Skilling the Australian workforce for the digital economy

Victor Gekara, Darryn Snell, Alemayehu Molla and Stan Karanasios
RMIT University

Amanda Thomas
Australian Industry Standards

Publisher's note

The views and opinions expressed in this document are those of the author/project team and do not necessarily reflect the views of the Australian Government, state and territory governments or NCVER. Any interpretation of data is the responsibility of the author/project team.

Additional information relating to this research is available in:

▪ *Skilling the Australian workforce for the digital economy: support document 1 – a review of digital skills frameworks literature*

▪ *Skilling the Australian workforce for the digital economy: support document 2 – case studies and survey findings*

These documents can be accessed from NCVER's Portal <https://www.ncver.edu.au>.

To find other material of interest, search VOCEDplus (the UNESCO/NCVER international database <http://www.voced.edu.au>) using the following keywords: *Technological change; Skill needs; Skill shortage; Skill upgrading.*

About the research

Skilling the Australian workforce for the digital economy

Victor Gekara, Darryn Snell, Alemayehu Molla and Stan Karanasios, RMIT University
Amanda Thomas, Australian Industry Standards

Digital technologies such as artificial intelligence, robotics and automation are transforming the world of work. Developing the appropriate digital skills in the workforce is an important component in Australia's effort to compete in this rapidly emerging global digital economy.

This research explores the current digital skills demand-and-supply situation in Australia for the general workforce (rather than for ICT specialists). The research approach includes a review of international frameworks of digital skills and case studies in the transport, postal and warehousing, and public administration and safety industries. These industries were selected because a key threat to their productivity, and therefore their contribution to the national economy, is a workforce with inadequate digital skills. A survey of human resources, skills and training decision-makers across Australian industry more generally was also undertaken, with specific attention given to the skills impact of digitalisation.

The research highlights that a multi-faceted approach from the Australian Government and industry stakeholders is required to enhance digital skills development in the general workforce. To facilitate this, the authors have developed a digital skills framework, whose purpose is to identify digital skills gaps within organisations and to assist in the development of targeted training programs.

Key messages

- The degree to which digitalisation is occurring in Australian workplaces is highly variable, as are the approaches of employers in meeting their digital skill requirements. Three different categories of employers were identified, based on their approaches to technology uptake and skills acquisition:

  - *Aggressive technology adoption and skills-development approach*: these employers tend to pursue a wide range of strategies in their digital skills acquisition, including aggressive external recruitment and internal skills development.

  - *Keen technology adoption but cautious skills-development approach*: these organisations undertake gradual change while ensuring that current productivity levels are not undermined. At the same time, they educate their workforce about the importance of new workplace technologies, with the aim of introducing gradual cultural change.

  - *Appreciation of growing need for digital skills, but no investment in skills development*: this group tended to expect that newly employed recruits possess the necessary digital skills (which were mostly relatively basic digital skills).

- More than half of the industry survey respondents were not satisfied with the digital skills of their vocational education and training (VET) graduate recruits and had concerns about the adequacy of VET qualifications in meeting industry skill requirements. An analysis of training packages in the two case study sectors indicated that a significant amount of digital training content was included in the packages. However, this content is mostly pitched at low levels of basic digital literacy. Furthermore, most of the digital skills training was in elective units as opposed to core.

- The employers in this research showed strong concern about the future availability of workers with sufficient digital skills. Despite this, many are not proactively developing a clear strategy for, and investing in, their future digital skills needs across their workforces.

Readers may also be interested in another National Centre for Vocational Education Research (NCVER) report: Seet et al. (2018)[1] investigated the implications of digital disruption for the VET sector, finding that disruptive technologies are influencing the demand for both technical and soft skills in many occupations, with some skills in decline and others in high demand.

Simon Walker
Managing Director, NCVER

---

1   Seet, P, Jones, J, Spoehr, J & Hordacre, A 2018, The fourth industrial revolution: the implications of technological disruption for Australian VET, NCVER, Adelaide.

Acknowledgments

Contents

Skilling the Australian workforce for the digital economy

Tables and figures

Tables

Figures

Executive summary

Digital technologies such as artificial intelligence, robotics and automation are transforming the world of work. Developing the appropriate digital skills in the general workforce is an important component in Australia's efforts to compete in this rapidly emerging global digital economy. While there are many definitions of digital skills, for the purpose of this project we define digital skills as a combination of[2]:

- digital knowledge (theoretical comprehension and understanding)

- cognitive knowhow (involving the use of logical, intuitive, innovative and creative thinking in the digital space)

- practical knowhow (including the use of digital tools such as hardware, software, information and security systems)

- competence (ability to learn, adapt and apply digital knowledge in a new setting)

- 'digital' attitude (value and beliefs), which workers need to master and demonstrate in the digital age.

This project investigates the current digital skills requirements of the Australian workforce, the capacity of the vocational education and training (VET) system to effectively meet the growing need for digital skills across the workforce, and employers' views, strategies and commitment to adopting digital technologies and meeting the associated digital skills needs of their workforces. Rather than focusing on the demand for skills in the information and communications technology (ICT) sector, this project primarily addresses the digital skills of the general workforce; that is, those not directly employed in specialised ICT roles but who are increasingly expected to use digital systems, technology and processes effectively in the emerging highly digitalised systems of work.

This project was undertaken over several stages and employed a number of methodological approaches; namely, a literature review, case studies and surveys, a content analysis of job advertisements and relevant training packages, and a review of international digital skills frameworks. A broader survey of human resources, skills and training human decision-makers in a cross-section of industries also informed the project, although much of the research was focused on two industry sectors: transport and logistics, and public safety and correctional services. This report synthesises the findings from all stages, further details of which can be found in an earlier working paper for this research project (Gekara et al. 2017) and the two supporting documents accompanying this report.

Findings

Job advertisement and training package analysis

A content analysis of the job advertisements and training packages associated with the two industry sectors found that:

---

2   See support document 1 for further detail.

- Only 24 job vacancies across the 1708 jobs analysed specifically mentioned particular digital skills. This raises important questions about employers' specification of digital skills, particularly given industry evidence that the economy is rapidly entering a digital age, one characterised by sophisticated efficiency and productivity-enhancing mechanical and digital technologies (Deloitte Access Economics 2016; Hajkowicz et al. 2016). Even in job advertisements where digital skills were specifically mentioned, the level of expected application is generally vague and mostly basic. This suggests that employers are not clearly articulating their specific skills needs.

- Within the 11 training packages analysed, digital skills-related keywords and terms were found in a large number of units of competency. Although not conclusive, this suggests that these units are to some extent designed to develop digital skills. A closer examination of the training packages, however, shows that the majority of the units that address digital skills tend to be electives as opposed to core units. In sum, the training system does not accord digital skills 'essential skills status' (at least in these two industry sectors).

- The digital skills training content in the training packages examined is mostly lower level, addressing basic digital literacy and the basic application of computer devices for data capturing and processing. There is a greater focus on skills for basic operational and non-supervisory occupation levels. From a skills supply perspective, this is likely to undermine the transition to a digital economy, where widespread adoption of digital technologies across all industries and occupational levels has been predicted.

Review of digital-skills frameworks

The review of international digital skills frameworks highlighted the issues associated with the conceptualisation, measurement and evaluation of digital skills. The review indicates that:

- Digital skills development needs to encompass not only efficient and effective use of digital technology, but also the development of complex cognitive, interpersonal, entrepreneurial and innovation dimensions.

- Safety, framed particularly in terms of cyber security, privacy and protection of personal data, is prominent and needs to be included in discussions of digital skills.

- The development of a framework to capture these broad and fluid areas of digital skills has to balance the framing of individual skills and proficiencies while taking into account the work context.

Case studies and survey

The findings from the two case studies point to several key themes. Employers tend to indicate their demand for digital skills in job advertisements in narrow terms, with reference primarily to the specific software and hardware tools that their employees need for day-to-day work. This, however, is not consistent with the range of digital skills needs to which human resources, skills and training decision-makers referred in the survey and interviews.

The human resources, skills and training perspective suggests that some Australian organisations expect their workforce to be equipped with digital skills that range from a

mindset (including entrepreneurial, creativity and experimental), to functioning within an increasingly digitalised workplace and confidently using the advanced features of generic and industry-specific digital technologies and enterprise systems. Also needed are employees skilled to troubleshoot the problems that arise in the increasingly digitalised workplace and who recognise the security, societal and environmental implications of digital technologies. In view of these expectations, employers from both the case study industries and the survey expressed dissatisfaction with the digital skills of VET graduates and the relevance of VET qualifications to current industry digital skills requirements.

The impact of the increasing use of digital technologies on skills requirements spreads beyond ICT departments to the general workforce and is creating gaps in the digital competencies of current workers in areas such as: analysing digital risks to identify cyber security threats and vulnerabilities; extracting insights from advanced data analytics systems and dashboards; and recognising and troubleshooting problems in digitalised workplaces and identifying innovative ways to resolve them.

The adoption of digital technologies — and the concomitant skills gap — is neither experienced at the same pace in all industries nor influencing all occupations to the same extent; for example, many employers in the case study industries are taking a relatively gradual approach to digital technology uptake. They have adopted past waves of digital technologies such as online transactional and information systems but are not widely embracing the current wave of technologies, which includes social media, mobile technology, analytics, cloud computing and the internet of things. This study shows that employer hesitation in adopting newer digital technologies is to a large extent influenced by the lack of basic digital skills among their workforces and the perceived costs of digital upskilling.

Summary

There is a need to advance digital skills development in Australia, an imperative that requires a multi-pronged strategy from government and industry stakeholders. Such a strategy necessarily requires the development of a national digital skills framework, which could be integrated into the Australian Core Skills Framework. For their part, employers should undertake an assessment of digital skills gaps to ensure that their workforces are upskilled to meet the challenges of the emerging digital economy. The digital skills embedded in VET programs and in industry training packages therefore need to be revised and updated to cater for future digital skills requirements.

To facilitate implementation of these recommendations and to support the development of targeted training programs, this study has developed a comprehensive digital skills framework, enabling the identification of digital skills gaps among Australian industries and workforces.

ⓘ Introduction

This report provides an overview of the key findings from a mixed-method study in which Australia's changing digital skill requirements are examined. The context is that the success of Australia's digital transformation depends heavily upon the development of appropriate digital skills and strategies to address digital transformation challenges.

Rationale for the study

Accelerated change in the nature of work in the past few decades, caused by the ongoing implementation of new operations and managerial technologies, has engendered great debate at both industry and policy levels. One focus of the debate is the future of work and employment and the kinds of skills required to maintain competitive economic productivity (see Baller, Dutta & Lanvin 2016; Foundation for Young Australians 2016; Hajkowicz et al. 2016; International Labour Organization 2016; Winthrop & McGivney 2016; World Economic Forum 2016; World Employment Federation 2016).

Australian industry, in common with many other economies around the world, is under great competitive pressure to adopt new technologies in the workplace, including automation and robotics, the internet of things, and a wide variety of advanced information and communications technology (ICT) programs, applications and systems. While these technologies are widely considered to contribute to improvements in firm productivity, concerns associated with technological disruption have arisen. These concerns may be presented from three different but ultimately integrated perspectives. From the workers' perspective, there is great concern about job loss and anxiety about skill mismatch with potential post-retrenchment jobs (Callan & Bowman 2015; West 2015; Edwards & Ramirez 2016; Smith 2016). Employers worry about how they will obtain workers with the appropriate skills to drive the new and emerging order of work, while government, educational institutions and local communities are concerned about how best to educate, train and prepare the next generation of workers to thrive in the fourth industrial revolution (Foundation for Young Australians 2016; World Economic Forum 2016). At the heart of the debate are questions about the nature and impact of the changes and the specific character of the skills that are and will be required by the workforce.

The existing literature identifies three broad categories of digital skills requirements (ECORYS 2016):

- Category 1: Basic computer literacy for everyday life

- Category 2: Digital skills for the general workforce, enabling the effective use of IT systems and general technology processes across all sectors

- Category 3: Digital skills for ICT-specific professionals.

There is an abundance of research on Category 1 (for example, Bynner et al. 2010; Innovation & Business Skills Australia 2013) and Category 3 (for example, Deloitte Access Economics 2016). However, little attention has been paid to Category 2 digital skills, in which the evidence suggests there is a growing deficit in the skills required to effectively implement the new highly digitised and mechanised systems of work (Deloitte Access Economics 2016; Hajkowicz et al. 2016). The consistent message is that for the Australian

Australia is under competitive pressure to adopt new technologies in the workplace, requiring the development of appropriate digital skills.

economy to 'take full advantage of the opportunities presented by new technologies … the workforce must be equipped with digital skills' (Deloitte Access Economics 2016, p.5). Recent NCVER studies show that this challenge applies not only to adequately skilling new workers but also to upskilling the existing workforce for continued productive employment (Callan & Bowman 2015; Snell, Gekara & Gatt 2016).

Study objectives and questions

The broad objective of this study was to provide a comprehensive understanding of digital skills needs and digital skills development in Australia's emerging digital economy. The study had five main objectives. These were to:

- identify employers' views and perspectives on adopting digital technologies and occupational change

- identify current digital skills requirements in the broader Australian workforce, specifically the workforce not directly employed in ICT occupations and positions

- examine the capacity of Australia's VET system and industry training programs to effectively meet this growing need for digital skills across the general workforce

- analyse employer strategies for meeting the digital skill needs of their general workforce

- develop a digital skills framework appropriate for the Australian context, which can assist Australian industry to identify and monitor digital skills demand and supply and accelerate the skilling of the Australian workforce for the digital economy.

The project was guided by three key research questions:

- What are the digital skills formation gaps (defined as the gaps between the skills that employers want and those that the training systems can produce and supply) in the general workforce?

- What are the weaknesses and shortcomings in existing industry strategies, government policies and training programs, with specific regard to developing workforce digital skills?

- How can these shortcomings be addressed in order to eliminate the skills gap and effectively meet Australia's growing demand for digital skills?

Study design and research methods

The study was based on an integrated mixed-method approach, involving qualitative and quantitative methods, the aim being to provide a comprehensive and in-depth exploration of emerging technologies and the changing skills needs of an increasingly digital economy. The methods used included:

- a review of the literature

- a content analysis of job advertisements and training packages (see Gekara et al. 2017)

- a review of existing digital skills frameworks (see support document 1)

- case studies of two selected Australian industry sectors, based on 25 stakeholder interviews and two industry workshops; and

- a survey of human resources, skills and training decision-makers across a broader group of industries (see support document 2).

Although the research followed the methods described above with a particular sequence of data collection and analysis phases, there were significant overlaps. In addition, while the survey covers a cross-section of industries, the content analysis, interviews and workshops focused on two selected case study sectors (transport and logistics, and public safety and correctional services) from the transport, postal and warehousing, and public administration and safety industries. As described in Gekara et al. (2017), the case study industry sectors were chosen because:

- Industry research specifically focusing on these sectors has revealed their growing need for digital skills and highlighted the threat to performance and productivity from an inadequately skilled workforce (Government Skills Australia 2015; Transport & Logistics Skills Council 2015). This is the consequence of the high rate of workplace technological uptake and operations mechanisation as a way of enhancing efficiency and productivity and mitigating operations costs (Government Skills Australia 2015; Transport & Logistics Skills Council 2015).

- These industry sectors hold great significance to the economy and society in terms of national revenue and essential public service provision (Government Skills Australia 2015; Transport & Logistics Skills Council 2015).

- They emerge as major current and future employers in the ongoing economic transformation (Fairbrother et al. 2012; Snell, Gekara & Gatt 2016).

- They have experienced persistent skills and workforce challenges, including recruitment and retention difficulties, general skills shortages and a rapidly ageing workforce (Government Skills Australia 2015; Transport & Logistics Skills Council 2015; Gekara et al. 2017).

Method 1: Literature review

To provide a global perspective on the key debates on emerging technologies, changing skills needs and skills-development strategies and policies, we undertook a review of the relevant academic and industry literature from 2010 onwards (see support document 1). The review was used to develop a preliminary working definition and list of keywords to inform the content analysis of training packages and job advertisements, frame survey and interview questions, and discuss and interpret the study findings.

Method 2: Content analysis of job advertisements and training packages

A full description of the method, along with the findings, can be found in Gekara et al. (2017).

Job advertisement analysis

We examined the digital skills requirements for the two case study industry sectors via a detailed analysis of 1708 job advertisements covering 74 selected occupations (Gekara et al. 2017 p.15). These occupations were drawn from a list identified as 'in demand' in the 2015 environmental scans produced by the respective industry skills councils of the relevant sectors (Government Skills Australia 2015; Transport & Logistics Skills Council 2015). Taking

the job titles from the environmental scan reports, we individually and manually searched for each job title (for example, 'customs broker') in <www.seek.com.au> in the period between 13 October and 15 November 2016. The search was nationwide in scope.

The analysis of the job advertisements involved categorising the digital skills specified in the advertisements (for example, 'data entry' and 'warehouse management system'), as well as capturing complete phrases referring to digital skills (such as 'using electronic data interchange [EDI] enterprise'). In total, 286 phrases were extracted.

Training package analysis

We also explored the digital skills provided by the VET system via a content analysis of 11 training packages (see appendix A), with a specific focus on the qualifications for the 74 occupations in the job-advertisement analysis. In this analysis, 758 unique units of competency were analysed to examine how and to what extent digital skills provision is embedded in qualifications (Gekara et al. 2017 p.17). We created a text database containing the descriptions of all units of competency in each of the 11 training packages. Then, taking the working definition and keywords from the first method, and in consultation with Australian Industry Standards[3], we developed a list of 44 search terms. These search terms were then partially stemmed, grouped into five categories of digital skills, and searched across the text database.

We compared the digital skills in demand (from the job-advertisement analysis) with those being supplied, in order to identify differences and similarities between what employers want (job advertisements) and the content of digital training provided by the training packages (see Gekara et al. 2017). This enabled us to develop an initial understanding of the nature of the digital skills required for each job title, including the skills description, how the skill is demonstrated and the level of performance expected. This insight was used as an input to the two case studies (see support document 2). It also contributed to the development of the digital skills framework included within this report.

Method 3: Review of digital skills frameworks

As indicated, one of the goals of this project was to develop a digital skills framework suited to the Australian context. Our content analysis of job advertisements revealed that employers express their demand for digital skills with reference primarily to specific software and hardware tools. Industry training packages do include digital skill competencies but mainly at the basic level of device operation. To further develop an understanding of how digital skills are identified, measured and evaluated, we undertook a systematic analysis of 63 digital skills frameworks. The aims were to:

▪ analyse the challenges associated with framing digital skills in terms of terminology and scope and to develop a better understanding of digital skills conceptualisation

▪ evaluate the existing frameworks for measuring and developing digital skills, particularly the extent to which these frameworks focus on employee skills

---

3 Australian Industry Standards (AIS) is a government-funded not-for-profit organisation that develops skills standards across a range of Australian industries (AIS 2018).

- develop a better understanding of the scope of the existing frameworks: what digital skills are commonly identified, how the content of digital skills frameworks has evolved over time, which skills have become more valued and other common themes

- identify the building blocks and structure for developing a digital skills framework as part of this project.

A full description of the method and procedures used to undertake this framework analysis, along with the findings, can be found in support document 1.

Method 4: Case studies and survey

Employer views of their digital skills needs and digital skills supply were sought through semi-structured interviews, two industry workshops with stakeholders and a survey of human resources, skills and training decision-makers. A full description of the methods and findings for these research stages are available in support document 2.

Case studies

This phase of research drew on case studies from two selected industries: transport, postal and warehousing, and public administration and safety. In this phase, the aim was to:

- investigate employer and other key stakeholder perceptions and experiences of technological change, including how it impacts on the nature of skills requirements in particular industries

- explore how managers and employer organisations define and understand digital skills, based on their context within which such skills are needed and applied

- identify how employers are addressing their digital skills needs and their key challenges.

The case studies themselves involved two steps. First, interview data were collected from representatives of different organisations in the two industries of transport, postal and warehousing, and public administration and safety. In total, 25 interviews, each lasting one hour on average, were conducted with a variety of industry stakeholders, including employers, policy-makers, training providers and unions. The interviews were digitally recorded, transcribed and thematically coded in NVivo[4] for analysis. The interviews were conducted between March and June 2017.

In the second step, two industry workshops were organised through our industry partner, Australian Industry Standards. The workshops, referred to as the AIS Skills Forum and the Supply Chain Skills Industry Roundtable, were held in Melbourne on 31 August 2017 and 27 September 2017, respectively. Each of the workshops was comprised of approximately 60 participants, including members of Australian Industry Standards' Industry Reference Committee, industry human resources and training managers and a few academic researchers. The summary findings from our survey were presented to the groups for deliberation and comment as a way of verifying our data and formed the basis for the discussions on industry digital skills requirements and the challenges involved in meeting them.

---

4   A qualitative data analysis software package.

Survey of human resources, skills and training decision-makers

Since the insights obtained from the case study interviews could be specific to the two industries of interest (transport, postal and warehousing, and public administration and safety), we strengthened the evidence base and developed more broadly relevant insights by also undertaking a survey. Here our aims were to:

- investigate the extent of industry digitalisation and how it is impacting on the nature of skills requirements

- examine the extent of digital skills needed vis-à-vis the skills level of the current workforce, thereby developing the indicators for a digital skills framework

- identify how employers are addressing their digital skill needs and their key challenges.

The survey was administered to a sample of human resources, skills and training decision-makers from a cross-section of Australian industries and used two different survey approaches. In the first approach we targeted relevant stakeholder respondents in the Australian Industry Standards databases of the transport, postal and warehousing, and public administration and safety industries. Secondly, we utilised Qualtrics[5] to target a panel of human resources, skills and training decision-makers from other industry sectors.

The survey reached 454 human resources, skills and training decision-makers and generated 371 complete and usable responses for analysis. These decision-makers represented different occupational levels: more than 60% were CEO/directors and human resources or training and development managers; 25% were supervisors; and the remainder belonged to a variety of other occupations and levels such as general manager, communications director, operations director and manager of quality and safety training. The data were collected between May and June 2017.

Development of a workforce digital skills framework

This study supported the development of a workforce digital skills framework appropriate to the Australian context. The aim of the framework is to enable the comprehensive and consistent identification and monitoring of digital skills demand and supply and thereby to accelerate the skilling of the Australian workforce for a digital economy. The initial analysis of digital skills in demand (through the job-advertisement analysis) versus supplied skills (through the training package analysis) enabled a description of the current situation compared with projected future requirements. Our analysis of existing digital skills frameworks highlighted the importance of three factors: precise definitions; a clear structure; and indicators that balance hard technical skills against complex cognitive, entrepreneurial and innovation dimensions.

Our analysis of job advertisements, training packages and frameworks was further developed and tested in the next phase of the study. We drew on interview data to populate our proposed framework with specific skills indicators, assessing individual skills and proficiencies within the broader workplace context. Our quantitative analysis of the survey of the human resources, skills and training decision-makers provided an empirical demonstration of how this framework could support the identification of digital skills gaps in practice.

---

5   An online survey, research and experience management tool

Report structure

The remainder of this report is structured as follows. First, it presents the definitional and conceptual challenges associated with digital skills. The research objectives, analysis and findings are then presented in five sections:

- an analysis of employers' views and perspectives on adopting digital technologies

- the identification of digital skills requirements

- an evaluation of Australia's VET system and industry training programs in terms of meeting the need for digital skills

- an overview of employer strategies for meeting digital skill needs

- a description of the digital skills framework proposed for the Australian context.

The report concludes with implications and considerations for further study. For a more detailed discussion of these findings we encourage the reader to consult the working paper (Gekara et al. 2017) and the two support documents associated with this report.

Defining digital skills

Rapid changes in the nature of work, influenced by the adoption of new technologies across all sectors, have stimulated an ever-increasing debate in industry, as well as in policy and academic writing in recent years. At the heart of the debate are questions about the nature and impact of the changes, and the specific character of the skills that are and will be required by the workforce. Three broad categories of digital skills requirements are identified within the literature: basic computer literacy for everyday life; digital skills for the general workforce; and digital skills for specialised ICT professionals (ECORYS 2016).

Although all these skill categories are important, a search of the literature shows that the majority of the research in this area has focused on the first and last categories, that is, basic computer literacy and digital skills for ICT workers (see Bynner et al. 2010; Deloitte Access Economics 2016; Innovation & Business Skills Australia 2010). For this reason, those two skill categories are better defined and understood, while the second category is less so. This is despite mounting evidence suggesting a growing lack of skills to effectively implement new highly digitalised and mechanised systems of work and, furthermore, that the Australian economy is struggling to meet the digital skills requirements of the general workforce (Deloitte Access Economics 2016; Hajkowicz et al. 2016). Existing research shows that Australia needs to urgently develop a pool of digitally skilled workers across all industries in order to 'take full advantage of the opportunities presented by new technologies' (Deloitte Access Economics 2016, p.5).

In order to succeed in this effort, however, we must develop a clear understanding of the nature of digital skills and devise effective approaches to developing them. Currently, there is no universally accepted definition of 'digital skills' (see Bawden 2001; van Deursen & van Dijk 2008) and different terms exist to describe skills related to the use of digital technology (Ilomäki et al. 2016; Zhong 2011). Common terms include 'digital literacy', 'digital skills', 'information and communications technology skills', 'digital competence', 'media literacy', 'information literacy' and 'internet skills' (Eshet-Alkalai 2004; Ilomäki et al. 2016; Iordache, Mariën & Baelden 2017). Within the last decade, the concept of social media skills has also gained prominence. These terms imply growth over time in how we view and understand digital skills, from an originally narrow focus to a much broader view, one now incorporating a wider range of non-technical 'cognitive, attitudinal, social and emotional skills' (ECORYS 2016, p.7). This reflects the rapid development of digital technologies across social and work domains (Dore, Geraghty & O'Riordan 2015).

A narrow definition of digital skills ordinarily refers to the acquisition and utilisation of computer skills or ICT skills (Dore, Geraghty & O'Riordan 2015). The focus here is mostly on the 'technical, operational and procedural' aspects of the hardware and the software components of the new computer-based technologies (ECORYS 2016, p.17). Skills descriptions such as 'computer skills' or 'ICT skills' represent the narrowest and basic conceptualisation of digital skills in the scholarly literature (Dore, Geraghty & O'Riordan 2015; ECORYS 2016).

The rise of the internet as a digital technology in the 1990s led to new considerations of the types of skills needed to function in networked online media environments (ECORYS 2016). Besides operational and technical skills, other non-technical skills became a key emphasis, such as the ability to find, evaluate and manage increasing amounts of information on the

internet. Terms such as 'information literacy' and 'digital media literacy' are key examples of this shift. The development of Web 2.0 during the 2000s added a further dimension to the internet, in that it transformed the internet from 'a relatively passive content consumption medium to one that enables actively produced user-generated content' (van Deursen & van Dijk 2008, p.7). This further expanded the range of digital skills descriptors to include attitudinal, social and emotional 'skills', perceived as necessary for engaging with the internet. Similarly, with the growing usage of 'Big Data analytics, social media platforms and mobile devices' (Spitzer et al. 2013) in more recent years, definitions of digital skills have been further broadened to include the range of competencies needed to function effectively in much more complex and demanding digital environments, including problem-solving and awareness of ethical issues such as security, privacy and copyright.

Figure 1   Different domains of digital skills
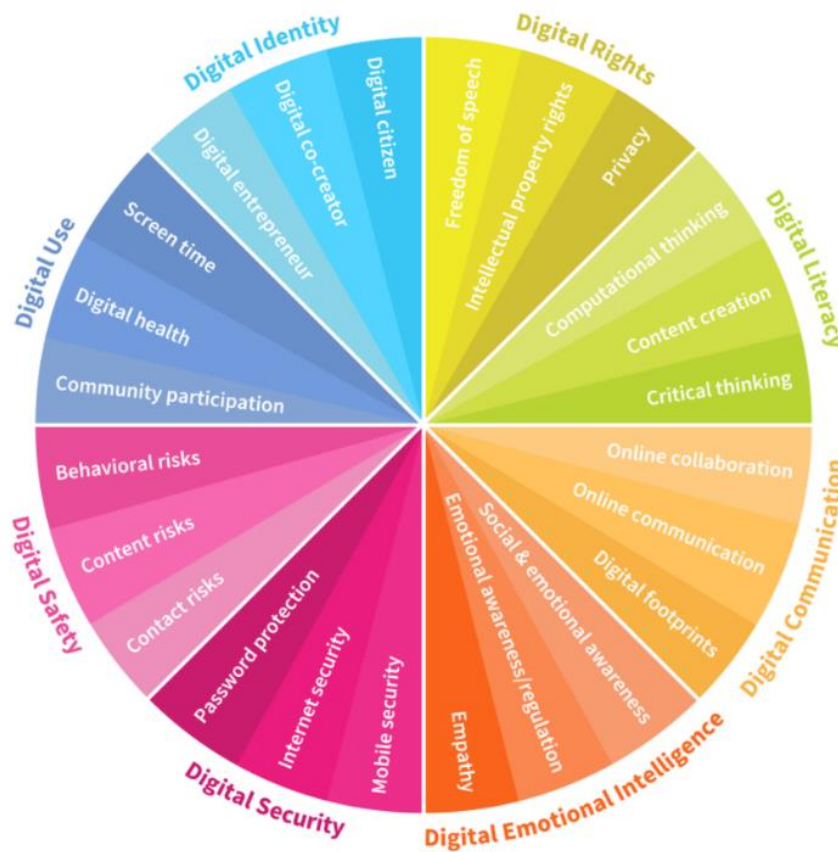
Source: World Economic Forum (2016).

An example of a broader definition of digital skills is provided by the World Economic Forum (figure 1), which identified and detailed eight different digital skills domains: use, identity, literacy, rights, communications, emotional intelligence, security and safety. The suggestion is that, in a mature digital society, digital skills and knowledge must be equally developed across these domains, leading to an established digital culture where most people are competent, comfortable, confident and safe in their daily navigation of a digitalised work and life environment.

This broader definition of digital skills is not without its detractors, those who suggest that attitudinal, emotional and other personal attributes (often referred to as 'soft skills') are not skills in the pure sense of the term and have little to do with changes in the digital workplace or the capabilities to work in such workplaces (Grugulis & Vincent 2009). The emphasis here is on drawing a clear distinction between what employers view as desirable characteristics among their workforce (for example, attitude, behaviour, appearance etc.) and what is required in terms of skills, knowledge and capabilities to perform in the digitalised workplace.

A further and similarly important development is that, while digital skills were initially viewed as predominantly the domain of highly technical ICT professionals, it is becoming increasingly evident that the general workforce, including those engaged in low-skilled occupations, requires digital skills to navigate workplaces that are becoming highly mechanised and digitalised (Hajkowicz et al. 2016; Winthrop & McGivney 2016). This inevitably shapes the ways in which trainers, workers and employers come to perceive and define digital skills. It is this particular view that forms the core focus of this study.

Based on the foregoing discussion, we adopt a broad definition of digital skills. We define digital skills as a combination of the following five areas, all of which workers need to master and demonstrate in the digital age:

- digital knowledge (theoretical comprehension and understanding)

- cognitive knowhow (involving the use of logical, intuitive, innovative and creative thinking in the digital space)

- practical knowhow (including the use of digital tools such as hardware, software, information and security systems)

- competence (ability to learn, adapt and apply digital knowledge in a new setting)

- 'digital' attitude (value and beliefs).

This definition encompasses the hard-technical skills needed to operate digital devices, software and systems; the cognitive skills required to work in an increasingly data- and information-intensive environment that encompasses a wide variety of information and data sources and types; ethical skills pertaining to security; and the strategic skills to troubleshoot and resolve work-related problems in the digital environment. This definition underpins our claim that an analysis of skills must target identifiable skills.

Findings and discussion

This section presents the key findings attached to each of the objectives of the project. The discussion is not intended to repeat findings from the working paper (Gekara et al. 2017) or support documents 1 and 2, accompanying this report. Instead, it aims to highlight and discuss the key themes that emerge from the data and correspond with the study objectives.

Uptake of digital technologies and occupational change

The previous decade has seen a significant rise in disruptive technologies in the form of the internet of things, big data and social media and analytics. Coupled with innovations in business models or processes, these disruptive technologies are leveraging breakthrough concepts such as the sharing economy, for example, Airbnb, Uber, Grab and increasingly prevalent shared work spaces. Disruptive technologies and market forces have consequently brought about a significant shift in the structure of many industries, challenging established patterns of company profitability and long-term viability — a phenomenon commonly known as 'digital disruption'.

The first objective of this project is therefore to examine the extent to which Australian industries are affected by digital disruption, which we achieved by exploring employers' views and perspectives on the uptake of digital technologies. In our consideration of this objective, we first draw on findings from the broader survey of human resources, skills and training decision-makers, to be followed by insights from the two industry sector case studies.

Digital disruption is rapidly breaking down long-established business models and blurring lines between companies and industries. In doing so, it alters organisational processes and traditional ways of operating and delivering goods and services; it also changes workforce needs, knowledge, skills and capabilities. Consequently, more than two-thirds of the survey respondents agreed that their industry is affected by digital disruption, with the impact of digital technologies being felt across the entire organisation, in terms of an increasing demand for digital skills both in the non-ICT department workforce and for the ICT professionals themselves.

The top five technologies with the greatest impact on skill requirements across Australian industries are: mobile, cloud, automation, big data and the internet of things. Less than one fourth of survey respondents identified emerging technologies such as drones, wearables, self-driving vehicles and augmented and virtual reality as impacting on skills. Nevertheless, the increasing digitalisation of work through the application of mobile and smart devices, robotics, enterprise systems, cloud computing and augmented and virtual reality will continue to significantly affect working methods and practices and the types of skills required to succeed in future workplaces. In addition to presenting different challenges for employers in meeting digital skills needs, these changes are making many existing jobs vulnerable to automation. On the one hand, the majority of respondents indicated that their need for ICT professionals, which are mostly high-skilled and well-paying jobs, has increased over the past five years, with the required skills becoming more difficult to find.

On the other hand, because of the adoption of digital technologies, some employers are having an easier time than previously in meeting their digital skill requirements.

Although there is great optimism in relation to an emerging digital economy, the adoption of digital technologies and the associated occupational changes are neither experienced at the same pace in all industries nor influencing all occupations to the same degree. The findings from the case studies suggest that many organisations are set to join the digital economy, having implemented digital technologies at their workplaces to varying extents. However, the findings also show that many organisations are taking a relatively gradual process to technological uptake. These findings are consistent with other Australian studies indicating that Australia's 'digital transformation' is much more gradual and, according to some reports, lagging behind other parts of the world, particularly among Organisation for Economic Co-operation and Development (OECD) countries (Chakravorti & Chaturvedi 2017).

Five explanations were given for the gradual adoption of digital technologies in the case study industry sectors:

- Many organisations are hesitant to implement a wholesale technological transformation of their operations because of a perceived shortage of adequately skilled people to manage and work with the technologies.

- There is resistance from the existing workforce, particularly older workers, towards such transformation in the nature of their work.

- Workers and unions are also greatly resistant to such large-scale transformation, fearing job loss and employment displacement.

- Many organisations, based on the scale and scope of their operations, viewed extensive and rapid transformation as unnecessary, because, as stated by one respondent, 'the anticipated productivity gains are not large enough to justify the cost and effort' (Transport company).

- Many organisations were prevented from undertaking comprehensive digital transformation by a lack of similar developments across the various collaborating partners in their supply chain; that is, digital changes made by just one partner would lead to a detrimental misalignment of operations. This was especially the case for transport, postal and warehousing companies.

Worth noting, however, is that there are important differences in technological innovation within and between the two case study industry sectors. On the one hand, most firms in the transport, postal and warehousing industry are less tech-intensive and comprise smaller capital-poor operators. These operators rely on largely unskilled and ageing workforces, whose digital skills are limited to basic devices for data capture and transmission, for example, smart phones, digital tablets and computers. On the other hand, major enterprises in transport, postal and warehousing and some sections of the public administration and safety industry (for example, the police) are tech-intensive and are pursuing a more aggressive approach to technological innovation, digitalisation and mechanisation.

Overall, the evidence suggests that the uptake of digital technologies in Australian industries can fall into one of the following three broad categories:

- aggressive technology adopters: organisations that lead in technological uptake

Skilling the Australian workforce for the digital economy

- keen technology adopters: organisations that are actively considering technological innovations

- slow technology adopters: organisations that delay technological uptake.

The above typology is particularly instructive when considering employer strategies for digital skills development.

Digital skills requirements in the Australian workforce

The second objective of this project is to identify current digital skills requirements in the broader Australian workforce and specifically the workforce not directly employed in ICT occupations and positions. To address this objective, we first discuss findings from the survey of human resources, skills and training decision-makers. To highlight the differences among industries, we draw from the experiences of the two case study industry sectors.

Many current enterprise innovations are based on digital technologies such as social, mobile, analytics, cloud and the internet of things. Organisations and industries have undergone, and are still undergoing, transformations largely driven by these technologies and other technological shifts (such as artificial intelligence and augmented reality), market volatility (driving fast-paced and new demands), and highly digitalised consumer and workforce requirements. The evolving nexus of digital technologies, and the complementary innovations they enable, transforms enterprise ways of working and affects the nature and mix of skills requirements. The impacts could be in terms of changing technologies, working methods and work practices, as well as increased job vulnerabilities due to automation (CEDEFOP 2008).

The survey results showed that organisations are under competitive pressure to expand the digital skills of their workforces. These skills range from a mindset (including entrepreneurial, creativity and experimental), to functioning within an increasingly digitalised workplace and confidently using advanced features of generic and industry-specific digital technologies and enterprise systems. They also include troubleshooting problems that arise in the increasingly digitalised workplace and recognising the security, societal and environmental implications of digital technologies. This was also illustrated in an interview from one of the case studies:

> Digital skill is not just about do I know how to click a button or use an iPad. Digital means new business models, new ways of working, new ways of creating that [aren't] necessarily the norm of organisations today. It requires an entrepreneurial, experimental and commercialisation mindset — a cultural change, a cultural shift which is very, very different to the types of skills that we traditionally see in workers. (Transport, postal and warehousing)

In summary, the digital skill requirements in the Australian workforce can cover four broad areas, as depicted in figure 2, which shows the degree to which the managers interviewed spoke about each of the categories.

Figure 2   Categories of digital skills requirements
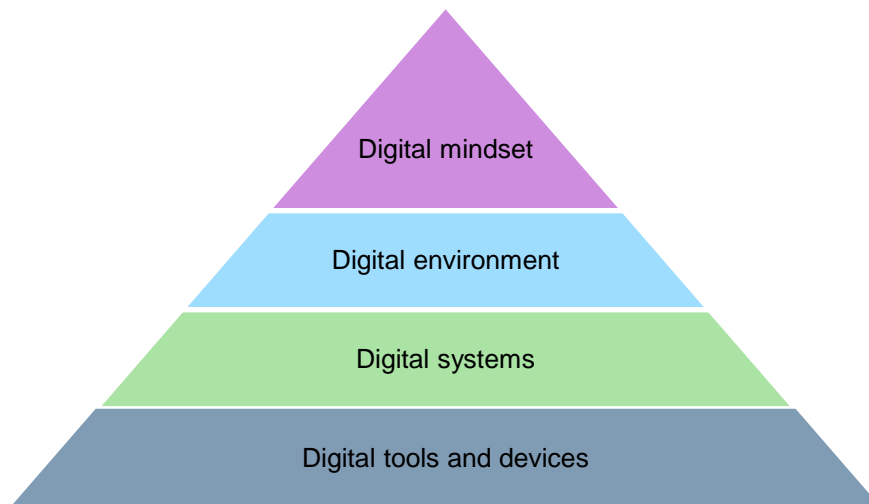
Despite the demand for digital skills both within and outside ICT departments, most of the survey respondents rate their current workforce's digital skills capability as either low or moderate. In some cases, employers pointed to a shortage of digital skills in the marketplace as exacerbating their skills challenges. The combination of these factors has created a digital skills deficit, which the majority of survey respondents highlight as a key barrier to digital transformation. This skill deficit relates to digital device use; information systems; analytics; communication and collaboration; problem-solving; creativity and innovativeness; security; and social and ethical responsibility.

The relationship between technological innovation and digital skills demand is not always straightforward. Technological change impacts on industries, occupations and workforces in different ways, while industry and organisational size also matter. The survey results reveal that the digital skill needs of enterprises in the transport, postal and warehousing industry are significantly lower than other participating industry employers. There are also relatively wider digital skills gaps in the public administration and safety enterprises than in other Australian industries participating in the survey. Understandably, small enterprises — those with fewer than 20 employees — lag behind other enterprises in both their digital skills needs and competence. Although digital skills are demanded in all types of occupations (Beblavý, Fabo & Lenaerts 2016), there are obvious occupational differences in the level of skills needed. However, most survey respondents indicate a great need for digital skills in the three occupational groups of managers, professionals, and technicians and trades workers.

These intra- and inter-industry and occupational differences are also reflected in the case study findings; for example, our analysis of job vacancy advertisements across the transport, postal and warehousing, and public administration and safety industries reveals that employers express demand for digital skills in terms of the specific software and hardware tools, indicating their requirements by reference to the various digital tools utilised, for example, email, smartphones and enterprise resource planning (ERP) systems. Some also referred to specific applications such as MS Excel and Pronto. Similarly, some interviewees from the two case study industry sectors tended to talk more about digital tools and devices and less about systems, a digital environment or a digital mindset.

In short, under the prevailing employer understanding and articulation of digital skills demand, the scope of required competence is confined to the specific tools needed by the workers. A broader appreciation of the digital environment is absent. This is a significant shortcoming in an emerging digital economy, where the future of work is likely to be dominated by digital technology and workers will be required to master not only specific tools in specific contexts but also a higher level of overall digital competency.

By contrast, middle-to-senior management staff and management support staff across all of the case study organisations were expected to work more intensively with digital systems and were therefore required to possess a higher level of digital competence. Historically, ICT staff have been those who interacted most with a wide variety of digital devices and systems, these ranging from basic to highly advanced. In one form or another and in varying sizes, this category of workers existed across many of the participating organisations. Advanced-level digital skills held in organisations tended to be concentrated in small groups of highly skilled workers in specialised ICT units. Consequently, in some organisations a gap has emerged, whereby digital skills are more highly concentrated in the ICT group, even though the organisation requires them across the workforce.

Capacity of Australia's VET system to meet the need for digital skills

The third objective of this study is to examine the capacity of Australia's VET system and the extent to which it prepares workers to work effectively in a digitally enabled environment. Findings from the survey, the content analysis of VET training packages and the industry sector case studies revealed mixed results.

On the one hand, more than half of the human resources, skills and training decision-makers surveyed are not satisfied with the digital skills of VET graduates recruited from the market. A similar proportion believes that VET training packages and industry qualifications are not current enough to meet industry digital skill requirements. Furthermore, nearly two-thirds of survey respondents report that the digital skills of the VET graduates they encounter fall short of their expectations.

On the other hand, our content analysis of VET training packages shows they do contain a significant amount of digital training. In many of the units of competency contained in the 11 training packages selected (because of their association with the two case study industry sectors; see Gekara et al. 2017), digital skills-related keywords and terms were found. Although not conclusive, this suggests that these units are, at least to some extent, designed to develop digital skills. Closer examination, however, reveals that most of the digital skills in units of competency tend to be electives as opposed to core units, which means that qualifications may be completed without these units. In other words, it is possible for someone to undertake entire qualifications with little, if any, digital skills training. Thus, for the two industry sectors we examine, the training system does not accord digital skills 'essential skills status' (Gekara et al. 2017), thereby allowing trainees to graduate without having acquired them.

Digital training content in the training packages analysed is expressed generically, with little reference to specific tools and systems. Furthermore, training is geared towards developing skills at the lower skills end; that is, for the basic use of computer hardware and software in processing data and information from organisational databases, as well as for

It is possible for someone to undertake entire qualifications with little digital skills training. Consequently, employers often struggle to find people with adequate training in digital skills.

online internet and web sources (see Gekara et al. 2017 for more detail). There is a greater focus on skills needed in basic operational and non-supervisory occupation levels, lending credibility to arguments in the literature that training design and delivery could be significantly influenced by the ways in which employers understand and articulate digital skills. Gekara et al. (2017), for example, observe that, because employers are more interested in specific institutional productivity needs, they rarely see beyond specific skills requirements. From a skills supply perspective, an ongoing lack of appropriately trained VET graduates is likely to undermine the anticipated transition to a digital economy: a digital economy necessarily implies the widespread adoption of digital technologies across all industries and occupational levels (Gekara et al. 2017).

The survey data and case study interviews also indicate uncertainty about the extent of government policy intervention to ensure that digital skills in Australia are adequately developed. The human resources, skills and training decision-makers were divided in their perceptions of Australian Government investment in the development of workforce digital skills and the training system's ability to deliver the requisite digital skills for their organisations. A little over one-third perceive the government's investment as sufficient, a quarter of the respondents believe it is insufficient and the rest were uncertain (see support document 2 for more detail). Accordingly, the government's approach to investment in education in general and in science, technology, engineering and mathematics (STEM) will be important in addressing digital skills needs and supply into the future.

Strategies for digital skills workforce development

Employers are pursuing a variety of approaches to meet their digital skills requirements. However, very few seem to have comprehensive and proactive strategies for the development of digital skills. The survey findings and the interviews with employers from the case study industry sectors suggest that organisations are pursuing different approaches to digital skills development (see support document 2). As noted above, three different categories of employers were identified, based on the approaches taken to technology uptake and skills acquisition.

Aggressive technology adoption and skill development

The first category of employers comprises companies with an aggressive approach to both digital technology adoption and digital skills development. Because these companies have pursued aggressive technological innovation, they view digital skills as essential and critical for the future of their operations and the success of their companies. They, therefore, tend to utilise a wide range of approaches in their digital skills acquisition, including robust external recruitment, as well as an internal skills-development strategy.

In terms of recruitment, they target highly qualified and experienced workers from the open labour market. The following quotes, from two such firms, illustrate how technological advancement and the associated demand for digital skills intersects with targeted staff recruitment:

> We've deliberately hired in and brought in new blood, new skills, new ways of thinking; that's permeated through the organisation and you will find more and more people pushing new ways of working, new technologies to apply. (Mail and parcel delivery)

> We're advertising for a position right now which I was interviewing, and that was one of the big focuses on their ability to use different systems — in getting data from them, analysing data. And that's a low-level administrator … and they need really good IT skills. (Transport and logistics)

These organisations also tend to invest heavily in in-house training programs, for both incoming workers and the ongoing upskilling of the entire workforce. Training occurs in a number of ways:

- in-house and on-the job training provided by company trainers

- a mix of in-house and externally provided training

- purely external training provided at VET training institutions, paid for by the employer.

This category of technology adoption and skill development appears to be the least prevalent of the three categories in the case study industry sectors.

Keen technology adopters but cautious skill development

The second category comprises organisations described as keen technology adopters but with a cautious digital skills-development agenda. Of all the employers interviewed from the case study industry sectors, the largest proportion belongs to this category. The dominant explanation for this approach to technological change was that the introduction of radical changes might jeopardise their current productivity levels, due to an overall shortage of people with the digital skills required to implement such change while still maintaining high productivity and competitiveness. According to the interviewed employers, older and semi-skilled and unskilled workers tend to be the greatest source of resistance to new technologies and the rapid and radical transformation of their way of working. The following quote illustrates this issue:

> The area that we do struggle with is the bigger trucks and the older drivers, so guys post 40 years old. We've found there have been issues around them actually just having no frickin' idea what to do with even a smartphone. (Transport and logistics)

Instead, these organisations maintain production processes with minimal essential technologies, which explains their need for basic, low-level digital skills.

When recruiting new workers, these organisations did not require a digital skills capability, the reason being, as explained by one interviewee, that such a requirement might discourage applicants from the socio-demographic catchments from which they traditionally recruit. Furthermore, they were hesitant to introduce radical changes to workplace technologies for fear of provoking techno-resistance from their existing workforce, who possessed little or no digital skills, as the following quotes illustrate:

> Any form of cultural change is difficult. You're trying to change the old guard right? Change the old ways of doing things … We have all manner of challenges that you can imagine, ranging from first of all convincing people that the change is even necessary. (Mail and parcel delivery)

> There was a little bit of hesitation from the workforce to embrace [the use of tablet devices]. We've got a lot of our aging workforce in the driver teams, the average age is 54 years, so there's a lot of hesitation to use the tablet, but it was just excuses. (Transport and logistics)

The strategy adopted by these organisations is to undertake slow and gradual change while ensuring that current productivity levels are not seriously undermined. At the same time, they educate their workforce about the importance of new workplace technologies, the aim being to introduce gradual cultural change. Organisations in this category justify their cautious approach to technological transformation by referring to the composition of their workforce and the challenges associated with substantial upskilling.

The absence of a requirement for digital skills in new workers limits the ability of such organisations to attract educated and digitally skilled young workers, since it maintains the common perception of transport and logistics occupations as unskilled and unprofessional. Furthermore, it has the potential to lead to acute workforce shortages and negatively impact on their operations and productivity.

Appreciation of growing need for digital skills, but no investment in skill development

The third approach adopted by employers is one whereby they pursue a 'laissez-faire' approach to the digital transformation of their organisations. This is shaped on the one hand by recognition of the growing need for digital skills in the general workforce and on the other hand by the view that that these skills are easily acquired through on- and off-the-job experiences in working with digital technologies. There is also a tendency among this group of employers to expect new recruits to have these skills when they are employed (that is, be 'digital ready').

These employers share the view of the 'keen technology adopters' that the workforce primarily needs basic device-operation skills. Thus, interviewees talked of their expectation that people's day-to-day usage of digital devices, such as smartphones and digital tablets, is easily transferrable to the workplace. On the other hand, and similar to the 'aggressive technology adopters', this group also recognises that digital skills of a higher level are becoming increasingly critical. They differ, however, in that they are not prepared to invest in appropriate workforce training. Instead, they are more interested in, as one interviewee explained, 'attracting the best digital minds [where necessary] by being an employer of choice' (Transport and logistics human resources interview). In other words, the strategy of these 'slow technology adopters' is to specify certain levels of digital skills in their recruitment in the expectation that they will attract appropriately trained and qualified people.

> We want to attract the best people, with the right skills … we pay well and treat our people well and provide opportunities for development … we get people with the right skills because we are an employer of choice. (Transport and logistics human resources interview)

Digital skills future: towards the Australian Workforce Digital Skills Framework

It is becoming increasingly critical to track the spread of digital take-up across industries and workplaces and the associated skill requirements. Our analysis reveals that to date Australia has not adopted a clearly defined digital skills framework, one that can be applied by employers, trainers, government agencies or individuals to assess their digital skills needs and requirements. The need for such a framework is illustrated by the many national digital skills frameworks that have been adopted and implemented across rapidly advancing digital

economies around the world (see support document 1). The findings from this study have enabled us to create the first Australian Workforce Digital Skills Framework (AWDSF).

Our review of 63 digital skills frameworks from other national contexts highlights a number of factors pertinent to their development and format. Firstly, frameworks tend to be overly general, with the inclusion of both work and non-work-related (for example, social) digital skills and do not specifically focus on employee skills. The tendency is for frameworks to focus on either:

- *digital competencies* (typically focused on technical abilities) needed to engage in a digital society

- *digital literacies* required to use technology in a meaningful way for work and social activity and includes the operational, cognitive, cultural and critical dimensions of literacy

- *digital skills*, which focus on the more practical and measurable application of digital technologies and the ethical and responsible use of technologies.

The conceptual boundaries between digital competencies, digital literacies and digital skills-oriented frameworks are becoming increasingly blurred. However, it continues to be relatively uncommon for frameworks to separate work-related skills, competencies and literacies from those related to broader social life and engagement.

Secondly, frameworks favour the conceptual and non-task-specific aspects of digital technologies and their utilisation, for example, 'accessing and searching for online information'. Furthermore, other than a few references to tools such as social media, cloud, mobile and analytics and the internet of things (for example, Asliturk, Cameron & Faisal 2016), frameworks mention few technology-specific skills. Skills related to information and communication are regularly included in digital skills frameworks. However, there are other varied definitions of digital skills: several frameworks consider personal, interpersonal and foundation/core skills and elaborate these in the digital domain (for example, Asliturk, Cameron & Faisal 2016; Iordache, Mariën & Baelden 2017). Examples include business interpersonal skills, which include aspects related to communication, social and marketing skills (including understanding how to use social media), management and continuous learning skills, and also entrepreneurship, which focuses on the digital elements of social media, mobile, cloud and analytics, as well as business aspects, such as identifying trends in business development (Asliturk, Cameron & Faisal 2016). The problem-solving focus of many frameworks (for example, Hadziristic 2017; Siddiq et al. 2016) is consistent with other (non-digital) skill frameworks (for example, OECD 2014). However, and as noted by others (Iordache, Mariën & Baelden 2017), strategic and analytical skills are largely neglected.

Thirdly, the digital skills frameworks developed more recently tend to consider the importance of complex cognitive skills, as well as the interpersonal, entrepreneurial and innovation dimensions of digital skills. Finally, notions of safety, framed around cyber security, privacy and protection of personal data, have become more obvious and more valued in recent discussions on digital skills.

Developing a framework with the capacity to capture the broad area of digital skills is therefore both a challenge and an identified need. For instance, the South Australian Office for Digital Government is 'conducting a training needs analysis across the entire public service to create a common framework of competencies and capabilities in digital and ICT

A digital skills framework needs to consider both hard technical skills and more generic and 'soft' interpersonal skills.

skills [with the expectation that the framework] will assist agencies in identifying skills gaps and planning their workforce development and digital strategies' (Deloitte Access Economics 2016, p.47). The Burning Glass Technologies company, which conducts labour market analyses and develops workforce-planning tools to inform careers, define academic programs, and shape workforces, has identified three clusters of digital skills to consider as part of any digital skills-development strategy: productivity software skills, advanced digital skills and occupation-specific digital skills (Burning Glass Technologies 2015).

The overarching message from these various frameworks, as well as our case study data, is that a digital skills framework needs to consider not merely the hard technical skills associated with operating digital technologies but also the more generic and 'soft' interpersonal skills that are increasingly required to work effectively in the digital workplace. In other words, frameworks need to consider the notion of 'trans literacy'; that is, accounting for the technical (for example, how to use technology) and cognitive aspects (for example, knowing how to use information) of digital skills, while also considering workplace and occupational context. These findings and considerations informed our development of the Australian Workforce Digital Skills Framework.

The proposed framework is therefore premised on a broad definition of digital skills, comprising five areas:

- digital knowledge (theoretical comprehension and understanding)

- cognitive knowhow (involving the use of logical, intuitive, innovative and creative thinking in the digital space)

- practical knowhow (including the use of digital tools such as hardware, software, information and security systems)

- digital competence (ability to learn, adapt and apply digital knowledge in a new setting)

- attitudes (values and beliefs) that workers need to master and demonstrate in the digital age.

The framework has two dimensions. The first dimension presents the digital skills categories, while the second dimension defines the level of need/performance. This structure is consistent with other frameworks such as the Australian Core Skills Framework (ACSF; Mclean et al. 2012).[6]

Digital skills categories of the Australian Workforce Digital Skills Framework

The digital skills category dimension of the proposed framework contains four high-level categories, eight sub-categories and 17 Indicators (see table 1).

In order to define broad and lasting digital skills categories, we adapt four broad areas that commonly appear in twenty-first-century skills frameworks (Dede 2010):

---

6 The Australian Core Skills Framework (ACSF; Mclean et al. 2012) provides a guide for identifying and analysing the core skills of learning, reading, writing, oral communication and numeracy skills performance.

- ways of thinking: cover creativity and innovation, critical thinking, problem-solving, decision-making, learning to learn and metacognition

- ways of working: refer to communication, collaboration and teamwork

- tools for working: include information and data literacy and information and communications technology literacy

- living in the world: encompasses skills related to life and career, personal and social responsibility.

On this basis, the four broad digital skills category dimensions of the Australian Workforce Digital Skills Framework are:

- *Digital ways of thinking*: these involve the digital creativity and innovation and problem-solving knowledge, cognitive and practical knowhow, competence and attitude that employers need and/or workers possess.

- *Digital ways of working*: these refer to the analytics, communication, collaboration, and teamwork knowledge, cognitive and practical knowhow, competence and attitude that employers need and/or workers possess.

- *Digital tools for working*: these include the information and communications technology and information systems knowledge, cognitive and practical knowhow, competence and attitude that employers need and/or workers possesses.

- *Living in the digital age*: these encompass the digital safety, security, knowledge of social and ethical responsibility, cognitive and practical knowhow, competence and attitude that employers need and/or workers possess.

Further, as is common in other skill frameworks (such as the Australian Core Skills Framework and the Skills Framework for the Information Age), we define sub-categories and specific behavioural indicators that capture the technological, informational and contextual knowledge, cognitive and practical knowhow, competence and attitudes that are fundamental to sustained workforce productivity in the digital environment. To do so, we draw on the findings from this project, as well as a synthesis of digital skills indicators from selected frameworks.[7] This led us to identify eight sub-categories, under which we grouped the 17 indicators used in our survey (table 1).

- *Digital ways of thinking* contains two sub-categories: Digital creativity and innovation (with five indicators) and Digital problem-solving (with two indicators among them).

- *Digital ways of working* contains two sub-categories: Data analytics (with one indicator) and Digital communication and collaboration (with two indicators).

- *Digital tools for working* has two sub-categories: Digital device (with three indicators) and Information systems competency (with two indicators).

- *Living in the digital age* contains two sub-categories: Digital safety and security (with two indicators) and Social and ethical responsibility (with two indicators).

---

7   Frameworks from which the digital skill indicators were drawn include the Innovation and Business Skills Australia ICT workforce skills framework (2015), the European digital competency framework and the Canadian framework on the skills spectrum in the digital economy (Asliturk, Cameron & Faisal 2016).

Table 1   Australian Workforce Digital Skills Framework: Digital skills category dimensions

Category	Subcategory	Indicator
Digital tools for working	Digital device	Keyboard skills (keyboard dexterity)
		Operate industry (job) specific digital technologies
		Learn and adapt quickly to nascent and emerging technologies (such as social, mobile, internet of things, apps, robotics, artificial intelligence etc)
	System competency	Use different enterprise information systems to complete complex transactions
		Ability to extract insight from data analytics systems, engines and dashboards
Digital ways of working	Data analytics	Ability to gather and analyse big data
	Digital communication and collaboration	Use advanced features of digital technologies with confidence for communication, cooperation and collaboration
		Effectively search, find, retrieve, process and communicate information from a variety of digital sources and in a variety of formats
Digital ways of thinking	Digital creativity and innovation	A mindset to function with an increasingly digitised workplace
		Entrepreneurial and commercialisation mindset in the digital workplace environment
		Creativity and experimental mindset in the digital workplace environment
	Digital problem-solving	Troubleshoot/solve problems that arise when using digital technologies
		Recognise workplace problems and needs in the digital environment and propose innovative solutions
Living in the digital age	Digital safety and security	Comply with organisational policies to protect hardware, software, information and systems
		Analyse digital risks to identify cyber security threats and vulnerabilities
	Social and ethical responsibility	Understand the importance of privacy in handling data and information
		Understand the positive and negative environmental impacts of digital technologies

Digital skills level of need/performance of the Australian Workforce Digital Skills Framework

The findings from this study indicate that, in addition to identifying digital skills categories, sub-categories and dimensions, it is essential to define a mechanism that can capture industry, organisational size and occupational differences in digital skills needs and capabilities. The second dimension of the digital skills framework reflects the level of need/performance for each of the major categories, sub-categories and indicators outlined above, according to occupation type and job complexity. Internationally, there is no consistently used model for describing skills levels. For example, the European Digital Competence Framework defines eight levels (Carretoro, Vourikari & Punie 2017). The Skills Framework for the Information Age defines seven levels (see, <https://www.sfia-online.org/en/framework/sfia-7/busskills>). Although it doesn't focus on digital skills, the Australian Core Skills Framework recognises five levels. A useful approach is to adapt the five levels of the latter, since these are consistent with the 'five levels of maturity' path used in most technology-based models, most famously, Blooms taxonomy. The Australian

Core Skills Framework also resembles Bloom's taxonomy, which describes learning outcomes as a hierarchy ranging from knowing and understanding through to analysing to creating (Australian Core Skills Framework, 2012). Thus, we define the five levels of need/performance of digital skills as follows:

- *Digital skills literacy*: cognitive awareness and understanding of digital tools, ways of working, thinking and living

- *Digital skills competency*: basic ability to use digital tools, ways of working, thinking and living to fulfil simple tasks

- *Digital skills proficiency*: well-developed ability to apply digital tools, ways of working, thinking and living to fulfil relatively complex tasks

- *Digital skills fluency*: advanced ability to apply digital tools, ways of working, thinking and living to fulfil complex tasks with ease and speed

- *Digital skills savvy*: ability to troubleshoot problems in digital tools, ways of working, thinking and living, and to create innovative work processes and products using digital tools, as well as capability to quickly adapt to the digitisation of the workplace.

When the five levels of need/performance are combined with the four categories of digital skills, the Australian Workforce Digital Skills Framework is formed, as presented in table 2.

Table 2   The Australian Workforce Digital Skills Framework

Digital skill content	Level of need/ performance				
	Literacy (1)	Competency (2)	Proficiency (3)	Fluency (4)	Savvy (5)
Digital tools for working	Understand various digital tools	Basic use of various digital tools	Application of advanced digital tools confidently and efficiently	Evaluate and select appropriate digital tools for working	Suggest solutions to solve problems in the use of digital tools
Digital ways of working	Recognise various digital ways of working	Basic ability to work digitally such as find, retrieve and communicate information from a variety of information systems in a variety of formats	Apply advanced features to work digitally such as to search find, retrieve, process and communicate information from advanced systems	Manage (analyse, compare, evaluate) the usefulness, relevancy, credibility, and reliability of digital ways of working	Identify and articulate digital ways of working issues; propose alternatives and participate in the implementation of new ways of working
Digital ways of thinking	Awareness of how to seek support and assistance when facing digital problems	Ability to communicate problems related to digital processes, routines and products	Investigates digital business processes, routines and products through an analytical and systematic approach to problem-solving	Analyse and evaluate the strengths and weaknesses of alternative digital solutions, conclusions or approaches to problems	Absorbs complex work problems and demonstrates a broad and deep ability to create innovative workplace digital work processes, routines and products
Living in the digital age	Awareness of digital threats and the social and environmental implications of digital technologies as well as basic privacy and copyright provisions	Follow/comply with basic organisational rules and policies to protect hardware, software, information and systems (for example, using anti-viruses and passwords)	Apply advanced tools, techniques and configurations to protect hardware, software, information and systems	Analyse digital risks and compliance to copyright and privacy to identify security threats and vulnerabilities	Create policies and guidelines to improve digital security and protect copyright and privacy and keep up-to-date with latest security, privacy and copyright developments

Application of the Australian Workforce Digital Skills Framework

The Australian Workforce Digital Skills Framework aims to provide a consistent approach to identifying and developing digital skills in the Australian workforce, specifically the workforce not directly employed in ICT occupations. The framework can also be used in the identification and development of digital skills across diverse personal, community, work and education and training contexts.

In this section, we demonstrate how the framework can be applied in digital skills gap analysis by utilising our survey data. A digital skills gap analysis is a useful technique for identifying skills mismatches across enterprises (Asliturk, Cameron & Faisal 2016; Beblavý, Fabo & Lenaerts 2016). Understanding digital skills gaps is particularly important in light of the digital disruption of work, whereby new occupations are created while others are transformed (Beblavý, Fabo & Lenaerts 2016; Burning Glass Technologies 2015). Various macro-level studies identify digital skills gaps as one of the key challenges to the growth of Australia's digital economy and as a significant hurdle that needs to be overcome by means of innovative policies. For example, research by the CSIRO reveals an analytical skills gap as a major challenge, since it undermines the ability of organisations to maximise their use of increasing volumes, variety and velocity of data (that is, big data; Hajkowicz et al. 2016, p.35).

We draw from our survey of human resources, skills and training decision-makers to demonstrate how the framework can be used to undertake a micro-level digital skills gap analysis. In the survey, we asked participants to assess both the digital skills needs of the organisation and the digital skills competence levels acquired by their current employees, using a five-point Lickert scale (see support document 2). Based on our framework and depending on the details a decision-maker needs, a gap analysis can be performed at the three different levels (that is, category, sub-category and indicators).

First, in order to get an overall picture of the digital skills shortage and estimate the extent of the digital skills gap, the four high-level categories of the Australian Workforce Digital Skills Framework (Digital tools for working, Digital ways of working, Digital ways of thinking and Living in the digital world) can be analysed by taking the mean difference between the digital skills needs and the existing competence responses. The result (figure 3) shows statistically significant evidence of a perceived gap in all four categories.[8] In relative terms, the need for the 'Living in the digital age' (mean = 3.61) is higher than the competence for 'Living in the digital age' (mean = 3.24, p = 0.04). The smallest gap between need and competence is observed in 'Digital tools for working' (need = 3.42, competence = 3.18, p = 0.03). In the other two categories, that is, 'Digital ways of working' (need = 3.56, competence = 3.28, p = 0.03) and 'Digital ways of thinking' (need = 3.50, competence = 3.17, p = 0.04), there are more or less similar gaps. This could indicate that many workers already possess a reasonable level of competence in operating digital tools for the purposes of work, while higher-level skills are still in short supply, particularly with regard to the more complex and abstract aspects of 'living' and 'thinking' digitally. The results could suggest a need to establish a more developed digital culture and mindset among workers.

---

8   Statistical significance was tested here by comparing the significance of mean value differences.

Figure 3   Digital skills gap (n = 371)
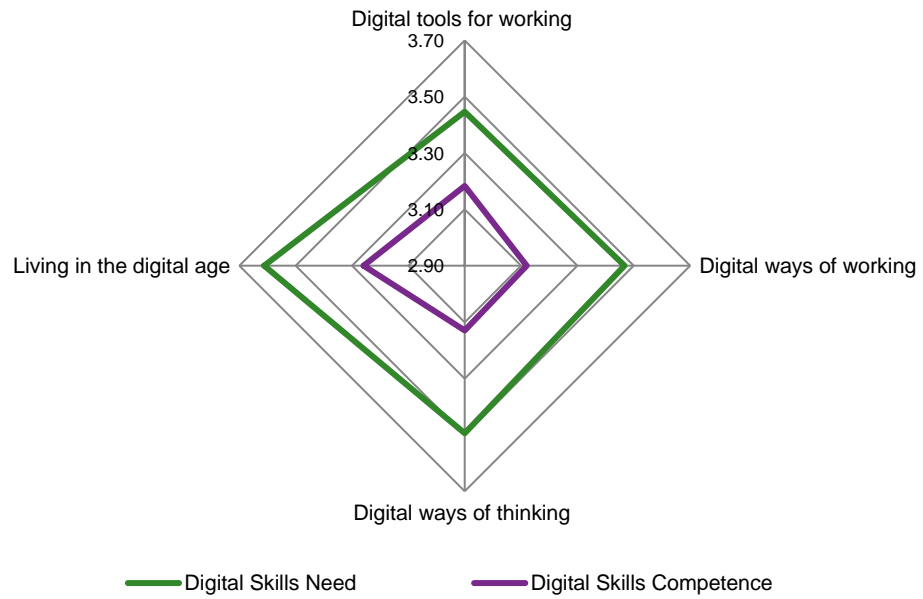
Second, for a more detailed level of analysis, the eight sub-category dimensions of the Australian Workforce Digital Skills Framework (table 1) can be used. Here we find a statistically significant gap between the needs of the organisations that completed the survey and the perceived competency of their staff for all eight sub-categories of digital skills (figure 4).

Figure 4   Detailed digital skills gap analysis (n = 371)
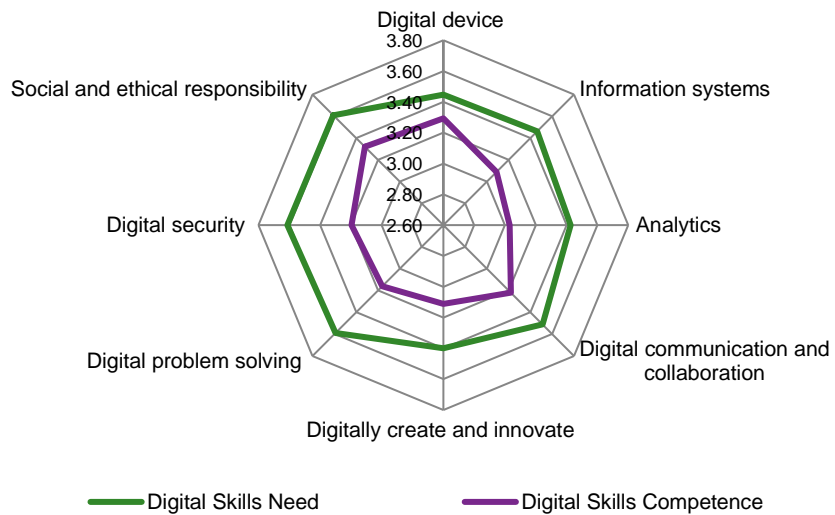
Third, a fine-grained analysis can also be undertaken, using the 17 indicators. Based on our survey data, this level of analysis reveals that there is a statistically significant gap between the purported skills needs of organisations and the competency of staff for all digital skills indicators, with the exception of keyboard-related skills. This could be due to changes in human computer interaction, with touch screens and voice-input devices gradually replacing keying as the main form of digital interaction. It could also mean that most of the workers are already competent in keyboard operations, meaning that employers do not face any problems in this area. The gap is larger for analysing cyber security threats and

Skilling the Australian workforce for the digital economy

vulnerabilities, as well as for recognising and troubleshooting problems in digitalised workplaces and proposing innovative ways to resolve those problems.

The framework can also be applied to understand industry differences in digital skills gaps. We demonstrate this by using the eight digital skills sub-categories of our framework. First, we grouped the survey respondents into three broad industry groups: transport, postal and warehousing; public administration and safety; and others. Figures 5 and 6 illustrate how our framework can be used to analyse inter-industry differences to develop both a national and industry-specific benchmark for monitoring and comparing digital skills development.

As can be seen from figure 5, there are statistically significant differences by industry in the digital skills needs of, and competence levels required by, enterprises. According to the Australian Industry Standards report on the transport and logistics sector (2018, p.29), there is increasing employer demand for higher-order skills to meet the demands created by the application of new technologies. Nevertheless, our survey indicates that the digital skills needs of respondents from the transport, postal and warehousing industry are still lower than those reported by all other industry respondents. In addition, employers in other industries have more digital skills needs compared with public administration and safety. However, employers in the public administration and safety industry expressed a relatively higher need for digital skills related to social and ethical responsibility. This may reflect the relative importance of privacy to the public sector and the sector's understanding of the environmental impact of digital technologies and systems. Overall, the digital competence of employees in other industries is much higher than those in the transport, postal and warehousing and public administration and safety industries (figure 5).

**Figure 5   Digital skills needs and competence by three industry categories (n = 371)**
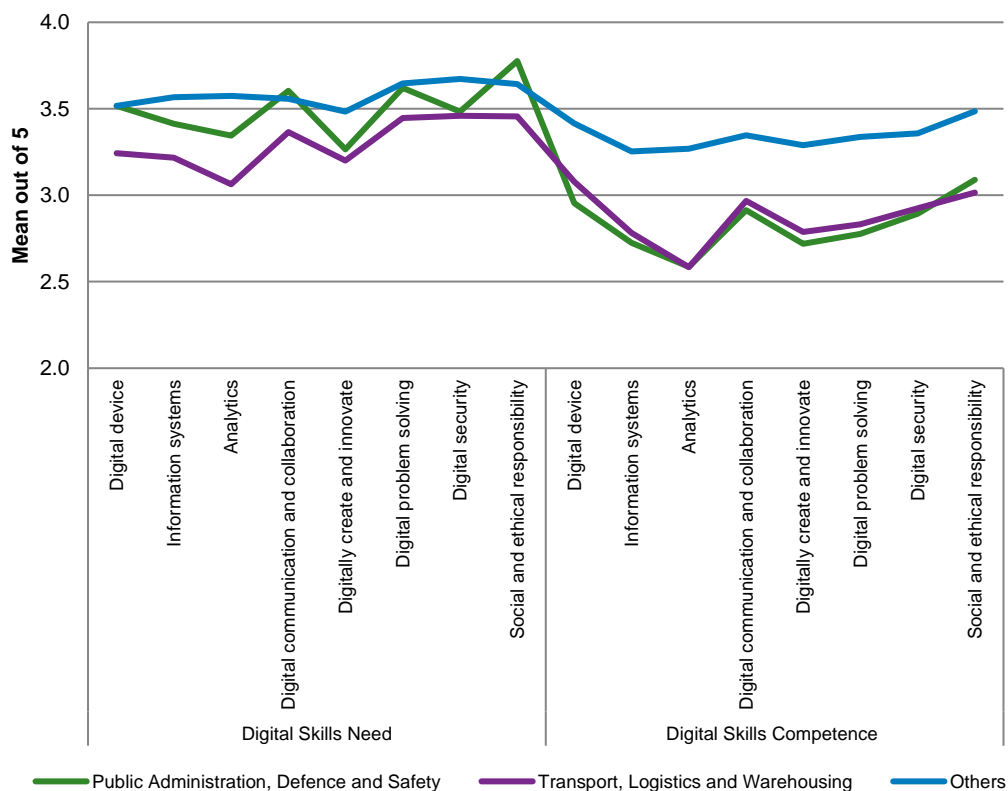
Based on evidence from our survey (figure 6), there are relatively wider digital skills gaps in the public administration and safety, and transport, postal and warehousing industries compared with other industries. In both industries, the gap is relatively larger in terms of skills for recognising and troubleshooting problems in digitalised workplaces and proposing innovative ways to resolve those problems.

Figure 6   Digital skills gap by industry (n = 371)
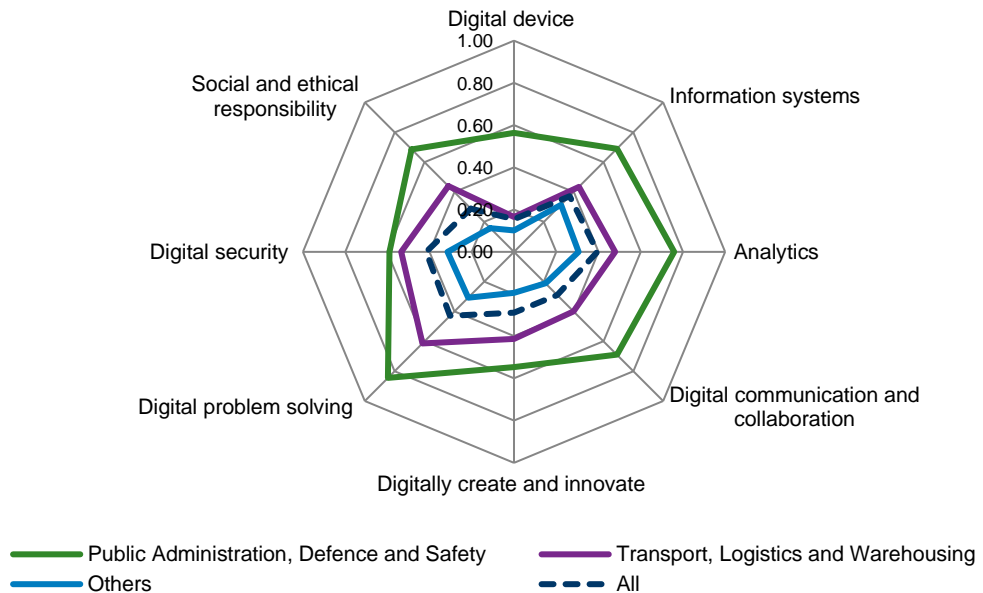
Finally, the framework can be applied to analyse digital skills differences due to variations in organisational size. For example, using the eight digital skills sub-categories, our survey data reveal that the digital skills needs and competence level requirements for small enterprises are lower than for other respondents (figure 7). In particular, small enterprises perceive analytics skills as a relatively low priority, while social and ethical responsibility skills are a higher priority. On the other hand, medium-to-large organisations prioritise digital problem-solving and security skills, while large organisations prioritise digital security and social and ethical responsibility. In terms of digital skills competence, medium-to-large enterprises perceive their workers to have better competence than that seen in small enterprises, which lag in all aspects (figure 7).

Figure 7   Digital skills need and competence by organisational size* (n = 371)
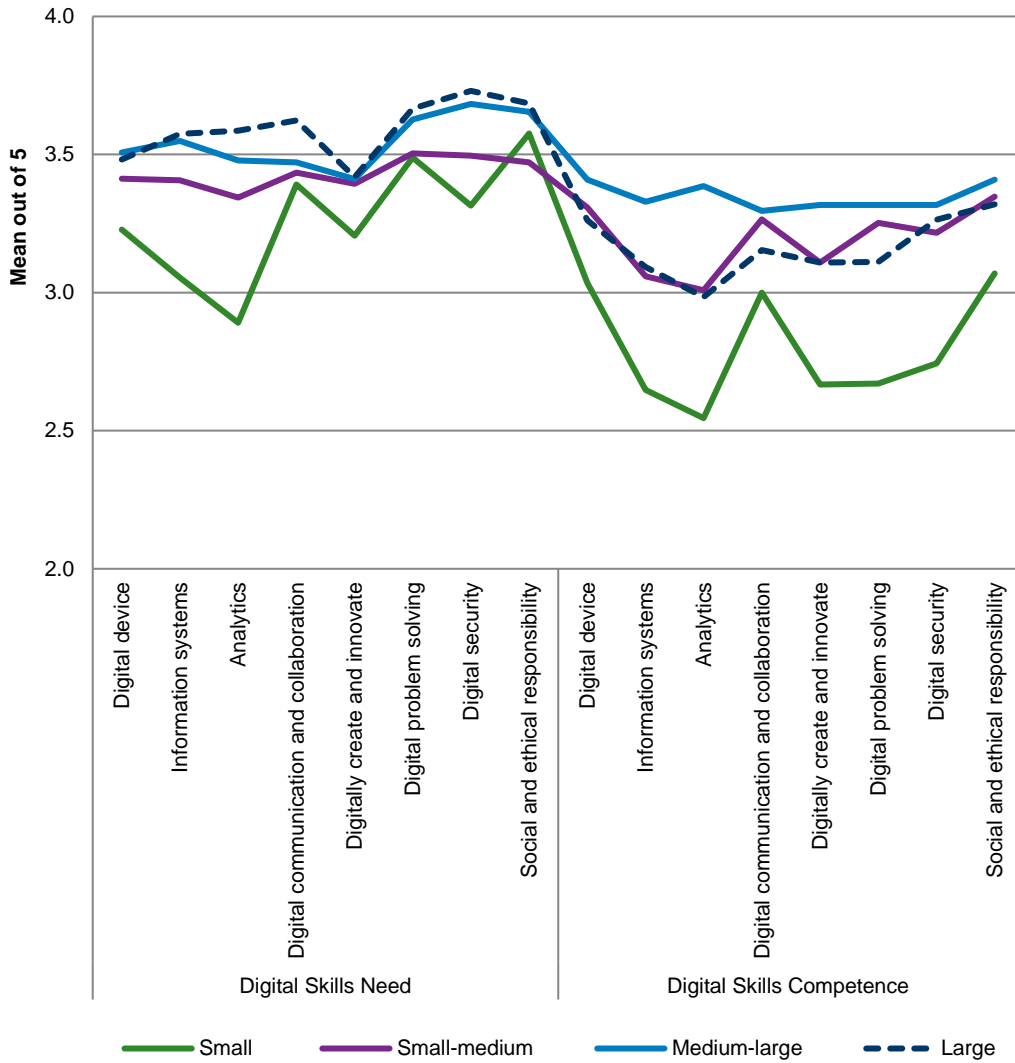
* Small organisations have 1–19 employees, small-to-medium have 20–99 employees, medium-to-large have 100–199 employees and large have 200+ employees.

As indicated in figure 8, medium-to-large and small-to-medium enterprises face a lower-than-average digital skills gap compared with large and small enterprises. There is a significant gap between the analytics skills needs of large enterprises and the competence of their workforce. For small enterprises, the gap is higher in digital problem-solving skills. For small-to-medium enterprises the gap is wider in the skills needed to absorb and use enterprise information systems, whereas for medium-to-large enterprises, the gap is wider in security-related skills. On balance, both small and large enterprises face above-average digital skills gaps.

Figure 8   Digital skills gap by organisational size (n = 371)
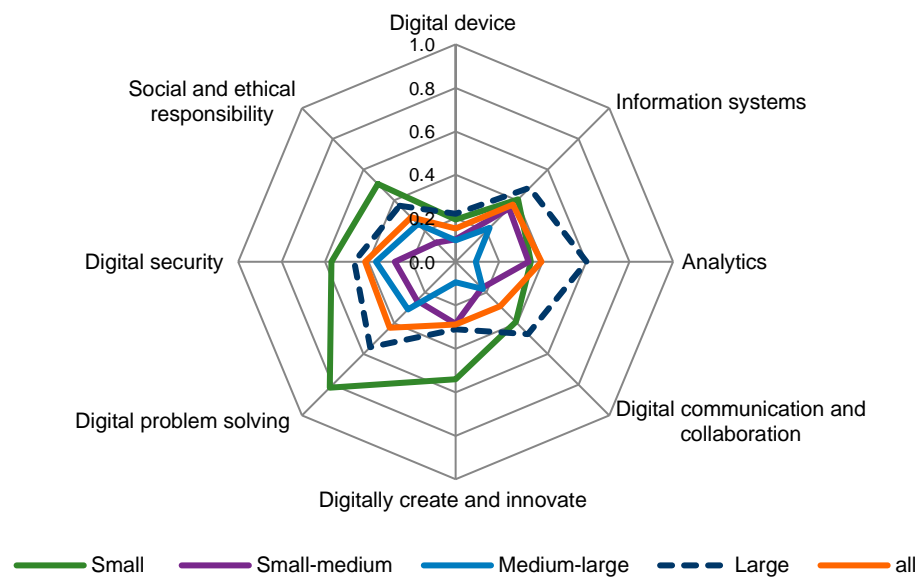
Overall, this example of how the Australian Workforce Digital Skills Framework can be applied demonstrates its usefulness as a mechanism for creating a consistent and systematic analysis of digital skills across Australian industries. Given that this is the first application of the framework, there is a need to engage relevant industry, government and VET stakeholders in further validation studies.

Implications and considerations

The findings from this research lend further support to the view that Australia's digital transformation is much more gradual and, according to some reports, lagging behind other parts of the world, particularly among OECD countries (Chakravorti & Chaturvedi 2017). The implications of the research findings presented in this report lead to the following industry and policy considerations.

Advancing digital transformation and digital skills workforce development

Our survey and case study data suggest a situation in which many employers are not taking a strategic approach to identifying the kinds and levels of digital skills required to maintain future productivity and competitiveness. In a global economy characterised by intense competition, and where only the most technologically advanced economies will remain competitive, this trend represents a cause for concern. Not only do employers need to think about how to recruit digitally competent workers, they need to develop a strategy to upskill their existing workforce in order to enhance the overall digital skills level of their organisation.

In a rapidly changing digital economy, workforce planning requires a high level of proactivity, especially given that many industries also experience non-digital skills shortages. As this study highlights, some employers appear hesitant to introduce technological change — despite such change in all likelihood improving the productivity of their organisation — because of the particularities of their workforce and their lack of basic digital skills. Digital skills training and upskilling of the workforce is the obvious answer to addressing this predicament. While these activities may represent an undesirable cost to employers in the short run, they are vitally important to the viability of their organisations in the longer term. The key message to emerge from this study is that organisations need to take technological transformation seriously by investing in both the technologies and the skills required to make the most effective and productive use of those technologies. The Australian Government, as part of its Digital Economy Strategy[9], should consider targeted programs that encourage employers to embrace digital technologies while also upskilling their workforces.

Further embedding digital skills into training packages

While our analysis suggests a significant amount of digital training is embedded in industry training packages, most units of competency containing digital skills tend to be electives. Furthermore, it appears that this digital skills training encompasses only lower levels of basic digital literacy and the basic application of computer devices for data capturing and processing. Given the pace of technological change and the importance of digital skills formation into the future, a reassessment of how digital skills are defined and treated in

---

9   <https://www.industry.gov.au/strategies-for-the-future/participating-in-the-digital-economy>.

training packages would appear to be timely. This is particularly important, given how frequently employers in this study expressed a lack of confidence that the training system is adequately developing digital skills. The training industry must also reflect upon the implications for resourcing and staffing their programs, since providers would need to be significantly competent in digital skills training.

Digital skills and workforce development from an employee perspective

Much of the research to date on digital skills has taken an employer or industry perspective (for example, Lowry, Molloy & McGlennon 2008; Hajkowicz et al. 2016). Our research is no different in this regard. Greater attention to employee perceptions and recognition of their digital skills requirements, along with their training needs, could greatly enhance our understanding of the process of digital skills transformation in Australian workplaces. Information gathered from an employee-oriented study might also assist in addressing employer hesitation in introducing digital technologies in the workplace and/or employee resistance to technological change. Such research could also be used to identify those workers most at risk of being left behind in the digital transformation and where targeted training programs should to be developed.

Monitoring digital skills development in Australia: refinement and further application of the Australian Workforce Digital Skills Framework

A comprehensive digital skills-development framework enables the identification of skills gaps, leading to targeted training programs and driving an overhaul of the skills ecosystem in Australia. For these reasons, and with reference to the survey results and skills frameworks in operation elsewhere, we propose the Australian Workforce Digital Skills Framework as a way forward. We envisage that this framework will provide a consistent approach to identifying needs and developing digital skills within the general non-ICT Australian workforce. The framework could also be used in the identification and development of digital skills across diverse personal, community, work and education and training contexts.

With further data-driven development, refinement, validation and implementation, the Australian Workforce Digital Skills Framework has the potential to provide:

- a consistent and clear model for expressing, assessing and developing digital skills in the workforce

- shared concepts and language for identifying and describing digital skills

- a consistent approach to baseline and benchmark digital skills demand and supply

- a mechanism to assess the digital skills requirements of a job or occupation, as well as the coverage of those skills in any VET training packages, in order to identify potential gaps in the demand and supply of digital skills in a wide variety of industry contexts

- a consistent and systematic description of digital skills in VET training programs.

In a context where many employers lack confidence in the quality of the digital skills currently developed through the post-schooling system, the Australian Workforce Digital Skills Framework provides a template for the consistent and systematic description of digital skills development in VET training programs and could thus support more appropriately targeted training efforts and programs.

References

Asliturk, E, Cameron, A & Faisal, S 2016, *Skills in the digital economy: where Canada stands and the way forward,* Information and Communications Technology Council, Ottawa, Canada.

Australian Core Skills Framework 2012, Commonwealth of Australia, viewed 22 February 2019, <https://docs.education.gov.au/system/files/doc/other/acsf_document.pdf>.

Australian Industry Standards 2018, *Australian industry standards*, viewed October 2018, <https://www.australianindustrystandards.org.au/>.

Baller, S, Dutta, S & Lanvin, B (eds) 2016, *The global information technology report 2016: innovating in the digital economy,* World Economic Forum, viewed September 2017, <http://reports.weforum.org/global-information-technology-report-2016/downloads/>.

Bawden, D 2001, 'Information and digital literacies: a review of concepts', *Journal of Documentation,* vol.57, no.2, pp. 218—59.

Beblavý, M, Fabo, B & Lenaerts, K 2016, *Demand for digital skills in the US labour market: the IT skills pyramid (no. 12055),* Centre for European Policy Studies, viewed November 2017, <https://www.ceps.eu/system/files/SR154%20IT%20Skills%20Pyramid_0.pdf>.

Burning Glass Technologies 2015, *Crunched by the numbers: the digital skills gap in the workforce, Burning Glass Technologies report,* viewed April 2017, <http://burning-glass.com/wp-content/uploads/2015/06/Digital_Skills_Gap.pdf>.

Bynner, J, Reder, S, Parsons, S & Strawn, C 2010, *The three divides: the digital divide and its relation to basic skills and employment in Portland, USA and London, England*, National Research and Development Centre for Adult Literacy and Numeracy, London, England.

Callan, V & Bowman, K 2015, *Industry restructuring and job loss: helping older workers get back into employment*, NCVER, Adelaide.

Carretero, S., Vourikari, R. and Punie, Y 2017, *The Digital Competence Framework for Citizens; with eight proficiency levels and examples of use*, Luxembourg: Publications Office of the European Union

CEDEFOP European Centre for the Development of Vocational Training 2008, *Skill needs in Europe: focus on 2020*, Cedefop panorama series 160, Office for Official Publications of the European Communities, Luxembourg, viewed 25 July 2018, <http://www.cedefop.europa.eu/en/publications-and-resources/publications/5191>.

Chakravorti, B & Chaturvedi, R 2017, *Digital planet 2017: how competitiveness and trust in digital economies varies across the world*, Fletcher School, Tufts University, Medford, Md.

Dede, C 2010, *Comparing Frameworks for 21st Century skills. 21st Century skills: Rethinking how students learn*, Edited by, James Bellanca, Ron Brandt. Bloomington: Solution Tree Press, 51-76.

Deloitte Access Economics 2016, *Australia's digital pulse: developing the digital workforce to drive growth in the future,* viewed June 2017, <https://www.acs.org.au/content/dam/acs/acs-documents/PJ52569-Australias-Digital-Pulse-2016_LAYOUT_Final_Web.pdf>.

Dore, L, Geraghty, A & O'Riordan, G 2015, *Towards a national digital skills framework for Irish higher education: All Aboard Project*, viewed 14 December 2016, <http://allaboardhe.org/DSFramework2015.pdf>.

ECORYS 2016, 'Digital skills for the UK economy', viewed June 2017, <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492889/DCMS DigitalSkillsReportJan2016.pdf>.

Edwards, P & Ramirez, P 2016, 'When should workers embrace or resist new technology?', *New Technology, Work and Employment*, vol.31, no.2, pp.99—113.

Eshet-Alkalai, Y 2004, 'Digital literacy: a conceptual framework for survival skills in the digital era', *Journal of Educational Multimedia and Hypermedia*, vol.13, no.1, pp.93—106.

Fairbrother, P, Snell, D, Bamberry, L, Condon, L, McKenry, S, Winfree, T, Stroud, D & Blake, J 2012, *Jobs and skills transition for the Latrobe Valley, final report for Department of Education, Employment and Workplace Relations (DEEWR)*, RMIT University/Swinburne University, Melbourne.

Foundation for Young Australians 2016, *The new mindset*, Foundation for Young Australians, Sydney.

Gekara, V, Molla, A, Snell, D, Karanasios, S & Thomas, A 2017 *Developing appropriate workforce skills for Australia's emerging digital economy (working paper)*, NCVER, Adelaide.

Government Skills Australia 2015, *2015 E-Scan report*, GSA, viewed November 2016, <http://governmentskills.com.au/usercontent/documents/Escans/Escan_2015_book_04DD.pdf>.

Grugulis, I & Vincent, S 2009, 'Whose skill is it anyway? Soft skills and polarization', *Work, Employment and Society*, vol.23, no.4, pp. 597—615.

Hadziristic, T 2017, *The state of digital literacy in Canada: a literature review*, Brookfield Institute, Toronto, Canada.

Hajkowicz, S, Reeson, A, Rudd, L, Bratanova, A, Hodgers, L, Mason, C & Boughen, N 2016, *Tomorrow's digitally enabled workforce: megatrends and scenarios for jobs and employment in Australia over the coming twenty years*, CSIRO, Brisbane.

Innovation & Business Skills Australia (IBSA) 2010, 'Scoping Study: Identifying Digital Literacy Skills', Innovation & Business Skills Australia, Melbourne.

Innovation & Business Skills Australia 2013, *Digital literacy and e-skills: participation in the digital economy*, IBSA, Melbourne.

Ilomäki, L, Paavola, S, Lakkala, M & Kantosalo, A 2016, 'Digital competence–an emergent boundary concept for policy and educational research', *Education and Information Technologies*, vol.21, no.3, pp.655—79.

International Labour Organization (ILO) 2016, *World employment and social outlook*, International Labour Organization, Geneva.

Iordache, C, Mariën, I & Baelden, D 2017, 'Developing digital skills and competences: a quick-scan analysis of 13 digital literacy models', *Italian Journal of Sociology of Education*, vol.9, no.1, pp.6—30.

Lowry, D, Molloy, S & McGlennon, S 2008, *Future skill needs: projections and employers' views*, NCVER, Adelaide.

Mclean, P, Perkins, K, Tout, D, Brewer, K & Wyse, L 2012, *Australian Core Skills Framework (ACSF)*, viewed July 2018, <https://research.acer.edu.au/transitions_misc/12>.

OECD (Organisation for Economic Co-operation and Development) 2014, *Measuring the digital economy*, OECD, Paris.

Siddiq, F, Hatlevik, OE, Olsen, RV, Throndsen, I & Scherer, R 2016, 'Taking a future perspective by learning from the past — a systematic review of assessment instruments that aim to measure primary and secondary school students' ICT literacy', *Educational Research Review*, vol.18, pp. 58—84.

Transport & Logistics Industry Skills Council (TLISC) 2015, *Environmental scan 2015: transport and logistics industry*, Transport and Logistics Industry Skills Council, Melbourne Victoria, viewed 22 February 2019, <https://www.voced.edu.au/content/ngv%3A69610>.

Smith, A 2016, *Public predictions for the future of workforce automation*, Pew Research Centre, Washington.

Snell, D, Gekara, V & Gatt, K 2016, *Cross-occupational skill transferability: challenges and opportunities in a changing economy*, NCVER, Adelaide.

Spitzer, B, Jerome, B, Valerie, M & Subrahmanyam, K 2013, *The digital talent gap: developing skills for today's digital organizations*, Capgemini Consulting, viewed 14 December 2016, <https://www.capgemini.com/resources/the-digital-talent-gap-developing-skills-for-todays-digital-organizations>.

Transport and Logistics Industry Skills Council 2015, *2015 E-Scan report*, TLSC, viewed Dec 2016, http://tlisc.org.au/wp-content/uploads/TLISC_134_E-Scan_lores_singlepages_FA.pdf.

van Deursen, A & van Dijk, J 2008, 'Measuring digital skills: performance tests of operational, formal, information and strategic Internet skills among the Dutch population', 58th Conference of the International Communication Association, 22—26 May, Montreal, Canada.

West, D 2015, 'What happens if robots take the jobs? The impact of emerging technologies on employment and public policy', Centre for Technology and Innovation at Brookings, Washington, DC.

Winthrop, R & McGivney, E 2016, *Skills for a changing world*, Brookings Institution, viewed 8 February 2019, <https://www.brookings.edu/wp-content/uploads/2016/05/Brookings_Skills-for-a-Changing-World_Advancing-Quality-Learning-for-Vibrant-Societies-3.pdf>.

World Economic Forum 2016, *The future of jobs: skills and workforce strategy for the 4th industrial revolution*, World Economic Forum, Cologne.

World Employment Federation 2016, *The future of work*, World Employment Federation, Brussels.

Zhong, ZJ 2011, 'From access to usage: the divide of self-reported digital skills among adolescents', *Computers & Education*, vol.56, no.3, pp.736—46.

📎 Appendix A

The 11 training packages analysed in Gekara et al. (2017) were:

- Aviation (AVI)
- Correctional Services (CSC)
- Local Government (LGA)
- Maritime (MAR)
- Aeroskills (MEA)
- Police (POL)
- Public Sector (PSP)
- Public Safety (PUA)
- Training And Education (TAE)
- Transport And logistics (TLI)
- Electrotechnology (UEE).

Skilling the Australian workforce for the digital economy