RESEARCH REPORT

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Readiness to meet demand for skills: a study of five growth industries

Francesca Beddie, Mette Creaser, Jo Hargreaves and Adrian Ong

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Francesca Beddie

Francesca Beddie & Associates

Mette Creaser
Jo Hargreaves
Adrian Ong

National Centre for Vocational Education Research

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The National Centre for Vocational Education Research (NCVER) is an independent body responsible for collecting, managing and analysing, evaluating and communicating research and statistics about vocational education and training (VET).

NCVER's inhouse research and evaluation program undertakes projects which are strategic to the VET sector. These projects are developed and conducted by NCVER's research staff and are funded by NCVER. This research aims to improve policy and practice in the VET sector.

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Level 11, 33 King William Street, Adelaide SA 5000
PO Box 8288 Station Arcade, Adelaide SA 5000, Australia

Phone +61 8 8230 8400 **Fax** +61 8 8212 3436

Email ncver@ncver.edu.au **Web** <http://www.ncver.edu.au> <http://www.lsay.edu.au>

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About the research

Readiness to meet demand for skills: a study of five growth industries

Francesca Beddie, Francesca Beddie & Associates; Mette Creaser, Jo Hargreaves and Adrian Ong, NCVER

The Australian Government is reviewing its industry investment and competitiveness agenda. As part of that process the Department of Industry asked the National Centre for Vocational Education Research (NCVER) to investigate the readiness of the education and training sector to meet demand from five industries where potential market opportunities have been identified: food and agribusiness; mining equipment, technology and services; biotechnology and pharmaceuticals; oil and gas; and advanced manufacturing.

The aim of this study was to identify issues pertinent to ensuring that the education and training system can respond to emerging skills demand in these industry areas. Some of those issues apply more broadly across the economy, and most need to be addressed in conjunction with other areas of industry policy.

Key messages

- The gap between the knowledge generated in the education system and the skills demanded by employers and individuals is widening. Differences within and between the industries notwithstanding, a common theme across all is the need for a significant cultural shift in thinking about the way skills are generated and deployed.
- The constraints on the readiness of enterprises to meet demand stem both from within the education system and the changing nature of global value chains. Overcoming these limitations requires:
  - better outcomes from both school and post-school education in developing generic and foundation skills. These need now to include Asia literacy
  - a priority focus on science, technology, engineering and mathematics (STEM), including the development of workplace skills in STEM undergraduate or research degrees and opportunities for continuing professional development in STEM disciplines
  - businesses to better understand their skill needs during different phases of their involvement in global value chains and to encourage workplace learning opportunities
  - funding policies for education and training that support continuing professional development.
- The role of employers is crucial. They must encourage and support a more nimble workforce, that is, one willing to learn new skills and adapt to change. This will require partnerships with schools, vocational education and training (VET) institutions, universities and research organisations.
- Knowledge hubs or clusters create opportunities to foster the creation of skill-intensive jobs, which can lead to innovation and productivity. These demand resources and continuous learning.
- The diversity within each of the five industries, in terms of the stages of their business development and their economic activity, creates challenges in gathering statistical data.
- Particular issues emerged for each industry:
  - In agriculture and manufacturing, older, lower-skilled workers require retraining to find acceptable jobs in their changing industries or elsewhere.
  - In oil, gas and mining, recruiting and maintaining workers in remote and hazardous locations are ongoing challenges.
  - In biotechnology, universities and companies must work closely to understand the business environment to thereby ensure a supply of appropriately skilled graduates.

Rod Camm
Managing Director, NCVER

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Introduction

This project considers the readiness of a number of industries to meet the future demand for key skills. These industries are food and agriculture; biotechnology and pharmaceuticals; advanced manufacturing; mining equipment, technology and services (METS); and oil and gas.

These industries align with the Australian Government's commitment to stimulating growth in manufacturing innovation, agriculture and mining exports, with the Department of Industry identifying several key growth opportunities in each industry as described below (Department of Industry 2014b, appendix 5).

Food and agriculture

The food industry produces a range of food and beverage products from meat, dairy, grain, fruit, vegetables, beer and wine. Agribusiness includes inputs to agricultural production such as fertilisers, pesticides, veterinary products and services, and agricultural equipment and machinery. Growth opportunities include: new markets in Asia's growing middle class; consolidation of Australia's market share in mature markets; new product opportunities from the transformation of primary production enterprises; and the development of new products specifically tailored to new and growing markets.

Biotechnology and pharmaceuticals (health and biomedical products)

The health and biomedical industry develops and manufactures health-related products. This includes medical, surgical, dental products and equipment, medicines, and assistive technologies such as the creation of prosthetic limbs. The biotechnology industry is the application of science and technology to living organisms in order to make or change products, for use across a wide range of sectors including agriculture and medicine. The pharmaceuticals industry contributes to the discovery, creation and supply of prescription medicines and vaccines. The growth in demand for medical devices offers diversification opportunities to a broad range of manufacturers with different capabilities.[1]

Advanced manufacturing

Advanced manufacturing activities are spread across numerous industry sectors. They encompass leading-edge practices and technologies, such as advanced materials, robotics and automation technologies. Industry segments known to be involved in advanced manufacturing activities include but are not limited to: aerospace; precision engineering; scientific instruments; machinery and equipment; electronic and electrical equipment; and specialised textiles. Advanced manufacturing capabilities help enterprises to adapt to the changing manufacturing landscape by enabling manufacturers to diversify their products and services in order to capture new markets and customers. The novel high-value-added products, services, technologies and processes provide Australian firms with competitive advantages that help to offset low-wage, low-skilled labour economies with larger economies of scale.

[1] While this definition embraces medical devices, the data analysis included in this report refers primarily to the biotechnology and pharmaceuticals industries.

Mining equipment, technology and services

Mining equipment, technology and services is another diverse industry and includes associated services such as contract mining and specialist oilfield services, suppliers, equipment and technologies for the mining and oil and gas industries. Spanning manufacturing and engineering and professional services, companies, whatever their size and scope, are linked by a core competency in mining and minerals. Firms provide specialised products and solutions to mining and minerals businesses and are now leveraging their strong reputation internationally in growth markets that include Asia, Africa and South America to enter new markets. Areas for growth and investment opportunities include: the adoption and continued development of new technologies to drive productivity; international growth of services into Asia and Africa; and diversification through high-value-added technologies into other industries.

Oil and gas

The oil and gas industry will soon make up about 2% of Australia's economy, with the majority of that now coming from gas. Australia's output of liquefied natural gas is expected to rise by 250% between 2013 and 2017—18. The industry is well placed to leverage off Australia's strong international reputation as a reliable supplier of equipment, technology and services to access growth markets, including Asia, Africa and South America. Areas for growth and investment in the oil and gas industry include: floating liquefied natural gas operations and maintenance, including advanced construction technologies; onshore shale gas exploration and extraction; subsea pipeline repair and maintenance; process automation, optimisation and de-bottlenecking; brownfields expansion and technical upgrades; environmental management and monitoring; water disposal and reuse (particularly in the coal seam gas to liquefied natural gas sector); carbon dioxide capture and sequestration.

Through a review of the available data and literature this study considers the role that education and training plays in helping to ensure that these industries have the people available with the right skills to realise opportunities as they arise, noting that this necessarily goes hand in hand with other interventions by government and industry.

About this report

Each industry differs in size, stages of development and skill needs. This is further complicated by the diversity of sectors within each industry and a number of overlaps between the industries. While the intent is to refer overall to the five 'growing' industries, some sectors within each of the five industries may actually be in decline. Furthermore, many of the points made apply more broadly than to merely the five industries considered in this study.

The primary aim of the study is to further inform the development of policies promoting close collaboration between industry and the education and training system, with a focus on ensuring adequate skills development within the identified five industries.

The report is structured as follows. We first assemble a profile of the five industries before synthesising the key issues emerging from the literature, beginning with a consideration of global value chains. This is a useful starting point and will assist an understanding of the new way by which many industries are operating and the way in which this influences skill development requirements. We then consider the role of schools, the apprenticeships system and tertiary institutions in their preparation of entry-level workers before discussing the key themes emerging for existing workers.

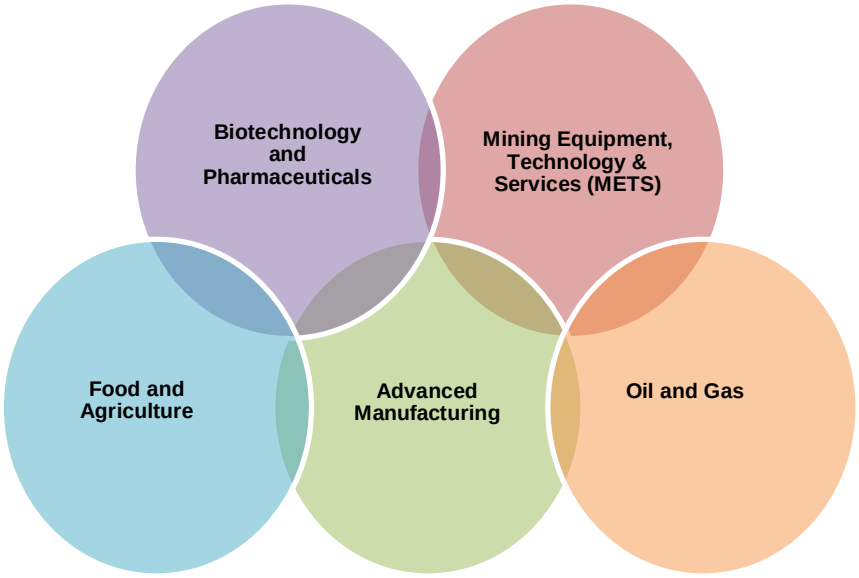
These include addressing skill gaps and future skills demand against a backdrop of specific workforce issues; the persistent problem of literacy and numeracy skills; the use of skill sets and recognition of prior learning for upskilling — particularly in the context of automation having an effect on many aspects of working life. We also consider issues relating to the continuing professional development and mobility of existing workers. Finally, the importance of skills for research and development is considered, along with the critical skills and capacity of the teaching workforce. The last section summarises the key points to be considered in ensuring that Australian industries and the education and training system are ready to meet demand.

Profile of the industries

Australian industry statistics are generally reported according to the Australian and New Zealand Standard Industrial Classification (ANZSIC). ANZSIC provides a means for the standardised collection, analysis, dissemination and production of economic data on an industry basis. The Australian Bureau of Statistics (ABS) uses ANZSIC to compile the national accounts in most of its economic collections. The classification is also widely used for financial, administrative and statistical purposes by users from government, academia and the private sector. In ANZSIC, industries are formed by grouping business units mainly engaged in undertaking similar economic activities. For statistical purposes, it is essential that standard definitions of business units are applied, so statistics can be collected and compiled without gaps or duplication (ABS 2006).

The five industries examined in this report (food and agriculture; biotechnology and pharmaceuticals; advanced manufacturing; mining equipment, technology and services; and oil and gas) do not conform to one industry grouping in the ANZSIC. The diversity of organisations within each of the five industries, in terms of the industries they service and the range of outputs generated, creates challenges in the gathering of statistical data. For example, components of the mining equipment, technology and services industry can be found across eight ANZSIC divisions and over 20 sub-divisions. A further complexity is that the five industries are not distinct, with each overlapping at least two others (figure 1).

Figure 1 Overlap between five industries examined in this report (not to scale)



Historically, the ABS has led the way in identifying user needs for statistics in a particular field and developing statistical data collection strategies to meet these needs. In 2006, the National Statistical Service, led by the ABS, released an information development plan (IDP) for biotechnology statistics that mapped the broad issues and information needs for this field; an action plan to improve information; and a framework for the systematic improvement, integration and use of data sources (National Statistical Service 2006). Despite this initiative, official statistics are not yet available on biotechnology, and information development plans have not been prepared for the other industries examined in this report.

While this makes the compilation of statistics on these industries difficult and does not enable ready comparisons, we have collated a range of existing information to help provide some context for the five industries under consideration (see appendix).

The information has been compiled from a range of sources, generally from secondary statistics assembled by government agencies and industry analysts. It relies on organisation-level statistics about employment, revenue and activity. As well as providing a broad definition for each industry, the data set out the monetary value of each industry, its current workforce numbers, their earnings, demographic profile, the numbers of apprentices, and the educational attainment of workers.

As a clear categorisation of these industries, occupations and therefore the future skills required within them is currently difficult to identify, this creates further challenges for those responsible for data collection and analyses. A new way of thinking about data collection is required, but this will depend on how the boundaries of the industries and the job profiles within them are ultimately delineated.

Global value chains

The production of goods and increasingly of services now involves intermediate inputs – goods and services – sourced globally and which make up a finished output for a worldwide consumer market. This fragmentation of production has seen the emergence of a system of global supply or global value chains, referred to by the World Economic Forum as 'the world economy's backbone and central nervous system' (cited in Drake Brockman 2014, p.59).

The highest value-add may no longer be a product but rather the intellectual effort expended during a research and development phase or the smart distribution and marketing of the goods and services. For example, the merchandise components of an iPhone represent less than a third of the value of the final product (Drake Brockman 2014, p.61).

A supply chain in advanced manufacturing

In Tasmania, the marine manufacturing sector has been dominated by one aluminium fast ferry constructor and its highly skilled innovative supply chain. The companies in this supply chain produce a broad range of products, including marine evacuation systems, rapid access passive fire-protection barriers, ride-control foils and hydraulics, wide-frequency antenna systems and anchoring winches. Companies in the supply chain have matured significantly in the past ten years and many are now successful international exporters in their own right.

(Tasmanian Government 2014)

According to the Organisation for Economic Co-operation and Development (OECD; 2013), the mining industry in Australia shows the highest forward participation potential in global value chains, with several manufacturing industries only marginally involved. Australia has hitherto had difficulty accessing and participating in global and regional value chains, although training in this area has been readily available in the vocational education and training (VET) system since 2004. Despite Australia's geographic location, this ability to participate in global value chains needs to change to underpin growth in manufacturing and agriculture, both major employers in Australia.

In terms of advanced manufacturing, Drake-Brockman suggests that value-chain mapping should be an essential step in developing an industry roadmap for Australia. It could be used more widely to help policy-makers understand what drives competitiveness and what is needed in terms of skills development and data collection. And as the OECD points out, manufacturing today involves much more than the pure production of goods, in that it offers increased opportunities in a range of service-related and value-adding activities (such as logistics, communication and business services, development, marketing and after-sales care) in both the upstream and downstream value chain (OECD 2013).

Value chains have also been used to conceptualise the process of innovation as a sequence of phases involving idea generation, idea development, and the diffusion of developed concepts (Hansen & Birkinshaw 2007). These phases call for different skills and workplace approaches during different phases of industry growth and mean that enterprises and trainers need to think beyond task-specific skills.

A refrain in recent studies of all five industries mirrors the issues described as the phenomenon of 'servification' of manufacturing: development of human resources; research and innovation; provision of infrastructure, especially digital infrastructure as well as logistics and transport; regulatory efficiency to ensure an enabling environment for business; openness to trade, investment and cross-

border people movement; adoption of global standards; and quality assurance. These are all areas pertinent to public policy, and require a shift in thinking about manufacturing in the context of 'services offered and needed' rather than manufacturing solely as a technical or engineering activity.

This report focuses on marshalling the right people and their ideas for the right jobs. First, we look at attracting new recruits, in particular young people; then we consider the skills and skill gaps of existing workers.

Preparing entry-level workers

Schools

According to reports on manufacturing, the mining industry and food and agriculture, there persists a negative perception of work in these industries. For example, a recent PricewaterhouseCoopers survey found that 14% (the highest rate for all industries) of young people were discouraged by the poor image of work in the oil and gas industry to consider work in the industry (Australian Workforce and Productivity Agency 2013b, p.192). And despite 90% of agricultural graduates finding jobs, the Australian Council of Deans of Agriculture (ACDA; 2014) has noted that career advisors are not encouraging students to take agricultural courses. The council suggests this is because the courses are not distinguished from the broader field of environmental science and management, where job outcomes are not as strong. It is therefore acting to improve information for prospective students.

Similarly, the notion that many of these industries are male-dominated means female students do not see themselves as working in them or studying the prerequisite STEM subjects. Nor, as the PricewaterhouseCoopers survey revealed, are girls (and women) well informed about the range of roles available to them (Australian Workforce and Productivity Agency 2013b, p.144).

Good career advice can change this, but the evidence suggests that this must be done early. It involves parents, teachers and career counsellors, who in turn need to better understand the range of opportunities available to young people both in the labour market and within the range of tertiary education provision. In addition, exposing school students in Years 9—12 to a suite of options can help them to make the right decision about their vocational pathway. A Group Training Australia (GTA; 2014) report on the experience of group training organisations found that structured workplace learning and work exposure improved engagement and retention in school, provided an understanding of the vocational pathways available and the nature of possible occupations, encouraged the development of 'employability' skills, and improved numeracy and literacy skills. The report reiterates the importance of strong collaboration between schools and employers in VET in Schools programs. It also points out the need for a change in the attitude in many schools — that VET pathways are a second-best option — which deters high-achieving students.

The right career information, along with meaningful work experience, is only one part of the picture. Students also need sound literacy and numeracy skills as well as the aforementioned STEM skills. The Australian Industry Group (AiG; 2013) reports that an estimated 75% of the fastest growing occupations require STEM skills and knowledge. The Chief Scientist recommends that the Australian education system, formal and informal, be organised:

- first to lay the foundation for all Australians
- then, to refresh constantly a STEM literate community
- to produce and regularly refresh a STEM skilled workforce — including the research workforce
- to develop proficient STEM practitioners in suitable numbers.

(Office of the Chief Scientist 2013, p.13)

Such calls are echoed by many in business. This means paying much greater attention to imparting this knowledge at school and at entry-level training. But this is unlikely to be sufficient. STEM skills are dynamic and change as new technologies and systems arise and this requires greater attention

to continually refreshing STEM skills via professional development and training opportunities in the workplace.

The Manufacturing Skills Australia (MSA) 2014 environmental scan also notes that 'STEM skills are the building blocks required for trade apprenticeships and are key to pursuing the high quality, high skill outcomes manufacturing needs' (2014, p.36). However, according to a recent study by the National Centre for Vocational Education Research (NCVER) that investigated changes in the quality of trade apprentices between 1995 and 2006, more apprentices in the later cohort came from the bottom two quintiles in relation to mathematics and reading achievement. A second finding of the report is that apprentices are not only less academically inclined but also from low socioeconomic status (SES) backgrounds. Higher-SES males, even with less good academic scores, are taking advantage of expanding university places (Karmel, Roberts & Lim 2014).

The Department of Industry notes 'Australian businesses introducing world-first innovations report much greater usage of science, research and engineering skills than less novel innovators' (Department of Industry 2014a). This report also suggests that issues about the supply and demand of STEM skills are complex, as 'sectors of the economy have different requirements in terms of quality and quantity of STEM skills' (Department of Industry 2014a).

The Office of the Chief Scientist has established a STEM Advisory Group to advise on:

- the means to a strategic framework for building a broad, high-quality STEM base in the Australian workforce and community
- priorities arising from the Office's industry working group and education roundtables
- a plan to achieve best practice in STEM education in Australia canvass.

<http://www.chiefscientist.gov.au/wp-content/uploads/Terms-of-reference_STEM-advisory-group.pdf>

Apprenticeships

The recent Australian Workforce and Productivity Agency (AWPA; 2014) report on the manufacturing workforce included work by ACIL Allen Consulting, in partnership with NCVER, on commencements and completions in engineering trade apprenticeships. That study found no single factor that affects completion rates. A variety of factors influence a student's choice to continue or withdraw from their engineering trade apprenticeship. They include the size and type of employer; workplace factors such as relationship with the employer; the level of apprentices' school attainment and skills level; the quality of pre-apprenticeship recruitment; and the level of apprentice and employer support. Wages are also a factor, but not a deciding one.

The study suggested strategies to raise successful completion rates: improve the quality and distribution of engineering-related information to secondary students; strengthen employer and apprentice matching; streamline employer advisory services; improve apprentice mentoring; and better coordinate apprentice and employer support at the various levels of government. The Australian Workforce and Productivity Agency concluded that many of these strategies could be extended to other areas to improve Australian Apprenticeship completions, including in manufacturing occupations (Australian Workforce and Productivity Agency 2014, pp.107—8).

Manufacturing Skills Australia (2014, p.34) likewise places emphasis on help within the firm:

> Employers need to be supported to properly determine what their skill needs are, and better informed in what the options are to meet their needs. They also need support in developing effective relationships with their apprentice.

The Manufacturing Skills Australia 2014 environmental scan highlights a concern among employers about competency-based progression within apprenticeships, which can see premature sign-off.[2] The scan also underscores the growing need for apprentices to learn how to navigate highly commercial work environments that require skills in quoting and contract negotiation and in project and business management (p.34).

As in other industries, notably mining, a prominent view is that employers, not governments, must take the lead in determining the relevance of training content and controlling the training process and the costs associated with the apprenticeship (Australian Workforce and Productivity Agency 2014, p.108), or as the 2013 Skills DMC environmental scan (p.4) put it:

> to ensure continual productivity of an operation, there needs to be greater focus on the skilling of a person against industry-defined competencies at a time and location that are work-place relevant to better reflect industry need (though not at the expense of quality).

Tertiary institutions

Employers often complain that graduates are not job-ready. This again points to a mismatch between the content of the courses students are taking and industry requirements. It also suggests that expectations are unrealistic about what a brand-new worker can do. A theme in the literature is the critical role of workplace learning and continuous professional development.

Delivering the right combination of skills and attributes cannot be the job of the education provider alone, especially since we know, for example, that mid-level qualifications currently provide weak links to the labour market, except when they are related to licensing requirements or regulations (Moodie et al. 2013), and that university graduates are not all readily finding jobs or, to put it another way, are not choosing the degrees that lead to the quickest employment (McCrindle 2014).

Karmel (2009, p.9), talking about VET[3] has put it succinctly:

> It is a mistake to think that there is a tight and deterministic relationship between VET and the labour market. VET provides skills that can be used in a variety of jobs. Most occupations, with the exception of some professions and the licensed trades, do not require particular qualifications. Similarly, training for an occupation does not imply that the training must be used only in that occupation. Much education, including VET, has a large component of generic education. This lack of a tight link partly reflects the type of society we live in and also because many skills are learned on the job — skills come from both formal training and experience.

This suggests that educational institutions should focus their efforts on preparing people for the workforce, not for a specific occupation. That said, a theme in the literature on the five industries in focus is the need for greater interaction between educational providers and employers, the aim being to design programs that best equip graduates for employment. The best of apprenticeships do this,

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[2] An AiG project is trying to tackle concerns about competency-based progression in engineering trades, which can also accelerate the training for those able to learn more quickly. See <http://www.aigroup.com.au/portal/site/aig/education/engineeringexcellence/>.

[3] Vocational training occurs also in higher education, although this was not the focus of the analysis.

which is confirmed by the Australian Workforce and Productivity Agency's (2013b, p.162) finding that: 'many companies do not have problems sourcing workers in the skilled trades and semi-skilled occupations, either as feed-in for internal training programs or as already experienced hires'.

However, that report goes on to say that companies do experience difficulties in sourcing people with the advanced skills and industry experience required, given the strict safety regimes required in the resources industry.

Recent graduates in biotechnology can have difficulty gaining their first professional position in the industry because of their lack of experience. One solution to this problem is through industry-based learning (IBL) programs within their courses (Allen Consulting Group 2010, p.19), which according to the Swinburne University website[4] give students the opportunity to:

- obtain valuable industry experience and professional skills
- gain insight into a professional career with networks
- gain income while learning
- increase professional communication and interpersonal skills
- enhance motivation, confidence and maturity
- gain a head start in the competitive graduate job market.

Industry-based learning comes at a cost:

> For training providers, arranging placements and supporting students while they are on placement involves significant work as there is a strictly limited number of employers in the biotechnology industry, many of which are small businesses. For employers, there can be substantial time required to induct, train and supervise students on placement, together with potential occupational health and safety issues. The time-related costs are particularly significant for small businesses … For the students themselves, one training provider reported that the additional time and expense associated with IBL — which can be up to one year in duration — represents a prohibitive barrier for a number of students. (Allen Consulting Group 2010, p.51)

Graduate programs and professional cadetships are other arrangements through which an employer agrees to contribute to, or subsidise the cost of, an employee's education and also to influence the curriculum to produce employable graduates. In the case of BHP Billiton (2014), these people need to be: 'mobile, flexible, achievement oriented, enthusiastic about their development and committed to working with us to build a career and contribute to our success'.

The Food Processing Industry Strategy Group set up to advise the then government suggested that the effects of a decline in graduate numbers (including suitably qualified and skilled graduates) and the inability of the industry to attract and retain skilled labour, especially in regional communities, could lead to a reduction in the ability to innovate and increase productivity. As a remedy for this, the group recommended the establishment of a Food Innovation Hub (Department of Innovation 2012, p.11). The hub could be a catalyst for more collaboration between researchers and industry with the involvement of governments, industry and researchers to oversee and prioritise food research; improve commercialisation from research; attract more talent to the industry; and better understand and manage entry into new markets. This recommendation has resulted in Food Innovation Australia Ltd (FIAL). Such industry collaboration and knowledge transfer underpin other initiatives, such as the

[4] <http://www.swinburne.edu.au/iel/programs/ibl>.

cooperative research centres, and have the potential to improve the preparedness of other industries in this study to meet future demand for skills and innovation.

Some of these attributes can be fostered in schemes like the New Colombo Plan, which offers scholarships and travel grants to Australian university students to support study and internships in the Indo-Pacific region (Department of Foreign Affairs and Trade 2014). Such experience will also build participants' 'Asia literacy', identified as necessary to improve success in export-oriented industries.

Capitalising on the rise of the Asian century has been identified as a critical issue in the agriculture and food industry. The Australian Workforce and Productivity Agency (2013a, p.72) lists the capabilities that will be required: adaptability, flexibility, resilience, creative and design thinking, and the confidence and readiness to interact with and operate in Asia; cross-cultural and representational skills are also flagged as important. Agrifoods also sees Asia-relevant capabilities as crucial, along with 'world-class business and leadership capabilities, entrepreneurial skills, marketing and global supply chain management skills (Agrifood Skills Australia 2013, p.iv). (It notes too the biosecurity risks attached to a more export-oriented industry [p.7]). Attention to Asia literacy has hitherto been mainly — and patchily — within schools and universities. With VET institutions now operating in the international market there is also potential for them to incorporate Asia literacy into their domestic programs.

As Australian manufacturers and agriculturalists move towards advanced and innovative operations, they will have a greater call on paraprofessionals such as engineering and laboratory technicians. Increasingly, however, diploma and advanced diploma programs are being used as stepping stones to higher study rather than as entry-level qualifications for some occupations (Manufacturing Skills Australia 2014, p.25). Similarly, there is high demand for technical personnel in oil and gas plant process operations and maintenance and for supervisors with appropriate levels of technical and safety experience and frontline management skills, but these skills are difficult to source, especially in the domestic labour market (Australian Workforce and Productivity Agency 2013b, p.152). The extension of Commonwealth Supported Places (CSP) to sub-degree programs may see this change.

Existing workers

> Our people face an unprecedented need to upskill in the face of jobs becoming more technical and demanding greater knowledge. Our once pyramidal industry — comprising owners and a mass of low level operators — is becoming diamond in shape as technology and automation continues to remove low-skilled job roles and a new breed of technicians, para-professionals and specialist contractors grow to form a critical, highly capable broad band of workers. Our managers face the greatest transition of all — steering companies through structural adjustment whilst at the same time driving efficiencies, seeking new markets and retaining their social license with consumers.

This quotation comes from the 2013 Agrifoods Environmental Scan (p.vii) but could as easily have come from the manufacturing industry, which is also undergoing major structural adjustment. Achieving the transformation of Australian industries will significantly depend on the existing workforce. The review of the literature identified several matters to be addressed to ensure these workers are equipped with the right skills.

As the review of the South Australian and Victorian economies explained, the type of training that workers will require will be determined by their existing skills. The more highly qualified will find it easier to transfer to other industries and are often more willing to move to new locations for better job opportunities. Many, however, have poor literacy and numeracy skills and few formal qualifications (Department of Industry 2014b, p.2).

There has been much discussion in recent years about skills mismatches and skills utilisation, with proper utilisation of skills being a key requirement for productivity improvement (Department of Industry 2014a). In a deregulated tertiary education system there will be a heightened imperative to ensure that students and existing workers are provided with the right skills for the labour market. It would be a mistake to interpret this too narrowly: also required is education and training that, to quote the World Economic Forum (2014, p.5), generates:

> the necessary economic dynamism to generate new jobs. Apprenticeships and the provision of workplace training can help both young people and the unemployed to build links with the labour market and gain useful work-related skills. Knowledge clusters, in which companies adopt innovative product market strategies and interact with educational institutions, can foster the creation of skill-intensive jobs and a better match with workforce skills … action is needed to reduce the gap between knowledge generated in the educational system and the skills demanded by employers. Second, continuing intervention is necessary during the employment life cycle, targeting continuous skill development and use.

Addressing skills gaps and future skills demand

This paper does not undertake any forecast of skills needs. Doing so is an inexact science. In 2013 the National Institute of Labour Studies, on behalf of the Australian Workforce and Productivity Agency, developed a methodology for determining skills demand. This uses four sets of indicators to trace changes that may be used to identify skills in over- or undersupply. The first draws on information on the state of the labour market; the second on information from the recruitment process; the third on university and VET data; and the fourth looks at labour market entrants, including skilled migrants on 457 visas (Mavromaras et al. 2013).

In the context of this study, it is important to note the necessity for education providers to have an understanding of labour market trends but also to continue to provide underpinning knowledge and skills to their students, who will need the capacity to adapt to changing industry requirements.

There is no one-size-fits-all way to help existing workers to gain additional skills or to retrain for different industries. In agriculture, for example, the learning culture 'is typically, incremental, socially embedded and occurs over a lifetime' (Agrifood Skills Australia 2013, p.iv), demanding that interventions are tailored not only to filling gaps but also to the way learners learn. For those forced to find new jobs, their options will depend on skills as well as on personal circumstance and the availability of work in their local area or on their willingness to move. When faced with the prospect of unemployment, some affected workers will move into lower-paid and/or part-time jobs requiring lower skills (Department of Industry 2014b, p.34).

The demand for skills is high across all industries. While the education and training system is generally well placed to respond, there are obvious constraints, some of which are imposed by Commonwealth and state/territory funding and governance policies. Solutions point to the need for increased collaboration between providers and industry as well as a cultural shift in the way generic skills are developed and deployed.

The current literature identifies a range of existing skill gaps for each of the five industries, as summarised in the first column of the following table. While many issues are common across the five industries, each industry and their sub-sectors are facing specific workforce requirements that will impact on the way in which the education and training system responds and influence which interventions should take priority. These inevitably cover broader impacts beyond the existing worker but are included here (in the second column) to provide the context impacting on skill gaps and future skill demand issues.

Addressing skill gaps and future skills demand for existing workers	Specific workforce issues impacting on the way the education and training system responds
Food and agriculture	
▪ A higher level of training for advanced production techniques ▪ A higher level of skills in leadership, management, mentoring, risk management and the ability to translate research and development into successful new products ▪ Highly skilled people who understand and can respond to the changing demands of the modern agricultural and food business operating environment and global market place	▪ Attraction of new workers ▪ Retention and skills utilisation of existing workers ▪ Development of business management, leadership and entrepreneurial capabilities. Stronger entrepreneurial, management and technical skills will be necessary to be successful in an increasingly interconnected global food industry. This is placing a premium on partnerships in value chains ▪ Adoption of higher-level skills and knowledge ▪ Diffusion of new research findings, innovative practice and technologies (Agrifood Skills Australia 2013) ▪ Specific to agriculture ▪ Fierce competition for labour, particularly from the mining and construction industries (Gelade & Fox 2008) ▪ Poor promotion of the industry, including some negative messages about agricultural working conditions ▪ An ageing population and a declining rural population ▪ Low levels of industry participation in education and training ▪ Low numbers of undergraduates and graduates in tertiary agriculture courses ▪ Poor awareness of agricultural career pathways and the limited capacity of the current education and training system to deliver innovative training solutions

Addressing skill gaps and future skills demand for existing workers	Specific workforce issues impacting on the way the education and training system responds
	▪ Disconnect between vocational education and training and universities, with relatively few students moving between the VET and higher education sectors (Training and Skills Working Group 2009).
Biotechnology and pharmaceuticals	
▪ Despite almost 95% of the workforce having either a university or TAFE or equivalent qualification, there are concerns about the disconnect between the current level of training offered by the higher and vocational education sectors and industry's future training needs. Bioinformatics and biostatistics are specific technical skill gaps. ▪ The broad educational background of the current workforce provides it with a degree of flexibility lacking in the workforces of some other industries. ▪ Students generally do not have all the necessary work skills when they leave university (Pharmaceuticals Industry Strategy Group 2009). ▪ Leadership and management skills are needed in the areas of business development, regulatory affairs, clinical strategy and project management (Department of State Development, Business and Innovation 2012).	▪ Smaller companies have more challenges in attracting and retaining staff. ▪ Industry's capacity to employ people is likely to significantly increase over the next five years. ▪ Finding people with adequate skills and experience in Australia, particularly at senior levels, is a real challenge. ▪ Finding people with commercial and business development skills in regulatory affairs, clinical strategy and project management, and technical and scientific skills in bioinformatics and biostatistics is difficult. ▪ Universities do not adequately understand industry needs. ▪ Academic and industry interests are not always aligned (Pharmaceuticals Industry Strategy Group 2009).
Advanced manufacturing	
▪ As the concept of manufacturing moves beyond technical and engineering activities to one of services offered and needed in global value chains, the occupation and qualification profiles and implications for future skills development will noticeably change. ▪ University-level skills and competencies are becoming the requisite level for many occupations in manufacturing. ▪ Emerging university graduates tend to lack practical competencies. ▪ The further development of advanced manufacturing technologies relies on high-level application of STEM and literacy skills, as well as ability to integrate R&D into manufacturing practice (Australian Workforce and Productivity Agency 2014). ▪ A balance of technical and theoretical skills is needed. ▪ There is an increase in diversity in the workplace profile, which increases the potential recruitment pool. ▪ Levels of numeracy, literacy and problem-solving in manufacturing are lower than in most other industries. ▪ Both VET and the higher education sectors need to emphasise employability skills and to foster agility and adaptability. ▪ Strategies will be needed to improve completions in apprenticeships, overcome barriers to work-integrated learning and address nationwide STEM issues (Australian Workforce and Productivity Agency 2014).	▪ It is estimated that almost 50% of workers in the manufacturing industry have language, literacy and numeracy (LLN) skills below the required functional level (Australian Workforce and Productivity Agency 2014). ▪ Structural adjustment is required, with employment over the last decade declining steadily in the majority of the industry's subsectors. Overall employment figures are expected to continue to decline, meaning a significant portion of workers have needed to look for new employment, both in and outside the manufacturing industry. ▪ The skills of manufacturing workers may not be easily identified as transferable. ▪ Attracting and retaining an appropriately skilled workforce is difficult. ▪ There are difficulties in recruiting employees with STEM skills. ▪ There is a lack of 'innovation' skills and digital literacy (Australian Workforce and Productivity Agency 2014).
Mining equipment, technology and services	
▪ It usually takes three to four years for graduates to increase their skills to the level the industry requires (<Mining-technology.com 2007>). ▪ The greatest barrier to recruitment is a lack of applicants with STEM skills. ▪ There is a lack of workplace experience and the content of qualifications is not relevant to business needs (Australian Industry Group 2013).	▪ There is an ageing workforce. ▪ There are difficulties in finding skilled staff with managerial and technical skills (including engineering , IT and marketing), in particular in non-metropolitan areas or in hazardous workplaces. ▪ The cost of recruiting and maintaining quality engineering, management and trades staff is high (Austmine 2013).

Addressing skill gaps and future skills demand for existing workers	Specific workforce issues impacting on the way the education and training system responds
Oil and gas	
▪ A skills gap exists at a highly technical and senior level (Australian Petroleum Production & Exploration Association 2014a). No official statistics are available on whether this skills gap is being met through migration. However, we observe that the number of visas granted during 2013 was 490, with the number of visa lodgements during that year being 450. This indicates a high incidence of obtaining a visa grant if someone were to apply under this industry (Department of Immigration and Border Protection 2013). Nonetheless, with recent changes to the visa requirements, it remains unclear if obtaining visas under this stream guarantees a good success rate. ▪ There is a growing demand for technical personnel in oil and gas plant process operations and maintenance and supervisors with appropriate levels of technical and safety experience and frontline management skills. ▪ In the operational phase of projects, the industry continues to face skills gaps and shortages in professional disciplines such as geosciences and various forms of engineering, as well as increasing competition for electrical and process technicians (Australian Petroleum Production & Exploration Association 2014a).	▪ Access to skilled labour is an issue, with local labour forces generally unable to meet all the demands of oil and gas projects. ▪ There will be competition for labour with many mining and infrastructure projects also planned for construction over the next five years. ▪ Workforce pressures are extending beyond traditional trades. The different stages of capital-intensive oil and gas developments require workforces of varying sizes. During the project capital expenditure ('capex') phase, there is a far greater labour requirement as large-scale civil works and facility development occurs. Conversely, project operations typically require fewer and often more specialised workers to manage the operation and maintenance of production facilities. ▪ The discordance of labour requirements over the life of the project creates additional issues for the industry in matching workforce supply and demand. The nature of the development means that there are many short-term jobs available, but fewer long-term opportunities after the capex phase (Deloitte Access Economics 2012). ▪ Employment in oil extraction is forecast to grow at 7.3%. ▪ Employment in the oil refining sector diverges from the wider energy sector. At present, 5500 people are directly employed in the sector, with growth declining because of reducing refining capacity. ▪ In general the energy sector's workforce is more highly skilled than other industries. This characterisation holds for petroleum refining and the fuel manufacturing industry. ▪ A large proportion of workers in the industry are employed in higher-skilled occupational groups. It can take up to 15 years for employees to become fully skilled in certain fields, so as refining capacity reduces there can be significant loss of skill, which cannot be easily replaced (Parliament of the Commonwealth of Australia 2013).

Literacy and numeracy skills

The Australian Workforce and Productivity Agency has repeatedly drawn attention to the persistent problem of literacy and numeracy in the Australian workforce. In its 2013 study of the food industry it suggested that integrating foundation skills with vocational skills and knowledge would lead to the improved capability of the workforce and the industry (Australian Workforce and Productivity Agency 2013a, p.77). This approach of building language, literacy and numeracy into VET is practised in some areas and does deliver success in terms of course completions and learner confidence, as shown by Black and Yakusawa (2011, p.3). It is, however, an expensive model and does not fit easily into current arrangements for VET delivery.

That said, boosting foundation skills is vital for increasing productivity. The Australian Industry Group has been emphatic about this point, particularly when it comes to manufacturing (Willox 2014, p.80). Its research on workplace literacy programs has also demonstrated the importance of employer engagement in the provision of English language, literacy and numeracy training in the workplace (Australian Industry Group 2014).

Upskilling existing workers

Automation

Automation is having an effect on many aspects of working life. In the mining equipment, technology and services and the oil and gas industries, this means a move away from employing unskilled and semi-skilled labour to the employment of technical professionals and technicians. Retraining existing workers displaced by new technologies will entail upgrading the qualifications not only of unskilled workers but also of mechanical, electrical, mining or oil and gas engineering graduates (Australian Workforce and Productivity Agency 2013b, p.148). This calls for collaboration between companies and tertiary education providers to ensure that training programs take automated technologies into account, and that training facilities are available to enable students to gain practical experience with these technologies (Australian Workforce and Productivity Agency 2013b, p.166). Even for workers who are not displaced, ensuring the breadth and universality of skills is important. As the speed at which new technologies are adopted increases, workers will need to acquire a broad range of skills, undertake multiple tasks, learn quickly and work flexibly (Department of Industry 2014b).

Skill sets

The Agrifoods Skill Council has been a champion of skill sets, particularly for upskilling its workforce. In its 2013 scan (p.v) it argued that:

> Publicly funded delivery of Skill Sets [as defined in training packages], and skill sets identified by Registered Training Organisations (RTOs) in response to individual needs, must be made broadly (as distinct from one-off funding via short-term programs).

The most recent scan of the mining industry (Skills DMC 2013, p.21) is also in favour of training that does not make workers with desirable experience gained in other industries start their training from scratch. Rather, it suggests that industry can work with training organisations to provide training that addresses workers' gaps in knowledge and which recognises prior learning. Research conducted by NCVER for the Minerals Council found that around 50% of mining employees are undertaking training in skill sets (Australian Workforce and Productivity Agency 2013b, p.15).

Recognition of prior learning

Recognition of prior learning (RPL) has the potential to increase the mobility of workers with few qualifications and to reduce the amount of gap training they undertake. As the Australian Workforce and Productivity Agency manufacturing study stated, this is particularly relevant to industries undergoing structural adjustment. However, delivering good RPL has proved complicated and expensive, thus reducing its appeal, especially to people with poor literacy, for whom producing evidence of their prior skills can be difficult (Australian Workforce and Productivity Agency 2014, p.89).

Retraining strategy for helping displaced workers

Preparation for retraining

- Career advice and placement support require careful planning.
- Support is needed to map the skills and identify training needs.
- Recognition of prior learning plays a key role in successfully changing jobs.
- Guidance should be provided about what jobs are in demand beyond vacancy lists.
- High-quality advice should be provided concerning employment and training opportunities are important for success.

Retraining

- Informal linkages are as important as formal institutional arrangements.
- Local coordinators are important for success.
- Recognition of prior learning plays a key role in successfully changing jobs.
- Training needs to be linked to jobs in demand, to increase employability.

Based on experience from previous plant closures such as Mitsubishi, Bridgestone and BlueScope (Department of Industry 2014a, p.16).

Continuing professional development

As noted above, not only workers with low qualifications need upskilling. The literature is consistent in its recognition of the problem of mediocre management ability (Roos 2014 p.8). The Australian Workforce and Productivity Agency's consultations in the manufacturing industry heard that management skills were required from the shop floor to the chief executive's office (2014, p.34).

In the biotechnology industry, senior managers and leaders are being recruited from other industries and abroad, with the greatest unmet demand being for regulatory affairs skills. Also needed are project management, business development, licensing negotiation and risk management skills (Allen Consulting 2010, pp.34—6).

As the 2012 Victorian biotechnology skills strategy notes (Victorian Department of State Development, Business and Innovation 2014, p.3), such skills shortages are more closely linked to experience than to qualifications, suggesting that a combination of formal training and in-house mentoring and team learning is required.

Labour and geographic mobility

According to the Productivity Commission (2014), in 2011 workers in industries with high growth in employment and high vacancy rates were more likely to have moved residence within the past year compared with those in other industries. The industries with the highest proportion of workers moving residence across regional labour markets include mining, construction and the accommodation and food services industry. This is most likely because of the inherent project-based or seasonal nature of the work. The commission suggests that better skills recognition and consistent occupational licensing across jurisdictions would improve geographic labour mobility. It also observes that a 'flexible, accessible and quality education and training system is important for meeting Australia's continually changing workforce and employment needs' (p.24).

This is further borne out by Mavromaras, Mahuteau and Wei (2013) in their analysis of labour mobility for those completing a VET qualification. They found that moving jobs within a particular occupation usually leads to a good outcome. However, when a worker changes industry and leaves behind valuable networks the result tends not to be advantageous. This finding could have implications for how workers meet industry demands for skills that cross occupational groupings.

Skills for research and development

A major challenge for these five industries will be to improve the commercial and economic outcomes from research and development (R&D), heeding at the same time the need to protect their intellectual property and market niche. The report into the South Australian and Victorian economies noted that real commercial success may require Australian institutions to take greater risks and accept occasional failure (Department of Industry 2014b, p.3).

The role of government in fostering innovation is multifaceted, with some arguing that it should promote experimentation in business as well as provide the enabling regulatory environment. In this paper, the focus is on skills development.

Governments play the major role in providing basic education and in funding research. The workplace is also crucial. Most innovation occurs at the business level and if the culture does not support innovation, it will not occur, regardless of the skills of the workforce. This presents a further challenge to employers; it also offers opportunities for new collaborations between enterprises and with both higher education and VET providers as well as with dedicated research organisations. The concept of openness in innovation means that organisations can thrive on strategic alliances and inter-firm networks, heeding at the same time their intellectual property and market niche (Stanwick 2011, p.7).

Despite pockets of excellence, there remains a gap between the knowledge generated in universities and industry practice. One bridge over that gap is the public TAFE system, which has strong links to workplaces and greater potential to translate research findings into practice (see Roos 2014; Curtin, Stanwick & Beddie 2011). Another is to connect young scientists into the business world.

The Walter and Eliza Hall Institute Business Development Internship Program

This program gives young talented scientists exposure to the technology transfer and business development skills needed in the biotech and pharmaceutical markets. The interns develop skills in:

- opportunity identification and analysis
- intellectual property management
- technology marketing communication
- collaboration and licence agreements
- transfer governance.

<http://www.wehi.edu.au/tech_transfer/training/?

Today's innovation is about more than research and development; it also involves renewing organisational and business models, and marketing. Businesses in the biotechnology industry are coming to understand that this demands a more diverse workforce than they needed in their start-up phase. An industry position survey in 2013 (Grant Thornton 2013, p.6), for example, noted an anticipated increase in demand for business development professionals, sales and marketing staff as the local industry matures.

The Department of Innovation food processing industry study highlights the importance of nurturing innovation in the workplace through investment in on-the-job training and education, and this is especially critical for small and medium enterprises (Department of Innovation 2012). This study

suggests workers and businesses benefit from the 'right environment and culture, including mutual respect as well as management and leadership skills development' (p.162).

The 2013 Agrifoods scan (p.viii) listed 'poor speed-to-market of publicly funded research findings … to be one of the major constraints in substantially lifting agrifood productivity levels'. The scan identified paraprofessionals and technicians as those responsible for much of the application of new practice and knowledge. They need therefore be equipped during their VET training to 'spearhead dissemination and application [of research findings] back at the workplace'.

The Australian Workforce and Productivity Agency survey of the food industry (2013a, pp.72—3) records the rise of a new set of workers in the farming sector: small business consultants, paraprofessionals and specialist contractors, many of whom have taken the place of extension services in conveying knowledge about new developments and techniques. As the 2013 scan (Agrifoods 2013, p. 9) noted, the rise of the micro-business and entrepreneurs with research capacity is also challenging the traditional research, development and extension bodies. Crowdsourcing and crowdtesting are tapping into creativity and encouraging dynamic problem-solving. It is a concept set to challenge the speed to market.

The Rural R&D for Profit Policy Initiative announced in the 2014 Budget continues the tradition of linking research with farmers.

The teaching workforce

Positioning Australians to work in these industries requires the right teachers and trainers. At present, the workforce has gaps in its skills and, like so many industries, must address its ageing demographic.

Science, technology, engineering and mathematics capacity of teachers

A report by the Australian Council of Learned Academies in 2013 found capacity gaps in STEM teaching, with a high proportion of Australian secondary school teachers teaching out of their field of expertise and without the qualifications or confidence to do so (Marginson et al. 2013, p.2).

Berghella and Molenaar (2013) investigated numeracy provision in the process manufacturing industry. They found a mismatch between what is required to address needs in the industry and the capacity of VET practitioners in terms of their understanding of numeracy requirements, and their qualifications, skills and experience. It is likely this mismatch is more widespread within the VET workforce.

Language, literacy and numeracy

The Manufacturing Skills Australia environmental scan (2014, p.39) notes that much of the work in language, literacy and numeracy requires specially trained practitioners. It stated that the need for additional support in this area was evident. In recent years there have been efforts to upgrade the qualifications of adult literacy teachers and, through the skills council, Innovation and Business Skills Australia, to provide additional professional development both in teaching foundation skills and more broadly to build the capability for undertaking this among VET practitioners.

Professional development for VET practitioners

Professional development opportunities are essential if VET practitioners are to maintain their industry currency, further upgrade their own skills and engage constructively in the innovation cycle. The Manufacturing Skills Australia scan reported (2014, p.38) that 45% of registered training organisations claimed to suffer from skills shortages, while enterprises increasingly report that training providers are not able to add any value to training programs by way of technical expertise, especially in niche skill areas.

Labour shortages

The Agrifoods 2013 environmental scan (p.11) quoted the Inquiry into Agricultural Education and Training in Victoria, which heard:

> There is a massive shortage of qualified Agriculture and Horticulture teachers across the state of Victoria and probably across Australia. Of those that are still teaching, many will soon reach retirement age and when they retire they leave a 'gap'. Filling that gap will be another step toward readying the training system to meet growing demand.

Conclusion

The question of how ready Australian industries and the education and training system are to meet demand for skills in the identified five industry growth areas has no straightforward answer, and there is no one-size-fits all response for all industries.

This study does however draw out some common themes across all five industries. Many of these themes point to the need for a significant cultural shift in thinking about the way skills are generated and used — in the educational system, by employers and by individuals in their engagement with continuing professional development. At present the gap between the knowledge generated in the education system and the skills demanded by employers and individuals is widening. Attention to the following points will assist in bridging that gap and improve the ability of industries to marshal the right people for opportunities as they present themselves.

A crude division of responsibility for training in the future will be for educational institutions at secondary and tertiary levels to provide a sound general education, including language, literacy and numeracy and STEM skills, as well as underpinning knowledge in specific subject areas, with enterprises preparing graduates for particular jobs and fostering workplace learning, continuing professional development and cooperation in the innovation cycle.

The predominant picture that emerges is the need to develop a more nimble workforce. This is primarily about willingness on the part of individuals to learn new skills and adapt to change. And it requires an industry culture committed to ongoing professional development, employers identifying and supporting continuous on-the-job learning and the accumulation of experience as well as improved managerial capability.

All industries need to maximise the incorporation of R&D into enterprise behaviour, to improve their capacity to manage and to operate in Asia and beyond, and to be a key partner in global value chains. They need to capitalise on innovation opportunities and the commercialisation of R&D. This necessitates a number of actions.

Industry collaboration with education and training providers is a key factor in ensuring greater industry input into the nature of education and training and in anticipating the extent and nature of future demand. Providers also need to foster collaboration in order to keep abreast of contemporary industry requirements. For some time industry has played a key role in the VET system; however, collaboration is more than injecting industry relevance into the skills and knowledge contained in training packages. It is also more than training providers responding to short-term demand.

The idea of knowledge clusters or hubs, in which companies adopt innovative strategies and interact with educational institutions, can foster the creation of skill-intensive jobs and a better match with workforce skills. Increasing this type of industry involvement as a measure to enhance ‘dynamism’ in the five industries will be an important strategy in improving the ability of the education and training system to meet demand.

Australia’s science, technology, engineering and mathematics capability must improve, not only at entry level in these industries (and others) but through continuing professional education. The current emphasis in public funding on entry-level training can work against the need to refresh STEM skills, as well as other skills, and potentially inhibits readiness to meet demand for growth in all industries.

Enterprises have to better understand and be able to prepare for different phases in the value chain. Their employees need the right 'innovation' skills, which will differ depending on the nature of the innovation. In addition, the capacity to channel R&D more quickly to the end-user will open up opportunities for small and micro-businesses engaged in knowledge diffusion.

Some particular problems and priorities are clear for each industry. In agriculture and manufacturing, older, low-skilled workers will need retraining to enable them to find decent jobs in their changing industries. These industries also have to find ways of attracting younger workers with a variety of skill levels. In the oil and gas industry, and in mining, there is the additional challenge of recruiting and maintaining workers who have to work in remote and hazardous locations. In emerging industries such as biotechnology, universities and businesses will have to cooperate to ensure a supply of appropriately skilled graduates. They also need to be equipped to operate in a global labour market.

The role of formal education should be to provide solid foundations for entry into the workforce. Strong literacy and numeracy skills are a prerequisite for entry-level jobs and for transition to new roles. Better career advice, starting at secondary school, is needed to attract young people to these industries and to lift female participation.

Sustained efforts are needed by government, industry and education providers to advance efforts in skill utilisation and to reduce skill gaps. Acknowledgment that recognition of prior learning demands adequate resources and the provision of funding for skill gap training (for example, using skill sets) will improve approaches to upskilling existing workers. Labour mobility is another solution for filling specific skill gaps. The more highly skilled a worker is the greater potential there is for geographic and occupational mobility.

The role of employers is crucial — in the workplace and in partnership with schools, VET institutions, universities and research organisations. Australian enterprise has still to meet the challenge of instilling stronger management and leadership qualities in its workforce. This is a task both for individual businesses and the formal education and training system.

To meet the demand for skilled labour, employers will need to look beyond traditional pools of workers. This requires employment and educational policies that encourage the participation of women and older workers, as well as conditions that continue to attract skilled migrants. In addition, employers play an important role in offering serious work placements and which are effective for all students, whether at school, in VET or at university. These solutions are not cheap.

Underpinning readiness to meet demand are the teachers and trainers providing the new knowledge and skills to work in these industries. Addressing skills gaps and shortages in the teaching workforce is necessary. Professional development opportunities are essential if practitioners are to maintain their industry currency, further upgrade their own skills and engage constructively in the innovation cycle.

How we view the industries and the job profiles within them is important. The clear categorisation of these industries, occupations and the skills required is challenging. Emerging job profiles will require generic skills that are attractive across the labour market. For those workers equipped with the right skills, job mobility will be easier. They will be better able to choose work that pays better or suits their circumstances. Employers therefore will have to offer attractive working conditions and learning opportunities and ensure that their recruitment strategies efficiently attract, select and retain talent. This also calls for a new way of thinking about skill demand and presents a challenge for those responsible for data collection.

In summary, there is no question that appropriate education and training for new entrants and existing workers is fundamental if the areas of growth identified in the five industries in this study are to be realised. Constraints from within industry and the education and training system as well as governance and funding policies are currently impacting on readiness to meet demand. Overcoming these limitations will require increased collaboration, a cultural shift in thinking about occupations and the way skills are gained and deployed, as well as greater flexibility in the education and training system.

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Appendix: Profile of the five industries

	Food and agriculture	Biotechnology and pharmaceuticals	Advanced manufacturing	Mining equipment, technology and services	Oil and gas
Definition	The *food and agriculture industry* encompasses many sectors, including production of the raw materials used in food (the farm and fishing sectors), the export, import and processing sectors, and domestic sales to consumers (Department of Agriculture, Fisheries and Forestry 2013). Some bodies, such as the Agrifood Industry Skills Council, also include activities like pharmaceutical processing and racing (Agrifood Skills Australia 2013).	The biotechnology and pharmaceuticals industries are often considered as two separate, but overlapping, industries. While the pharmaceuticals industry has had a long history in Australia the biotechnology industry is relatively recent and over the last ten years or so has been showing signs of growing importance. The *biotechnology industry* is defined as those organisations involved in the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services (OECD 2005). The *pharmaceuticals industry* is defined as those organisations that contribute to the discovery, creation and supply of pharmaceuticals products and services, including prescription medicines and vaccines. The stages of the value chain include discovery and research, and basic research and development, through to clinical trials, and then the manufacturing and marketing of pharmaceuticals (Pharmaceuticals Industry Strategy Group 2009).	*Advanced manufacturing* is defined as a family of activities that: ▪ depend on the use and coordination of information, automation, computation, software, sensing, and networks, and/or ▪ make use of cutting-edge materials and emerging capabilities enabled by the physical and biological sciences, for example, nanotechnology, chemistry and biology (President's Council of Advisors on Science and Technology 2011).	The *mining equipment, technology and services (METS) industry* is comprised of organisations that provide specialised support and solutions to the mining and minerals industry (Austmine 2013). METS work across a range of minerals and mining divisions. While some companies remain highly specialised in a certain commodity, the great majority work across several mineral types. A large percentage is also involved in oil and gas extraction (Austmine 2013). There are three broad segments of the METS industry: ▪ mining services ▪ mining and mineral processing equipment ▪ firms providing highly specialised technology equipment, software and related services (Scott-Kemmis 2013).	The *oil and gas industry* encompasses the exploration, appraisal, development, construction and production of natural gas and petroleum liquid resources. The upstream segment of the petroleum sector involves the processing and delivery of products to either export terminals or domestic gas transmission pipelines (Deloitte Access Economics 2012).

	Food and agriculture	Biotechnology and pharmaceuticals	Advanced manufacturing	Mining equipment, technology and services	Oil and gas
Value	Collectively, food and agriculture industries contribute over $237 billion to the national economy, accounting for 18% of Australia's GDP (Agrifood Skills Australia 2013). In 2013, the food and beverage sector alone contributed $184.2 billion (Agrifood Skills Australia 2013). In 2013, the pharmaceutical sector (included in the total for food and agriculture) alone contributed $22.3 billion (Agrifood Skills Australia 2013).	In 2012–13, the pharmaeuticals industry generated $23.4 billion in revenue, with exports of $3.89 billion (Department of Indusrty, Innovation, Climate Change, Science, Research and Tertiary Education 2014). In 2011, the Australian biotechnology industry generated $US4.712 in revenue (Ernst & Young 2012).	The manufacturing industry contributes over $100 billion to the national economy (Department of Industry 2014). Advanced manufacturing accounts for around half of Australia's estimated $100 billion annual manufacturing output and is one of the fastest growing export industries including aerospace, automotive, machinery, tooling, instruments, chemicals, plastics and many other products with a high degree of transformation (Australian Manufacturing 2012; Austrade 2014; Global Alliance of SMEs 2014).	Australia's METS sector contributes approximately A$10 billion annually to the economy with yearly exports of at least A$3 billion (Austrade 2013).	The oil and gas industry contributed around $28.3 billion to the national economy in 2011, accounting for 2.1% of Australia's GDP in 2011 (Deloitte Access Economics 2012). Australia's gas industry is delivering about $8 billion a year in tax revenue (Australian Petroleum Production & Exploration Association 2014b).
Workforce overall	Employment figures for the food and agriculture industry vary considerably, highlighting discrepancies between sources in how the industry has been categorised. The food and agriculture industry employed approximately 825 000 workers across 180 000 enterprises in 2013 (Agrifood Skills Australia 2013). **Food industry** The food industry – ranging from farm and fisheries production to food and beverage service – employed around 1.64 million people in 2011–12, around 15% of total employment in Australia (Department of Agriculture, Fisheries and Forestry 2013). **Agriculture, forestry and fishing Industry** Employed approximately 316 800 workers in 2013,	The biotech and pharmaceutical industry employed about 41 000 workers in 2008. About a third of the employment is in pharmaceutical manufacturing (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education 2013; Pharmaceuticals Industry Strategy Group 2009). In 2012–13, about 15 500 were employed in pharmaceutical manufacturing (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education 2014; IBIS World 2014). In 2011, 13 140 were employed in biotechnology (Ernst & Young 2012).	The manufacturing industry employs around 854 600 workers (ABS 2013b). No figures are available for Advanced Manufacturing.	The METS sector employs approximately 31 300 people (Austrade 2013). While metropolitan centres house the greatest number of companies, METS are also located in regional and remote areas. The spread is such that it is difficult to pinpoint an exact geographic centre of METS activity, and it can only be said that METS has a truly national footprint (Austmine 2013, p.17).	The oil and gas industry employed about 28 300 workers in 2012 (Australian Workforce and Productivity Agency 2013b, p.52). As of February 2014, there were 26 400 workers employed in oil and gas extraction (ABS 2014). Like other industries in the resources industry, workers in the oil and gas industry tend to be highly mobile, in terms of both work patterns and job tenure. The workforce is also geographically mobile, with workers moving to regional locations and established mining towns to work on remote sites. There is also an increasing trend towards extensive commuting, commonly referred to as 'fly-in, fly-out', although it also includes other modes of travel (Australian Workforce and Productivity Agency 2013b).

	Food and agriculture	Biotechnology and pharmaceuticals	Advanced manufacturing	Mining equipment, technology and services	Oil and gas
	accounting for just under 3% of the total Australian workforce (Australian Workforce and Productivity Agency 2013d). 86% of workers are employed in small enterprises, while a further 11% are employed in medium-sized enterprises (Australian Workforce and Productivity Agency 2013d).				
Earnings	In 2013, median weekly earnings (full-time and before tax) in the agriculture, forestry and fishing industry was $1146 (ABS 2013b)	Not available	In 2013, median weekly earnings (full-time and before tax) in the manufacturing industry was $1282.	In 2013, median weekly earnings (full-time and before tax) in the mining industry was $2268.	In 2012, median weekly earnings (full-time and before tax) for workers in oil and gas extraction (a sub-sector of the mining industry) was $1878 in 2012 (Australian Workforce and Productivity Agency 2013b).
Workforce demographics	**Agriculture, forestry and fishing Industry** ▪ 70% of the workforce is male. ▪ 56% of workers are aged 45 years or above. ▪ 87% of jobs are in regional and remote areas (Australian Workforce and Productivity Agency 2013d). In 2011, about 1.5% of workers were Indigenous (ABS 2011).		No demographic information is available for advanced manufacturing. All available reports point to the manufacturing industry in general. *It should be noted there are variations between the sectors, which are not reported here*. **Manufacturing industry** ▪ Employment is spread relatively evenly between small enterprises, medium-sized enterprises, and large-sized enterprises. ▪ 35% of workers are employed in regional and remote areas (Australian Workforce and Productivity Agency 2013c). ▪ 65% of workers are male (Australian Workforce and Productivity Agency 2013c).	No demographic information is available for METS. All available reports point to the mining industry in general. **Mining industry** ▪ 70% of workers are employed in large enterprises, with only 15% employed in small enterprises (Australian Workforce and Productivity Agency 2013e). ▪ Mining recorded the strongest employment growth of any industry over the past five years, at 79% (Australian Workforce and Productivity Agency 2013e). ▪ 61% of workers are employed in regional and remote areas (Australian Workforce and Productivity Agency 2013e). ▪ 84% of workers are male (Australian Workforce and Productivity Agency 2013e).	The oil and gas industry has a similar demographic to mining industry. The oil and gas extraction industry employs a lower proportion of Indigenous workers (at 1.3%) compared with mining generally (3.1%) (Australian Workforce and Productivity Agency 2013b; ABS 2011). **Mining industry** ▪ 70% of workers are employed in large enterprises, with only 15% employed in small enterprises (Australian Workforce and Productivity Agency 2013e). ▪ Mining recorded the strongest employment growth of any industry over the past five years, at 79% (Australian Workforce and Productivity Agency 2013e).

	Food and agriculture	Biotechnology and pharmaceuticals	Advanced manufacturing	Mining equipment, technology and services	Oil and gas
			▪ 41% of workers are aged 45 years or above (Australian Workforce and Productivity Agency 2013c). ▪ 14% of workers work part-time (Australian Workforce and Productivity Agency 2013c). ▪ 85.3% of employment is full-time (Australian Workforce and Productivity Agency 2013c). ▪ In 2011, about 1.1% of workers were Indigenous (ABS 2011).	▪ 97% of workers are employed full-time (Australian Workforce and Productivity Agency 2013e). ▪ Around 34% of the workers are aged 45 years or older (Australian Workforce and Productivity Agency 2013e). ▪ In 2011, about 3.1% of workers were Indigenous (ABS 2011). See also figures for the manufacturing industry.	▪ 61% of workers are employed in regional and remote areas (Australian Workforce and Productivity Agency 2013e). ▪ 84% of workers are male (Australian Workforce and Productivity Agency 2013e). ▪ 97% of workers are employed full-time (Australian Workforce and Productivity Agency 2013e). ▪ Around 34% of the workers are aged 45 years or older (Australian Workforce and Productivity Agency 2013e).
Workforce — apprentices and trainees	As at 31 December 2013, there were 29 380 apprentices and trainees in training with the *Agrifood Industry Skills Council*. Of these, 76% were male. And 51% were were in non-metropolitan areas (NCVER 2014).	Not available	As at 31 December 2013, there were about 51 319 apprentices and trainees in training with the *Manufacturing Industry Skills Council*. Of these, 90% were male. And 43% were located outside the major cities (NCVER 2014).	As at 31 December 2013, there were about 10 865 apprentices and trainees in training with the *mining industry*. Of these, 89% were male. 61% were located outside the major cities (NCVER 2014).	As at 31 December 2013, there were about 554 apprentices and trainees in training with the *oil and gas extraction industry*. Of these, 92% were male. And 41% were were in non-metropolitan areas (NCVER 2014).
Workforce educational attainment	These figures are not comprehensive, but rather a snapshot of sectors within the broader industry to highlight the diversity in levels of educational attainment. **Food product manufacturing industry** ▪ 60% do not hold a post-school qualification. ▪ 18% of workers have completed a certificate III or IV qualification. ▪ 22% have completed a diploma or higher-level qualification (ABS 2012).	Companies involved in the earlier stages of the industry value chain tend to have a higher proportion of bachelor and postgraduate qualified employees than companies involved in the later stages of the industry value chain. Companies involved in the later stages of the industry value chain tend to have a greater proportion of their workforce with a certificate or diploma as their highest qualification (Pharmaceuticals Industry Strategy Group 2009).	**Manufacturing industry** ▪ 48% do not hold a post-school qualification. ▪ 26% of workers have completed a certificate III or IV qualification. ▪ 26% have completed a diploma or higher-level qualification (ABS 2012). Universities have historically been a minor source of skilled employees for the manufacturing industry. Currently 15% of workers in the top 20 employing occupations hold a qualification at the bachelor level and above, and in many of the highest employing occupations,	**Mining industry** ▪ 38% do not hold a post-school qualification ▪ 36% of workers have completed a certificate III or IV qualification ▪ 26% have completed a diploma or higher-level qualification (ABS 2012). See also figures for the manufacturing industry as a whole.	**Oil and gas extraction industry** (a sub-sector of the mining industry) ▪ 21% do not hold a post-school qualification. ▪ 17% of workers have completed a certificate III or IV qualification. ▪ 62% have completed a diploma or higher-level qualification (ABS 2012). See also figures for the mining industry as a whole.

	Food and agriculture	Biotechnology and pharmaceuticals	Advanced manufacturing	Mining equipment, technology and services	Oil and gas
	Agriculture, forestry and fishing industry ▪ 61% do not hold a post-school qualification. ▪ 18% of workers have completed a certificate III or IV qualification. ▪ 21% have completed a diploma or higher-level qualification (ABS 2012).	**Pharmaceutical and medicinal product manufacturing industry** ▪ 20% do not hold a post-school qualification. ▪ 9% of workers have completed a certificate III or IV qualification. ▪ 72% have completed a diploma or higher-level qualification (ABS 2012).	university-educated workers are almost non-existent (Australian Workforce and Productivity Agency 2013g, citing ABS 2011).		
Migration	Migrants play an important role in supporting fluctuating labour market needs in agriculture and food processing (Australian Workforce and Productivity Agency 2013a). Employer-sponsored skilled worker temporary visas (457), working holiday visas (417) and the seasonal worker programs are used extensively to fill food and agriculture labour shortages (Australian Workforce and Productivity Agency 2013f).				Enterprise Migration Agreements have emerged as a flexible option to address skills shortages for short-term resource construction works. This policy allows developers to staff large resource developments (valued at more than $2 billion) using overseas workers on 457 visas during the intense up-front construction period (Deloitte Access Economics 2012).

National Centre for Vocational Education Research

Level 11, 33 King Willliam Street, Adelaide, SA 5000
PO Box 8288 Station Arcade, Adelaide SA 5000, Australia

Phone +61 8 8230 8400 **Fax** +61 8 8212 3436
Email ncver@ncver.edu.au **Web** <http://www.ncver.edu.au> <http://www.lsay.edu.au>
Follow us: <http://twitter.com/ncver> <http://www.linkedin.com/company/ncver>