVICES	 MINING EQUIPMENT, SERVICES & TECHNOLOGY
Alluvium Consulting Astron Environmental Services BlueSphere Environmental Earth Systems Eco Logical Australia	Aspec Engineering DownUnder GeoSolutions
	 SPORT
	Brumbies Rugby Tennis Australia Western Bulldogs

they are: the thesis is “a transformative rite of passage”.³⁵ Those who complete a PhD generally earn qualities such as resilience, innovation, creativity, adaptability, perseverance and the ability to solve complex problems. As one study concluded, research graduates develop personal resourcefulness.³⁶ As a consequence, a PhD degree is a “powerful toolbox” with skills which “are essential to any workplace, across all sectors of industry.” (Penny Li, PhD graduate and former APR.Intern at ANZ).³⁷

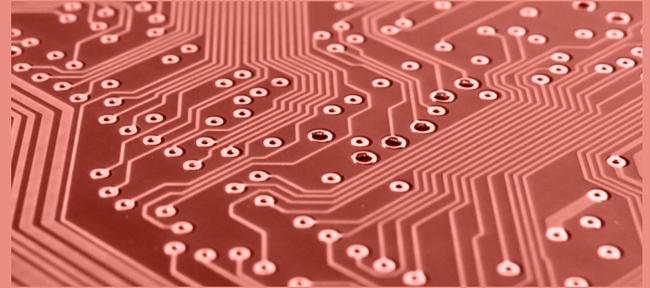
The PhD student: “...I’m not surprised by setbacks. When things don’t work, I know that’s just how it is.”³⁸

Figure 13: Percentage of employers indicating they are “satisfied” or “highly satisfied” satisfaction with graduate skills³⁹

	Under-graduate	Postgraduate coursework	Postgraduate research
Foundation	93.9	92.4	97.5
Adaptive	88.9	90.2	95.1
Collaborative	91.5	84.8	90.4
Technical	94.2	92.5	98.3
Employability	87.1	85	90.7
Overall satisfaction	85.8	82.7	89.7

Conclusion - Bridging the gap between research and industry: PhD internships

Even though in theory there is plenty of interest on both sides—from research graduates and industry—to engage with each other, in practice there are still some hurdles to overcome. There is the often-reported reluctance from graduates to seek work outside academia, or their difficulties in finding employment after graduation. The existing compartmentalisation of the labour market between the academic sector on the one hand and the “world outside academia” on the other is unhelpful as many graduates end up seeking employment outside the academic sector. Newly graduated PhD degree holders might not be sufficiently aware of the skills they can bring to a commercial environment⁴⁰, and what additional training they might need to make them attractive to prospective employers. On the other hand, some businesses are hesitant to hire PhD graduates even if they are looking for employees who have deep analytical skills and the ability to tackle complex challenges.



Recognising transferable skills

When cybersecurity start-up, **Cydarm Technologies**, identified alert triage as the key to efficient incident response, the team collaborated with APR.Intern to enlist the skills of **Federation University Australia** IT PhD candidate, Paul Black. With over 30 years of technical experience in industry, mature-age student, Paul was able to bring both new and well-seasoned programming approaches to the internship. The result was an innovative machine learning system, automating the severity assessment of security alerts.

“The project really helped to identify the transferability of my new skills and modernise my thinking.”

Paul Black, PhD Intern at Cydarm Technologies

“Machine learning has become a critical aspect of cyber security research and the opportunity to put new theory to practice improved my techniques,” Paul added. For Cydarm CEO & Founder, Vaughan Shanks, welcoming an APR intern allowed his business to rapidly develop a new end-to-end system, increasing efficiency via automated alert triage. Cydarm Technologies saw value in Paul’s skills and extended the project from four to five-months to see completion.

“Initial testing demonstrated accurate predictions and fine-tuning will cement validation for external use. The system’s delivery within a short time frame was a great success.”

Vaughan Shanks, CEO Cydarm Technologies

Following his time at Cydarm Technologies, Paul was offered a security researcher position at the Internet Commerce Security Lab (ICSL) in Federation University Australia where he will draw from his experience solving industry problems with computing expertise.

TOP 50 PhD EMPLOYERS IN GOVERNMENT, HEALTH, DEFENCE & NOT-FOR-PROFIT



DEFENCE & SPACE

Australian Army
 Dept of Defence
 Defence Science & Technology Group
 Royal Australian Air Force



FEDERAL GOVERNMENT

Australian Bureau of Statistics
 Australian Institute of Sport
 Australian Taxation Office
 Bureau of Meteorology
 Dept of Agriculture & Water Resources
 Dept of Foreign Affairs & Trade
 Dept of Human Services
 Dept of Industry, Innovation & Science
 Dept of the Environment & Energy
 Geoscience Australia
 IP Australia
 Reserve Bank of Australia



STATE GOVERNMENT

Dept of Agriculture & Fisheries QLD
 Dept of Education & Training VIC
 Dept of Environment & Science QLD
 Dept of Environment, Land, Water & Planning VIC
 Dept of Health & Human Services VIC
 Dept of Jobs, Precincts & Regions VIC
 Dept of Justice & Community Safety VIC
 Dept of Primary Industries & Regional Development WA
 NSW Department of Education
 Queensland Department of Education
 Transport for NSW
 VicRoads
 Victoria Police



HOSPITAL & HEALTH CARE

Alfred Health
 Austin Health
 Cancer Council NSW
 Cancer Council Victoria
 Department of Health
 headspace
 Monash Health
 NSW Health
 Orygen
 Peter MacCallum Cancer Centre
 Queensland Health
 Royal Prince Alfred Hospital
 SA Health
 St Vincent's Hospital Melbourne
 The Royal Melbourne Hospital
 Therapeutic Goods Administration
 Walter & Eliza Hall Institute of Medical Research
 Westmead Hospital



MUSEUMS & INSTITUTIONS

Australian Museum
 Museums Victoria
 Western Australian Museum

“I’m one of 10 PhDs on National Library staff; we come from many disciplines, and we work in every part of the Library’s business—from web archiving, to exhibition, to governance. I know that the analytical and conceptual thinking a PhD hones adds huge value to our work, not least in dogged persistence in what can be long and sometimes lonely roads.”



Dr Marie-Louise Ayres
Director-General National Library of Australia

PhD in Australian Literature

The case stories from the APR.Intern program provide powerful illustrations of successful collaborations between industry and academia, as well as strategies on how to close the gap between academic and business mindsets.

For PhD candidates, the chance to be challenged by “real-life” research problems can be a powerful motivator to apply for an internship. Apart from enhancing employability and developing insight into how things work in other employment sectors, internships provide an opportunity to start building a network of industry contacts.⁴¹ A very important benefit of an internship is learning to identify one’s transferable skills. This is essential to discover where the employment opportunities are. There are plenty of jobs requiring advanced research skills if one knows where and how to look. Recent research from the Australian National University and Data61 has shown that 80 per cent of job advertisements seeking employees with high levels of research skills did not mention the PhD as a desired qualification.⁴² It is therefore essential for PhD graduates to look below the surface, have a good understanding of their skillset and the ability to communicate this effectively to prospective employers.

The company Chief Executive:

“Most PhD graduates restrict their job searches to what they feel qualified to do, rather than exploring what they are capable of doing.”⁴³

For employers, fostering collaboration with universities through placement of PhD interns offers important benefits. It is a means to enhance the skillset of their workforce, and to potentially develop new and innovative products and services. Engaging with research capacity in this way can foster the long-term growth and development of the company.⁴⁴ Internships are a central way to bridge the gap and make employers outside academia aware of the added value of PhD training.

Meeting complex challenges with research expertise



The emergence of big data, artificial intelligence and cloud computing has created opportunity and demand for data analytics capabilities that are intrinsic to post-graduate research. Global engineering and infrastructure advisory company, Aurecon, is harnessing the dedicated expertise needed to consolidate and extract value from this data, recognising the importance of linking client domain knowledge, engineering expertise and cutting-edge research. Hosna Tashakkori was recruited as an intern by Aurecon while finishing her PhD at the **University of Melbourne** to conduct research on three client projects across asset management, 2D and 3D information visualisations, and machine learning.

“The most valuable part of the APR.Intern program for Aurecon has been the opportunity to source research expertise, from across multiple disciplines, to meet some of the most complex challenges in industry. Internship project outcomes are having an immediate impact with our clients and within Aurecon.”

Dr Slaven Marusic, Aurecon Digital Insights Leader

“The most important thing I learnt in my internship was how to work in an agile and changing business environment, to be bold in presenting innovative solutions but at the same time understanding that any solution developed to an industry problem, no matter how good it is, needs to be applicable and practical for delivery at the end of the day.”

Hosna Tashakkori, PhD Intern at Aurecon.

Aurecon offered Hosna a full-time role after the internship and have embraced the program, and its value, by continuing to place more PhD students into the business.

About the APR.Intern program

Delivered by AMSI, APR.Intern is a not-for-profit program that places PhD students in internships in all sectors of industry. The program is open to PhD students of all disciplines and from all Australian universities. The program facilitates PhD placements with small-to-medium and large enterprises as well as government agencies. APR.Intern provides a platform for industry to develop and innovate through short-term research projects of four to five months. These opportunities enable postgraduate students to apply their analytical research expertise while gaining invaluable experience in an industry setting.

380+ PhD interns nationwide placed nationwide by APR.Intern

42% “job ready” PhD interns found employment related to their field

98 industry & government partners have taken part in the NRIP program

Established in 2007 as a small-scale program to place mathematical sciences PhD students in internships, it was expanded into a program for postgraduate students from all disciplines in 2010. From 2017, with the support of the Australian Government Department of Education

and training, the APR.Intern program is delivering PhD student internships into industry over four years through the ‘Supporting more women in STEM careers: Australian Mathematical Sciences Institute (AMSI) – National Research Internships Program (NRIP)’.

To date (as at 31 March 2019), APR.Intern has placed 383 PhD interns nationwide (of which 204 Interns from 28 universities through the NRIP program – with over 1140 student applications for available intern positions). Of the 204 NRIP internships placed by the program, 41.2 per cent have been females. Over the last twelve months, 81.7 per cent of those interns were placed in STEM-related roles. Industry internships have proven to be beneficial to both PhD students and the companies and organisations that place them.

A total of 98 industry and government partners have taken part in the NRIP program to date. More than 20 per cent of PhD interns placed through the APR.Intern program found subsequent employment with the company or organisation where they were placed as interns, according to post-internship surveys. Around half of them entered positions newly created for them. Overall, more than 42 per cent of those PhD students placed by the program who self-identified as being “job ready” following their internship, found employment in a role within industry that was directly related to their field of study and expertise. This highlights the program’s usefulness to PhD students who want to maximise employment opportunities outside academia.

“Mathematicians are highly employable. The logic and rigour of mathematics have played an important role in my executive and non-executive director career. To add to this, PhD training has given me a distinct ability to understand complex situations and break them down into simple manageable steps.”



Dr Eileen Joy Doyle
NED, Business Angel and author
PhD in Applied Statistics

Appendix: The online survey

Survey methodology

The online survey was distributed nationally via a number of channels:

- 1 AMSI's network of students, universities and PhD employers, through publishing in the Research and Higher Ed and APR.Intern online newsletters;
- 2 Ribit's platform of students interested in career related work while studying;
- 3 Selected Higher Degree by Research coordinators across Australian universities.

Most of the 446 responses received were from current PhD students from a diverse range of disciplines covering sciences, humanities, business and arts. PhD candidates from over 80 different fields of research were included in the survey; fields as diverse as food science, building and evolutionary biology were represented. The geographic and institutional representation was also broad, covering students enrolled at 27 Australian universities from every state and territory in Australia, as well as a handful of overseas universities.

Survey questionnaire - Australia's top PhD employers short survey

1 Are you?

- A current PhD Student
- A PhD Graduate
- Former PhD student but didn't graduate
- Future PhD Student
- Thinking about a PhD

2 What is the field of research of your PhD?

[Selection from official 147 field of research across all disciplines]

3 Which University are you studying at?

[Selection from Australian Universities]

4 Which University are you studying at?

[Selection from Australian Universities]

5 What does your ideal workplace look like?

- Large global or national enterprise
- Startup or small to medium sized enterprise
- Government or public service
- Not-for-profit research or community organisation
- University or research institute

6 Which industry would you like to work in?

[Choice from 24 high level industries in Ribit Schema]

7 Who would your ideal employer be?

[Free text field]

8 Who would your second choice of employer be?

[Free text field]

9 Any other comments about your personal aspirations, experiences and plans for finding employment you would like to share?

[Free text field]

10 If you leave your email, we'll send you the results of this survey.

[Email]

Summary of results and sample responses

1 Mostly a survey of current PhD Students

The overwhelming majority of respondents were current PhD students (87.9%) with most of the remainder being recent graduates (8.6%). A small number of respondents (2.8%) were planning to enrol or considering a PhD.

2 Results represent a broad cross section of PhDs across all fields of research

Over 80 distinct fields of research were covered across all disciplines. No individual field of research represented more than 5% of total responses. Top five field were: business and management (4.4%); electrical and electronic engineering (4.4%); information and computing sciences (3.7%); education (3.4%) and biological sciences (3%).

3 All states and territories are represented

The survey received responses from students enrolled at 27 Australian universities (out of a possible total of 42 Universities) from every state and territory in Australia well as a five universities located overseas.

4 Most PhD students want to work at a university or research organisation

Research: University or research institute (48.7%); Not-for-profit research or community organisation (6.7%); **Business:** Large global or national enterprise (17.5%); Start-up or small to medium sized enterprise (9%); **Government** (13.7%); and Other (4.5%).

5 Preferred industry

After higher education and health preferred industries are diverse.

6&7 Ideal employers

Many students named employers in industries aligned to their field of research, although some expressed a desire to work for employers in other industries. A few examples of are included below as an illustration of the type of responses received.

PhD field of research	University	Ideal employers	
Banking and Finance	Melbourne	Atlassian	Quantum
Biomedical Engineering	Swinburne	CSIRO	Boston consulting group
Biological Sciences	Macquarie	BASF	NIASA
Design Practice	Swinburne	Deloitte Digital	Dentsu
Education Systems	Flinders	UNESCO	United Nations
Pharmacology	Sydney	Astra Zeneca	Chanel
Plant Biology	Flinders	Bayer (Monsanto)	Syngenta
Psychology	Melbourne	Qantas	Any shift work industry

8 Personal comments included: "I am drawn towards being a part of a start-up or continuing at a research organisation, preferably not in academia." Electrical and Electronic Engineering PhD Candidate, QUT

"My second choice would be to continue research primarily for the purpose of maturing technology that would enable the founding of a start-up. Tenure would not be a career end-goal."

Computation Theory and Mathematics PhD Candidate, UNSW Australia

About the authors

Paul X. McCarthy is a consultant with CSIRO Data61's student-employer matching platform, Ribit.net. McCarthy is also Adjunct Professor of Computer Science and Engineering at UNSW Australia, an Honorary Fellow at Western Sydney University and Chairman of Australia's Media Technology Incubator The Studio. His bestselling book *Online Gravity* explains how technology is changing economics. **Dr Maaïke Wienk** is the Australian Mathematical Sciences Institute's Research and Policy Officer.

Acknowledgements

This report is the result of a collaboration between the Australian Mathematical Sciences Institute (AMSI) and CSIRO Data61's Ribit.net. Publicly available LinkedIn data were used for this report and published in aggregate form. The government program '*Supporting more women in STEM careers: Australian Mathematical Sciences Institute (AMSI) – National Research Internships Program (NRIP)*' is carried out by AMSI's APR.Intern and funded by the Australian Government Department of Education and Training.

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