Digital Skills and Inclusion Research Working Group
Evidence Brief

‘What digital skills do adults need to succeed in the workplace now and in the next 10 years?’

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Contents

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Executive Summary

Information and Communication Technologies have become integral to personal and professional life; individuals, businesses and governments are increasingly inter-connected. Digital technologies are also changing our jobs: while a few decades ago digitisation affected only a handful of occupations, now the majority of workers use the Internet as part of their jobs in most OECD countries and digital literacy is predicted to become critically important for the vast majority of workers in the future (Berger and Frey, 2016).

The Warwick Institute for Employment Research was commissioned by the Department for Digital, Culture, Media and Sport and the Department for Education to conduct a review of evidence to address the policy question: *'What digital skills do adults need to succeed in the workplace now and in the next 10 years?* The emerging findings of the review were discussed by the members of the Digital Skills and Inclusion Research Working Group, a group of academic researchers and practitioners with an expertise in the area of Digital Skills and Inclusion. Their comments are included in this evidence brief.

Defining general digital skills

The research team has adopted the Ecorys UK (2016) definition of general digital skills for the workforce: these skills include essential digital skills and the skills linked to the use of applications in the workplace. While there are differences across sectors, there are some minimum requirements linked to processing information which are applicable across all sectors. It is important to note that while this evidence brief (and most literature in the field) discusses 'digital skills', this term is used as a shorthand to mean, competencies, capabilities, knowledge, behaviours, attitudes, and character traits. See section 3.1.

In this evidence brief selected classifications and frameworks for digital skills are reviewed and presented with a focus on their relevance to the world of work. Developmental frameworks for digital skills (including the UK Essential Digital Framework) are designed to inform training and skills development, assessment and certification. These frameworks identify a handful of key areas of skills and competencies, namely: Information and data literacy, Digital communication and collaboration, Digital content creation, Digital safety and Digital identity. The digital competence of workers is described as a 'T-shaped skill set', with workers possessing good knowledge across many areas and in-depth knowledge in one area

(European Schoolnet and DIGITALEUROPE, 2016). Digital skills also include non-technical, so-called '21st century skills', which can be grouped under a cognitive, intrapersonal and interpersonal domain. In contrast to the comprehensive frameworks for digital skills and competencies, some scholars call for more context-specific definitions, which clearly identify the group of people who need the skills, the context in which they need to use the skills and the timeframe in which these skills are relevant. See section 3.1.

Conceptualising success in the workplace

This evidence brief also discusses how success in the workplace can be conceptualised and what individual and contextual factors beyond digital skills can support and hinder success in the workplace. Beyond individual factors, including skills, the other key employability factors are individual circumstances, employer/organisational practices, and local- and macro-level factors. In addition, enabling support factors, such as labour market intermediaries from the public, private and voluntary sectors are also relevant here. While most evidence about employability focuses on labour market entry and the challenges facing lower-skilled workers, the role and responsibility of employers in supporting the development of workforce digital skills is also highlighted. See section 3.2

Current demand for workforce digital skills

The main finding from the review of recent empirical evidence is that essential digital skills are needed in a wide range of occupations in the European Union, from elementary occupations and plant machine operators to managers (Curtarelli et al., 2017). The use of productivity software is required in medium- and high-skilled occupations and the use of productivity software, such as word processing and spreadsheets is found to be an 'entry ticket' to many medium-skilled occupations. See section 3.3.

Workers also need additional specialised skills and knowledge, which may relate to a key task of a job role (e.g. creating presentations) or to the use of an application which is particularly important for a sector (e.g. a health informatics system or Customer Relations Management (CRM) tools). These specialised clusters of digital skills are explored in the three case studies of the Health and social care sector, in Culture and creative industries and in the Financial services sector. See sections 3.5, 3.6 and 3.7, respectively.

Future demand for general digital skills

Evidence about the future demand for general digital skills for work points at the increasing importance of 21st century skills, particularly interpersonal skills and 'cognitive competencies and learning strategies'. It is also argued that occupations where workers use digital skills creatively and to solve problems, such as engineering, are likely to grow, while occupations where digital skills are used for routine tasks, as in some HR occupations, are likely to decline.

The key argument emerging from the literature is that a narrow focus on digital skills is not sufficient: given the fast pace of change of ICTs, technical digital skills are likely to soon become obsolete (Berger and Frey 2016). Instead, workers need non-technical, 21st century skills to be able to adapt to fast-changing technologies (Djumalieva and Sleeman, 2018), and solid literacy and numeracy skills as critical foundational skills (Quintini, 2017).

See section 3.4.

Evidence gaps

A number of gaps in the evidence base have been identified. These include the scarcity of information about how digital skills are deployed in workplaces; the motivational factors to learn new (digital) skills and the links between workforce digital skills and labour productivity. In response to these gaps, the members of the Research Working Group have developed a number of research ideas, such as: investigating digital skills and job quality from the perspective of employees; and exploring why people do or do not improve their digital skills and capabilities and attempt to improve the current situation. See section 4.

Conclusions

The key findings from the evidence review include:

Although much of the relevant literature discusses 'digital skills', this term is used as a shorthand to mean, among others skills, knowledge, behaviours, attitudes, competencies, capabilities, and character traits.

Current frameworks for digital skills include a handful of key areas of skills and competencies, namely Information and data literacy, Digital communication and collaboration, Digital content creation, Digital safety, Digital identity and Awareness of

digital rights at different levels of proficiency. Digital skills also include non-technical, so-called '21st century skills', which can be grouped under a cognitive, intrapersonal and interpersonal domain.

While there is a trend to create comprehensive frameworks for digital skills, these attempts to give a general definition of 'digital skills' has been criticised. There is a call for more context-specific definitions.

The review has found that it is difficult to establish the boundary between essential and more specialised digital skills for the general workforce and identify a list of digital skills beyond the essential level. Descriptions of digital competence as a 'T-shaped skill set', in which individuals possess in depth knowledge in one area and good knowledge across many other areas may be useful here.

The future demand for general digital skills points at 21st century skills, especially interpersonal skills and cognitive competencies and learning strategies. It is argued that occupations where workers use digital skills creatively and to solve problems are likely to grow, while occupation where digital skills are used for routine tasks are likely to decline.

The drivers of change are suggested to be the effect of automation on future occupations, but there is much debate as to whether jobs will be fully automated or whether there will be a major change in task composition. See section 5.

1. Introduction

Information and Communication Technologies have become integral to personal and professional life; individuals, businesses and governments are increasingly inter-connected. Digital technologies are changing our jobs: while a few decades ago digitisation affected only a handful of occupations, now the majority of workers use the Internet as part of their jobs in most OECD countries (OECD, 2013) and it is widely asserted that digital literacy will become critically important for the vast majority of workers (see, for example Berger and Frey 2016). The types of digital skills businesses need depend on their industrial sector, market position and business strategies (Curtarelli et al., 2017). The UK Government's Digital Strategy places great emphasis on the need for digital skills, arguing that in order for the UK to be a world-leading and inclusive digital economy, everyone needs the digital skills that allow them to fully participate in society' (Department for Digital, Culture, Media & Sport, 2017). At the time of writing this evidence brief, a government consultation on improving adult basic digital skills is underway on the new national standards for basic digital skills and basic digital skills qualifications and training (Department for Education, 2018).

According to the results of a representative survey, four fifths (79%) of adults in the UK have the 'full set' of basic digital skills and 8 per cent have none (Lloyds Bank, 2018). [1] Looking at those in employment, the survey found that one in ten people completely lacks basic digital skills. However, the survey also found that work was an important motivation for people to improve their digital skills: a third of those who had improved their digital skills in the year prior to the survey had done so to improve their performance at work (Lloyds Bank, 2018).

[1] The Tech Partnership and Lloyds Bank commissioned Ipsos MORI conduct a representative survey measuring basic digital skills (as defined by Go On UK, 2015) of adults aged 15 and older in the UK. 4,000 face-to-face interviews were conducted in November 2017. Respondents were given 11 digital tasks, and were asked two questions. The answers to these questions were combined to identify a respondent's digital skills (Lloyds Bank, 2018, p. 10).

The ongoing development of ICTs means that digital skills are notoriously difficult to define, as it is clear from the following quote:

> *Current definitions of digital skills and competencies are related closely to recent ongoing trends in ICTs. New devices, applications and genres of technology will often involve altered, sometimes additional, skills and competencies*.
>
> (UNESCO Broadband Commission Working Group on Education, 2017, p 23).

The research team at Warwick Institute for Employment Research was commissioned by the Department for Digital, Culture, Media and Sport (DCMS) and the Department for Education to conduct a review of evidence to address the policy question: *'What digital skills do adults need to succeed in the workplace now and in the next 10 years?* The research brief specified that the evidence review should include a definition of general digital skills for the workforce; identify the type of general digital skills that the workforce needs to succeed in the workplace now and in the future, taking into account the effect of digitalisation on the labour market. The research brief also specified that evidence on the type of general digital skills should be presented by skills levels and by different jobs.[2] The specific research questions the evidence review aimed to address are:

- How are general digital skills for the workforce defined?
- What general digital skills do workers need to succeed in the workplace now and in the next ten years, taking into account the effect of digitalisation on the labour market?
- What general digital skills do workers with lower, medium and high level skills and educational qualifications need, now and in the future?
- What general digital skills do workers in different occupations and industries need, now and in the future?
- What are the links between workers' success in the labour market (entry and progression) and their general digital skills?
- What are the gaps in the publicly available evidence about digital skills?

[2] For the purposes of this evidence review success in the workplace is defined as entering, staying in and progressing within the labour market.

To address these questions, the research team has conducted an evidence review, the findings of which were discussed by the members of the Research Working Group.

This evidence brief is structured as follows: in the next section our approach to conducting the review and writing up the evidence brief is outlined. Section 3 discusses the findings of the review, while Section 4 focuses on the evidence gaps the review has identified. In Section 5 the findings are summarised and conclusions are drawn.

2. Approach to the review

The research parameters and the keyword search strategy were developed and refined in consultation with the DCMS project team (the keywords are included in Annex A, Table 1). This strategy was then used systematically across a selected number of electronic bibliographic databases, including: ABI/Inform Global (by ProQuest), Business Source Complete, Science Direct and Sage Journals. In addition, Google Scholar was also searched. Finally, relevant websites, such as Department for Digital, Culture, Media and Sport (DCMS), Eurofound, Cedefop, OECD, Nesta, the Royal Society of Arts (RSA) Future Work Centre, Institute for Public Policy Research (IPPR), NHS Digital and the archived UK Commission for Employment and Skills (UKCES) website; and relevant academic and non-academic journals (namely SSRN; *New Technology, Work and Employment*; *New Media and Society*; and *Medium*) were 'hand searched' for evidence. This combination of sources ensured that a range of academic, practitioner research and grey literature were included in the review. After the initial screening phase, 348 pieces of literature were added to the bibliographic software programme, Endnote, to manage the evidence. Further screening and analysis of the evidence, and in consultation with the DCMS project team, resulted in 197 pieces of literature being included in the review.

The review included studies with an explicit and documented evidence base, including grey literature, and focused primarily on UK evidence, but also included evidence from other developed countries (US, Australia, OECD countries and the EU). In the data extraction phase key information from each piece of literature was recorded: the aims of the study in question, the methodological approach and key findings. The quality of the evidence was

assessed by an analysis of its strengths and limitations.[3] Relevant evidence was not excluded, rather put in the context of other evidence found and reported in the evidence brief, with comment on its 'quality' (for instance, if a study was based on a small and/or non-representative sample or if there were particular problems with the study methodology).

The final phase of the review involved an analysis of evidence to address the research questions. This analysis provided the framework for this evidence brief where evidence has been synthesised and presented in section 3.

This evidence brief benefitted from the comments and research ideas of the Digital Skills and Inclusion Research Working Group (RWG), a group of academic researchers and practitioners with an expertise in the area of Digital Skills and Inclusion. The aim of the Group is to support digital skills and inclusion policy-making by strengthening the evidence base in the area and undertaking research into discrete subjects agreed with DCMS. The Group was convened by the DCMS and it meets several times a year to discuss the evidence base on specific policy questions. It is chaired jointly by the DCMS and the Department for Education. Members of the Research Working Group (RWG) met on September 25, 2018 and discussed a draft version of this report. They provided useful comments, asked questions and engaged in a discussion that benefited the evidence review and this brief.

3. Findings

This section presents the findings of the evidence review to address the policy question. The findings are organised in four subsections: section 3.1 discusses current definitions of and frameworks for digital skills, focusing on general digital skills for the workforce. Section 3.2 presents the evidence on what general digital skills workers need to succeed currently, while section 3.3 presents evidence on skills demand in the next ten years, including the drivers of future demand. Where the available evidence allows, the discussion focuses on different groups of workers: those with lower, medium and high-level skills and

[3] Assessment of the quality of evidence used the EPPI-Centre methodology (2002), comprising three components which are identified to help 'weight' the findings and conclusions of different studies. Such 'weights of evidence' are based on: the soundness of studies (internal methodological coherence), based upon the study only; the appropriateness of the research design and analysis used for answering the review question; and the relevance of the study topic focus (from the sample measures, scenario, or other indicator of the focus of the study) to the review question.

qualifications[4] and those working in different industries and occupations. The findings section also includes three case studies (sections 3.4-3.6), which explore what general digital skills workers need to succeed in the Health and social care sector, in Culture and creative industries and in the Financial services sector, primarily in the UK. Lastly, section 3.7 presents evidence about how 'success' in the workplace is conceptualised in the literature and how workers' general digital skills and other factors may influence success.

3.1. Definitions of general digital skills

The research question for the first part of the evidence review was: How are digital skills for the general workforce defined and described? An overview of these definitions is useful, because it helps to make sense of the evidence about current and future digital skills requirements. Digital skills frameworks provide insights into what digital skills and competencies workers need to succeed in the labour market: influential frameworks have been developed through consultations with employers and other stakeholders, such as trade unions, educational institutions, training providers and academics.

There are several definitions of digital skills and there is a wide variety of related concepts, such as digital competencies, capabilities and digital literacies. As the discussion below reveals, few definitions and conceptualisations focus exclusively on general digital skills required in workplaces. Indeed, the UK Government's definition of digital skills also refers to skills people need 'in life and work' (Hunt, 2018).

The starting point for the discussion is the most recent and comprehensive report on digital skills in the UK economy (Ecorys UK, 2016, p 23), which is based on an extensive literature review and consultations with stakeholders. It defines general digital skills for the workforce as one of three categories of digital skills:

Basic digital literacy skills: skills needed by every citizen to become 'digitally literate'. These are the skills needed to carry out basic functions such as using digital applications to communicate and carry out basic internet searches.

[4] Low-skilled occupations are at Regulated Qualifications Framework (RQF) level 2 or lower; medium-skilled ones are at RQF level 3, 4 and 5 and high skilled occupations are at RQF level 6 and above (degree-level or higher). For example, Laboratory technicians are at RQF Level 3 and are therefore categorised as medium skilled.

Digital skills for the general workforce: all essential digital skills, plus skills needed in a workplace and generally linked to the use of applications developed by IT specialists. These skills are likely to differ across sectors, however, there will be some minimum requirements linked to processing information that will be relevant to all sectors.

Digital skills for ICT professions: all of categories 1 and 2, plus skills needed to work in the IT sector. They include digital skills linked to the development of new digital technologies, and new products and services.

In the remaining part of this section, evidence which is relevant to the first two categories of digital skills is presented and discussed. Selected frameworks and typologies are discussed to highlight what types of digital skills and competencies they include and how they can help us understand the links between workers' digital skills and their success in the labour market.

In the 'digital skills mapping' included in the report by Ecorys UK (2016, p 46), basic digital literacy skills are grouped in four categories: Understanding digital information and communication (literacy, numeracy, writing, communication skills and understanding the basic legal and ethical framework that applies to the use of ICTs); IT management (functional skills, such as backing up and deleting data, installing software and creating passwords); Managing information (online and offline) and Digital communication (p 46). Go On UK's Basic Digital Skills framework (2015) sets out five main areas of digital capability (summarised in Box 1) and gives examples what the categories mean in terms actions for individuals, organisations, and in terms of online safety.

Box 1 Five areas of digital capability in Go On UK's Basic Digital Skills framework (2015)

Managing information: find, manage and store digital information and content.

Communication: communicate, interact, collaborate, share and connect with others

Transacting: purchase and sell goods and services; organise your finances; register for and use digital government services.

Problem Solving: increase independence and confidence by solving problems and finding solutions using digital tools.

Creating: create basic digital content in order to engage with digital communities and organisations.

In 2018, the UK Government adopted an Essential Digital Skills Framework (HM Government, 2018), replacing the Basic Digital Skills Framework (Go On UK, 2015, cited in Ecorys UK, 2016). The new framework is designed for those who support adults to improve their digital skills and defines the digital skills "adults need to safely benefit from, participate in and contribute to the digital world" (HM Government, 2018). The most important new features of the framework are as follows:

- It includes the category of 'Foundation skills', which may be required by those who are not currently using digital technology or using it in limited ways (for example, turn on the device, use the controls on the device, connect the device to a safe and secure Wi-Fi network).
- The skills formerly under the category 'Creating' are now included under 'Communicating' (for example, using a word processing application to create a document and use different formats, such as pdf) and 'Problem Solving' (for example, using appropriate software to manipulate and analyse data to help solve problems at work). These skills are highly relevant in a work context.
- 'Additional skills for work' are listed separately under each category, where this is relevant, as shown in Table 1 and more information is included in Table 1 in Appendix B.

Many of the digital 'skills' included in the framework would be more accurately defined as 'competencies' (see, for example Neelen and Kirschner 2016). Members of the RWG also highlighted that the term 'capabilities' would be more accurate, as this includes behaviours and attitudes, as well as skills.

Another framework for essential digital skills is the Australian *'Core Skills for Work Development Framework* '(Australian Government, 2013), which is included in Table 1 in Annex B. In contrast to those discussed earlier, this framework is focused entirely on skills, knowledge and understandings, which underpin successful participation in work. These work-related digital capabilities are grouped into four 'focus areas': Use technologies; Connect with others; Access, organise and present information; and Manage risk. The framework also specifies five proficiency levels.

Discussing the distinction between using digital skills for 'life' and 'work', members of the RWG noted that the confidence in using digital technologies for 'life' often does not

translate into confidence in using technology at work. Part of the explanation for this may be that technology used in the home is often designed for only one purpose and is supported with user-focused, intuitive interfaces, while those at work are more generic, complex and require more knowledge and imagination. RWG members agreed that to effectively use increasingly complex technologies in the workplace, workers must have a level of genuine understanding of these technologies.

Table 1 Examples of digital skills for 'life' and work from the Essential Digital Skills Framework (Source: Essential Digital Skills Framework, HM Government, 2018)

Category	Selected 'skills for life'	Selected 'additional skills for work'
Handling information and content	I understand that not all online information and content that I see is reliable.	I understand and conform with my organisation's policy for IT use.
Communicating	I can communicate with others digitally, using email and other messaging Apps.	I can communicate in an appropriate way for my organisation by using email, online and collaborative digital tools.
Transacting	I can set up an account online, using appropriate websites or apps that enable me to buy goods or services.	I can complete digital records for absence, holidays or expenses online.
Problem Solving	I can use the internet to find information that helps me solve problems.	I can use the internet to find information that helps me solve problems at work.
Being safe and legal online	I understand the risks and threats involved in carrying out activities online and the importance of working securely.	

Essential digital skills are typically incorporated into broader frameworks as a level of proficiency. Tables 1 and 2 in Annex B include a number of relevant digital skills frameworks and typologies.

A very influential framework for digital competencies is the European Union's DigComp framework was designed to serve as a common reference framework of what it means to be 'digitally savvy'. Its most recent version, DigComp 2.1 (Carretero et al., 2017) describes 21 digital competences and groups them in five areas: Information and data literacy;

Communication and collaboration; Digital content creation; Safety; and Problem solving, and across eight proficiency levels from 'foundation' to 'highly specialised'. The framework also gives examples of the use of these competencies in work and education. DigComp has been used by Public Employment Services and businesses in EU Member States to assess, certify and improve individual digital skills and it has also influenced the development of the UK *Essential Digital Skills Framework*. Box 2 gives an example of a job seeking 'employment scenario' from Competence area 1.

Box 2 Example of the outline of a competence area from DigComp 2.1 (Source: Carretero et al., 2017, p 19).

Competence area 1: Information and data literacy

Competence: 1.1 Browsing, searching and filtering data, information and digital content

Proficiency level: Lower intermediate (3)

Employment scenario: Job seeking process

By myself:

- I can name the job portals I routinely use to help me look for a job.
- I can use well-defined keywords to find jobs portals in my smartphone's app store, and explain to the employment adviser how I access and navigate between them.
- I can explain to the employment adviser why I usually use certain keywords to find job portals and apps in my smartphone.
- I can fix problems such as accessing to the wrong portal or job app, or navigating away from portals that I routinely use.

The DigComp framework has been used to develop skills development programmes, for example, the modules of the European Computer Driving Licence (ECDL) (see ECDL, 2017) have been mapped against DigComp 2.0 (the details are included in Annex B Table 2). This practical application of the DigComp framework illustrates how a complex framework may guide institutions developing training programmes.

The key areas of digital skills and competencies that commonly recur in these frameworks are summarised in Box 3 below.

In addition to the frameworks of digital skills and competencies, there are also a number of classifications of digital skills and competencies (listed in Annex B Table 2), which are highly relevant to our research questions. These are less elaborate, and in contrast to frameworks,

mapping the development of individual skills for the purposes of skills development, training and assessment is not in their focus. Selected classifications are discussed below along the same research questions: what types of digital skills and competencies for the general workforce are included in them; and how they can help us understand the links between workers' digital skills and their success.

Box 3 Areas of digital skills and competencies that commonly recur in the reviewed frameworks

Areas of digital skills and competencies that are key to most digital skills frameworks include:

- 'Information' or 'data literacy'. Skills are based on the ability to find, assess and manage digital information. Competencies range from basic issues of data storage, management and organization, to the ability to manipulate and use data to construct calculations and answer questions. An individual's capabilities to manage the digital data that is generated as a result of their technology use are also included here in most frameworks, while in the Essential Digital Skills framework (HM Government/Tech Partnership, 2018) it is under 'Being safe and legal online.'
- Digital 'communication' and 'collaboration': skills in using online communication and collaboration tools, such as email, telephone and video conferencing, shared online spaces.
- 'Digital content creation': skills focused on writing and editing online content, as well as using a range of online tools (such as WYSWYG editors).
- 'Digital safety': skills in understanding different virus software and firewalls, encrypting and storing data.
- Awareness of digital rights. It is argued that users must understand their rights (including human rights, consumer rights and the right to equality irrespective of gender, age, race, sexual orientation or disability).
- Digital identity: skills to manage online profiles on different social media sites and vacancy boards.

Ecorys UK (2016, p 32 and p 46) identified three categories of digital skills for the general workforce, in addition to the basic or essential skills: Information management and

processing (such as spreadsheets, word processors, databases, presentations); Safety and security and Sector-specific digital skills (for example 3D printing, Computer-aided Design (CAD), digital marketing, but also automated milking on farms).

The OECD (2016) defines two categories of skills that are relevant to the general workforce: 'generic ICT skills', which enable workers to use digital technologies in their daily work (for example access information online or use software) and ICT-complementary skills (the capability to process complex information, communicate with co-workers and clients, solve problems, plan in advance and adjust quickly).[5] Unlike the digital skills and competence frameworks discussed earlier, the classifications included in Annex B Table 2 do not specify several different levels of proficiency at digital skills.

Based on the overview of digital skills frameworks and classifications, a few general points emerge about the types of digital skills workers need to succeed in the labour market:

Firstly, there seems a consensus about the distinction between foundational (literacy, numeracy and writing); essential or basic (digital literacy) and more specialised skills and knowledge. Beyond these, the skills and knowledge required for success in the workforce are more elaborate and specialised, in the sense that they are 'not required for all' and not necessarily in the sense that they are more complex. For example, there may be specialised sets of skills and knowledge areas relating to a key task of a job role (e.g. creating presentations) or to the use of an application which are particularly important for a particular sector (e.g. a health informatics system or CAD). Descriptions of digital competence are sometimes framed in terms of a "T-shaped skill set and mindset" in which individuals possess depth in one area and good knowledge across many other areas (European Schoolnet and DIGITALEUROPE, 2016).

Secondly, it is clear from the frameworks and classifications mentioned earlier, that digital skills and competencies are not limited to the use of digital technologies, that is, they are not all 'technical' skills. While this is not a novel argument, it is discussed here in some detail, because recent evidence has highlighted the importance of these non-technical (ICT-complementary, 21st century) skills. Members of the RWG also recommended that 21st century skills should be in the focus of this evidence brief.

[5] The OECD Programme for the International Assessment of Adult Competencies (PIAAC) survey builds on this distinction when measuring digital skills.

While many of the so-called 21st century skills were relevant before the digital revolution started (for example, problem solving), the concept, which was created by the 'Partnership for 21st Century Learning', a consortium of industry, practitioner and academic interests, has only recently become popular. 21st century 'skills' are a combination of skills, knowledge, character traits and dispositions (see for example Broadband Commission, 2017).

Van Laar and colleagues (2017) identified seven core 21st century skills: information management, communication, collaboration, critical thinking, problem-solving and creativity and technical. Others have developed broad classifications, in particular, the US National Research Council (2012) discusses three broad domains: a cognitive domain relating to cognitive processes and strategies, knowledge and creativity (includes competencies of critical thinking, information literacy, reasoning and argumentation, and innovation), an intrapersonal domain relating to intellectual openness, work ethic and positive core self-evaluation (includes competencies of flexibility, initiative, appreciation for diversity and metacognition) and an interpersonal domain relating to teamwork, collaboration and leadership (includes competencies of communication, collaboration, responsibility and conflict resolution). Members of the RWG felt that training focusing on digital skills in the UK is often too technical and too 'specific' and recommended that there should be more emphasis on 'softer' skills in the UK digital skills training provision.

The classification of digital skills developed by the OECD (2016) maintains the technical versus non-technical distinction when it refers to 'ICT-related' and 'ICT complementary skills'. People need ICT complementary skills to work effectively in technology rich environments, for example, the sales skills required in e-commerce will be different from the skills used in face-to-face commercial transaction (OECD, 2016).

Some scholars are critical of the attempts to give a general definition of 'digital skills' and call for more context-specific definitions. In particular, Orlik (2018) argues that any definition of digital skills should clearly identify the following three elements: people (the group of people who need the skills), place (the context in which they need to use the skills) and the period (the timeframe in which these skills are relevant). In other words, the question 'What are digital skills?' should be reformulated, for example, in this way: 'What digital skills do primary school teachers in Scotland need in the next three years?'

Some studies reviewed in this report define digital skills more narrowly. Researching current and future digital skills demand through analysing online job advertisements, Beblavý and colleagues (2016), Burning Glass Technologies (2017, 2019) and Djumalieva and Sleeman (2018) link their definition of digital skills to the software programmes that employers list in the adverts, for example Windows Office or PeopleSoft and to specific skills, such as 3D animation or data mining.

This subsection discussed current conceptualisations of digital skills, with a focus on general digital skills for the workforce. The key argument emerging from the literature is that a narrow focus on digital skills is not sufficient as "the digital skills of today are likely to be obsolete sooner than we may think" (Berger and Frey 2016). Instead, in an increasingly digital work environment workers need non-technical, 21st century skills to be able to adapt to fast-changing technologies (Djumalieva and Sleeman, 2018; Orlik 2018; Quintini, 2017). Finally, basic cognitive skills, that is, solid literacy and numeracy skills provide the critical foundation for this adaptability by enabling workers to continuously upgrade their skills (Grundke et al., 2017; Quintini, 2017). In their report for the World Bank, Ridao-Cano and Bodewig (2018, p. 37) give the example of an electrician and state that to succeed in a fast-changing labour market that is affected by digitalisation, this worker needs strong cognitive skills (such as critical thinking and problem-solving), social-emotional skills (such as conscientiousness, goal orientation and ability to work in teams) as well as up-to-date job-specific technical skills (skills that enable an electrician to work as an electrician) and digital skills.

3.2. Current demand for workforce digital skills

This subsection presents the evidence about what general digital skills workers need now to succeed in the labour market. Where it is available, detailed evidence about different groups of workers will be included, looking at those with lower, medium and high-level skills and qualifications and those working in different industries and occupations. The discussion on digital skills definitions and frameworks in section 3.1 has already provided some insights into what skills are required in workplaces - in this section the main focus is on evidence gathered from employers and to a lesser extent, from employees. Before turning to the evidence, a brief description of the research methods used to collect this information is in order here.

Demand for different types of (digital) skills in the labour market can be measured in various ways, such as: by analysing data on the occupations of people who are in employment; analysing data on current vacancies and the skills of workers who have recently started in a new job people; and by asking employers about what (digital) skills they require and employees about what skills they use at work. Most of the evidence presented in this section is based on employer surveys and the analysis of online vacancies.

An important feature of employer surveys is that "employers tend to conceptualise and articulate digital skills from a tools perspective" (Loveder, 2017): instead of listing the skills they require, they describe the tools they would like employees to be able to use. Another characteristic of these surveys is that they often focus on 'skills problems', such as 'skills gaps' and 'skills shortages' to provide insights into what digital skills are currently required.[6] While employer surveys are a very important source of information, some are based on a non-representative or small sample of employers, which makes these surveys less reliable. Finally, some employer surveys are 'ad-hoc' and are not conducted regularly, which makes it difficult to identify changes in digital skills requirements over time.

Another, relatively new method used in measuring skills demand is based on the analysis of online job advertisements (introduced by the company Burning Glass Technologies). This method has important advantages: online adverts provide the largest sample size and most detailed information about employer skill needs; the information is nearly real time and offers more granular data than skill surveys, because in job advertisements employers can describe their skill needs more precisely than in surveys (Beblavý et al., 2016). The adverts describe digital skills in the language used by employers, thus the analysis is more useful for job seekers and training providers than employer surveys (Djumalieva and Sleeman, 2018). Furthermore, machine learning and artificial intelligence technology may be used to break down the adverts into the skills and qualifications employers demand.

The limitations of this study methodology are also important to note. Online job advertisements do not cover all the employer demand and are somewhat biased towards high-skilled occupations. Furthermore, some adverts do not include complete information on employer requirements, which means that data may be missed. To overcome these

[6] Employers report skills gap when the level of (digital) skills their employees have does not meet the requirements of the job. Skills shortages arise when vacancies are not filled because staff with the required skills cannot be hired.

limitations, researchers often focus on demand for workers and skills in selected occupations, rather than aiming to map the entire demand in a given economy.

With these caveats in mind, the remaining part of this subsection discusses research findings on the types of digital skills currently required in workplaces.

The findings from an employee survey (the *Skills and Employment Survey*) are also included in this section. Noting the imbalance between data from employers and employees, RWG members agreed that analysing skills requirements data from different stakeholders (employers, employees, training providers, etc.) is key, because they have different perceptions of skills needs. Another relevant question is about how employers utilise the skills of their staff.

The Research Working Group discussed the benefits and limitations of the current methodological approaches: some called for developing a complete, occupations-based typology, while others felt that instead of creating a 'complete' list of digital skills required in workplaces, researchers should create the method for automatically defining such a list. The RWG also recommended that documents such as Apprenticeship standards and the description of T-levels skills descriptors should also be included in the Evidence review on digital skills in the UK.

The *European Digital Skills Survey* collected information from employers in six EU Member states, including the UK.[7] It revealed that digitisation of workplaces is transforming existing jobs and creating new ones and new occupations are also emerging, leading to an increased demand for digital skills (Curtarelli et al., 2017). Basic IT skills, such as using a desktop computer and broadband technology are in high demand. These skills are required across all occupations, but in particular in high- and medium-skilled ones. Looking at the occupations in more detail the survey reveals that almost all workplaces require managers to have at least basic digital skills and around 90 per cent of employers said that professionals, technicians, clerical workers and skilled agricultural workers are also required to possess at least basic digital skills. Eighty per cent of workplaces require basic digital skills for sales workers. Workplaces also often require basic digital skills for building workers (almost half

[7] The survey was commissioned by the European Commission. It covered six EU member states, including the UK and was conducted in 2015-16. The sample of employers surveyed was representative for the six countries together and for the EU-28, but not for the individual countries covered by the survey.

of workplaces), plant machine operators (34% of workplaces) and even employees in elementary occupations (27% of workplaces).

To better understand how the use of ICT affects skill requirements and work tasks at the level of jobs, a study by Ecorys and the Danish Technological Institute (2016)[8] presents twelve job profiles which have changed substantially as a result of developments in ICTs, for example building electrician, machine operator in the metal industry, dairy farmer or a teacher in Further Education. The study uses three categories of digital skills: IT specialists, Advanced users (competent users of advanced, sector specific software tools and Basic users (competent users of generic tools, e.g. Microsoft Office software). While none of the job profiles described in the study can be categorised as ICT specialists, using ICTs is of key importance in some of the jobs, such as example animators, desktop publishers and industrial designers. In addition to digital skills, the job profiles also describe 'other complementary skills', which include professional or technical knowledge and skills (for example, a dairy farmer needs skills and knowledge related to food production, cattle health and accounting) and personal skills and competences such as analytical and planning skills. The job profile of an electrician is summarised in Box 4.

Focusing on the UK, a survey by the British Chamber of Commerce (BCC) found that the most important digital skills for UK businesses were: 'basic computer skills', 'communicating and connecting through digital channels' and 'management of digital information'. Eighty-four per cent of firms reported that digital and IT skills were more important to them than two years earlier, with 51 per cent saying these skills were becoming significantly more important (BCC, 2017).

As for survey findings about 'skills problems',[9] the most recent wave (2017) of the well-established *UK Employer Skills Survey*[10] asked employers about skill-shortage vacancies and reported that 33 per cent of these were at least partly attributed to a lack of applicants with the right 'digital skills'. These skills include both basic computer literacy (23%) and/or more advanced or specialist IT skills (21%). Similarly, the survey by the British Chamber of

[8] The study is linked to the report 'ICT for work: Digital skills in the workplace. The job profiles are based on a survey of employers in six EU countries (DE, FI, PT, SE, SK and the UK), desk research and interviews with trade organisations, experts and researchers and employers (Ecorys and Danish Technological Institute, 2016).

[9] A skills shortage exists when there are not enough individuals with the required skills within the economy to fill existing vacancies (at market-clearing wages) (Curtarelli et al., 2017).

[10] The survey was commissioned by the UKCES and more recently the UK Department for Education. It relies on a representative sample of firms and uses robust methodologies, which allows for comparisons over time.

Commerce (BCC) found that more than 75 per cent of businesses are facing a shortage of digital skills in their workforce, with 52 per cent reporting a slight shortage, 21 per cent a significant one and 3 per cent a critical shortage (BCC, 2017).

Box 4 Digital and other complementary skills electricians need (Source: Ecorys and Danish Techonological Institute, 2016, pp 25-28).

Electrician: Digital skills

- ***Updated digital knowledge to counsel the customer on the delivery of integrated systems.*** The increasing use of building automation systems means that building electricians must be able to advise the customer on the delivery and use of total, integrated systems.
- ***ICT specialist skills to install and integrate ICT- and electronic systems.*** The building electrician needs digital skills to install, integrate and test electronic systems with embedded ICT components. These tasks require relatively advanced digital skills and knowledge of software.
- ***ICT specialist skills for digital information search on-site.*** The permeation of ICT in electronics and the complexity of building automation systems mean that the building electrician must be able to find technical information, for example on components and system configurations. Consequently, the building electrician must be good at using digital referencing tools on site to search and find relevant technical information on given components and systems. Such digital referencing tools can be accessed via APPs on a smartphone.

Electrician: Other complementary skills

- ***Self-management –ability to work independently*** ICT tools enable the building electrician to work more independently and on-site because relevant information and partners can be accessed online.
- ***To carry out quality control of own work on-site*** The digital analytical tools make it possible to do complicated calculations and simulations of the circuits on-site, which enables building electricians increasingly do quality control of their own work on site.

While most public debates about digital skills demand in the UK concentrate on skills shortages (see, for example House of Commons Science and Technology Committee, 2016a), a number of sources indicate that digital skills shortages are becoming smaller. Bakhshi and colleagues (2017) note that in the UK and the US there are no clear signs of serious skills shortages outside the employers surveys, but they also acknowledge that skills shortages are difficult to measure. In their research on manufacturing firms in the US, Weaver and Osterman (2017) did not find significant digital skills shortages of computer skills and other critical-thinking or problem-solving skills. They did, however, find shortages of higher-level mathematics and reading skills.

As for digital skills gaps, the *European Digital Skills Survey* has reported that 15 per cent of workplaces face digital skill gaps in their workforce: a proportion of their employees are not fully proficient in carrying out tasks that involve digital skills. Larger digital skills gaps are reported in the high- (managers, technicians) and in medium-skilled (clerical workers, sales workers) occupations. Digital skills gaps are also reported in lower-skilled occupations, with the exception of workers in elementary occupations. Looking at the industrial sectors, the survey has found that workplaces in the manufacturing or construction sectors are more likely to report digital skill gaps (Curtarelli et al., 2017).

The *UK Employer Skills Survey 2017* also reported gaps in workers' digital skills, with just over a third of all skills gaps (35%) involving a deficiency in digital skills. This includes both basic computer literacy and IT skills (25%) as well as more advanced or specialist IT skills (19%). The proportion of skills gaps that can be at least partly attributed to a lack of proficiency in digital skills is very high among establishments in the Public Administration (50%) and Education (42%) sectors (Winterbotham et al., 2018).

The Skills and Employment Survey (SES)[11] is unique among the surveys discussed in this section, because it analyses digital skills requirements from the perspective of workers. The findings from the 2017 wave of survey suggest that technological change in UK workplaces is less common than it was in 2012. Henseke and colleagues argue that the introduction of new ICTs at workplaces appears to have become less skills demanding. They suggest that as ICTs are 'maturing' and their use become more widespread, workers find it easier and less

[11] The Skills and Employment Survey 2017 collected data from working adults aged 20-65 years old in England, Wales and Scotland. This is the seventh in a series of nationally representative sample surveys of individuals since 1986.

'skill intensive' to adopt new general purpose ICTs. This argument is also supported by the finding that the proportion of survey respondents who state that additional computing skills would enable them to do their job much better halved from around 25 per cent in 2001 to 12 per cent in 2017.

Online vacancy analysis

A study based on the analysis of online job advertisements in the US found that on average, 35 per cent of advertisements expected applicants to have one or more IT skills (Beblavý et al., 2016).[12] Similarly to the findings of the European Digital Skills Survey, in the US labour market there was also a very strong demand for basic ICT skills, such as knowledge of working with a computer. Basic ICT skills, such as email, internet browsing or generic computer skills were required across the economy, even among low-skilled jobs. Similar types of skills were demanded across low-, medium- and high-skilled occupations, suggesting that basic ICT literacy was a selection criterion for workers at all skill levels. Intermediate IT skills (productivity software skills) were required for medium to high skilled occupations. The use of Microsoft Office software was the most commonly demanded skill, suggesting that these skills may be an 'entry ticket' to mid- and high-level jobs. Advanced[13] ICT skills, such as computer programming, but also social media management or data management were required only in a few jobs. Unlike the basic and intermediate skills, the types of skills requested and their frequency vary significantly across different types of occupations. Somewhat surprisingly, about 10 per cent of advertisements for 'low-skilled jobs' included at least one advanced IT skill (such as Databases and data management) as a requirement.

There was also a large variation in the 'digital intensity' of occupations: fewer than 5 per cent of advertisements for 'personal care assistants' mentioned any ICT skills, while more

[12] The study focused on the 30 most frequently advertised occupations in the US over a 12 month period in 2013-2014 and explored: the 'digital intensity' of these occupations and the types of IT-skills people in these occupations needed. The study defined three levels of ICT skills: 1) basic digital skills, for example 'computer skills', 'internet' and 'e-mail'; 2) intermediate digital skills: word processing, spreadsheets, Power Point, office packages and SAP; and 3) and advanced digital skills, which were divided into 9 categories: customer relationships management (CRM); databases and data management; data analysis and statistics, programming and programming languages; digital media and web design; desktop publishing, CMS; social media and blogging and search engine analysis (SEO).

[13] In the terminology adopted by this Evidence Brief some of these skills are indeed ICT specialist skills (e.g. programming), while others are job specific 'general' digital skills (e.g. social media management).

than 92 per cent of adverts for 'meeting and convention planners' did. Occupations with high digital intensity included secretaries and customer service representatives. The study also found that higher-skilled occupations[14] (such as Professionals and Managers) typically demanded more IT skills than low- and medium-skilled ones.

A report by Burning Glass Technologies (2019)[15] that analysed job advertisements posted online in the UK has found that digital skills are required evenly across all skill levels: three quarters of low-skilled jobs, 78% of middle-skilled jobs and 80% of high-skilled jobs are 'digitally intensive'.[16] Looking at different occupations, the report has found that Microsoft Excel skills are most likely to be specified in advertisements for secretaries and human resources assistants. Blue collar and service roles also commonly use digital skills: forklift drivers and warehouse workers are often expected to use inventory management systems such as SAP and retail workers are required to use point of sale systems.

Advanced digital skills are required in medium- and high-skilled occupations and many such occupations have a digital skill area that is of key importance, for example designers need to be fluent in software programs like Adobe Photoshop, and a key digital skill for engineers is AutoCAD. Commenting on these findings, the RWG added that the key issue is not what skills the workforce has, but the deployment of these skills – a creative, problem-solving engagement with skills will be more 'automation-proof than a routine engagement.' The issue of automation introduces the next section, which focuses on future demand for digital skills.

Another piece of research by Burning Glass Technologies (2017) analyses how digital skills influence an individual's progression in US workplaces. The study focuses on 'middle-skill jobs', which are defined as jobs that require less than a bachelor's degree while paying a living wage.[17] The main finding is that digital skills, especially productivity software skills first

[14] According to the occupations' ISCO (International Standard Classification of Occupation) code.

[15] The research analysed 10.2 million online job postings, collected in the UK in 2017-2018. Two categories of digital skills are defined: Baseline digital skills (the use of productivity software tools such as word processing programs and spreadsheets) and Advanced digital skills. These are broken down into 7 clusters of related skills, which are commonly required together by employers. Three of these clusters (Programming, Computer and networking support, Data analysis), are linked to occupations in the field of ICT, while the other three are linked to other, high skilled areas. (For more details see Table 3, Annex B).

[16] Occupations are categorised as digitally intensive if at least 10% of job postings for that particular occupation specifically request a digital skill.

[17] Middle-skill occupations are those where less than 80% of online job adverts call for a bachelor's degree and offer a median hourly wage above the national living wage ($15/hour).

serve as 'door openers' to middle-skills jobs and then enable workers to build their careers.[18] Furthermore, the report argues that digital skills provide a level of "future-proofing" for job seekers, as middle-skill jobs which require digital skills are typically at a lower risk of future automation than other middle-skill jobs. Looking at the findings in more detail, 36 per cent of middle-skills jobs are in occupations whose only digital requirements are the ability to use productivity software (occupations ranging from clerical positions to basic finance roles and sales). The rest of the advertisements request more technical digital skills, such as use of CRM and digital design software. However, half (53%) of these vacancies are in entry-level jobs, which represents strong opportunities for entry-level job seekers, according to the report (Burning Glass Technologies, 2017).

3.3. Future demand for general digital skills

Research on the future skills demand is closely linked to discussions about technological change and its effects on employment and labour markets, such as job losses and creation, the transformation of occupations and the reorganisation of workplaces. The main technological developments that shape the labour market are: automation, digitalisation, artificial intelligence (AI), big data and the internet of things.

Most research that aims to forecast the effect of technological change on work and occupations is based on the analytical approach that breaks down occupations into a number of different tasks (Autor, Levy and Murnane, 2003). An important finding emerging from this line of research is the trend that as a result of computerisation, routine cognitive and manual tasks performed by workers are declining, while non-routine tasks (both cognitive and manual) are growing in importance.[19] Levy and Murnane (2004, cited in Bakhshi et al., 2017) attribute the growth of non-routine cognitive tasks to growing demand for skills in 'expert thinking' and 'complex communication'. The growing importance of communication was also highlighted by Deming (2015), who found that in the US employment in occupations that require social skills have grown since 1980, while employment in occupations that require only high analytical skills without social skills have decreased.

[18] According to a representative study conducted by Ipsos Mori, working adults in the UK who have all five Basic Digital Skills earn on average £13,000 per year more than those with fewer or no digital skills: £34,500 compared with £21,250 (Lloyds Bank, 2018, p 24).

[19] Autor, Levy and Murnane (2003) analysed US data between 1960 and 1998.

Another line of research assesses the 'probability of computerisation' of currently existing jobs, assuming that new technologies are implemented across a range of industries. Using different methodologies, the two most relevant studies (Frey and Osborne, 2013 and Arntz et al., 2016) predict that 35 per cent of the UK workforce will have to adapt significantly as a result of 'computerisation', but disagree whether jobs will be fully automated, or undergo a major change in task composition. Looking at the labour market of London, research by Frey and Osborne (2014) focuses on how digital change is likely to affect employment in London and found that jobs in office and administrative support; sales and services; transportation; construction and extraction; and manufacturing are most at risk from technology, while jobs least at risk are in skilled management; financial services; computers, engineering and science; education; legal services; community services; the arts and media; and healthcare. Bakhshi and colleagues (2017) used a more complex approach to predict occupation growth or decline in the UK and US economies in 2030 and considered the effect of not only technological change, but also other key sources of structural change: demographic change, globalisation, environmental sustainability, urbanisation, increasing inequalities and political uncertainty. The study also identified which associated skills, knowledge types and abilities will experience growth or decline in demand.[20] The key finding is that about 30 per cent of the current UK (and US) workforce is in occupations which will very likely be affected by structural change. These estimates imply that a large segment (about 70 per cent) of the workforce in both countries face uncertain future demand.

Focusing more closely on future skills demands, a study by Bakhshi and colleagues (2017) confirms the growing importance of cognitive and interpersonal (21st century) skills. In the UK, the most important 21st century skills are cognitive competencies and learning strategies but 'system skills (Judgement and Decision-making, Systems Analysis and Systems Evaluation) are also prominent in the forecast. In the US skills demand forecast, interpersonal competencies are the most central.[21] A study by Djumalieva and Sleeman (2018) looked into UK data and their findings support predictions about the increasing demand for digital skills to carry out cognitive, non-routine tasks.[22] The authors predict

[20] The research methodology is based on the O*Net survey database.

[21] Important knowledge areas, associated with occupations that are predicted to grow include English language, Administration and Management. and Biology.

[22] Djumalieva and Sleeman (2018) analysed online job advertisements. Their study defines 'digital skills' to include knowledge of specific software (e.g. People Soft) as well as competences (such as CAD or 3D printing).

increased demand for digital skills used in animation, engineering, education and computing, and reduced demand for skills related to using administrative software, for example in payroll, accounting, supply chain and sales. The key argument of the study is that occupations where people use digital skills creatively and for problem solving (engineering or animation) were likely to grow, while occupations with digital skills being used less creatively (e.g. finance officers and HR administrative occupations) were likely to decline.

3.4. Case study one – Health and social care

The health and social care sector is the largest sector in the UK, employing three million people. It is wide-ranging and complex sector that includes activities ranging from acute care delivered in hospitals to personal care and support delivered in residential care settings or in people's homes. The main drivers of transformations in the sector are technological change, advances in treatments and growing expectations of patients and service users (Howat et al., 2015). Population trends and the reliance on care at home are also important factors that drive change in the sector.

The introduction of digital clinical record systems has been a foundational transformation in the health and social care sector (Department of Health, 2014), followed by the implementation of different 'telehealth' and 'telecare' systems. The former refers to managing health care over the telephone, using videoconferencing and the remote monitoring of signs and symptoms, while the latter is monitoring safety in the homes of vulnerable clients where care is supported by web applications (Royal College of Nursing, 2018).

A report by Howat and colleagues (2015) predicted that existing occupations in the health and social care sector are likely to expand and new roles are likely to emerge to fill the gaps between the traditional professions. However, the evolution of technology and medicine means that skills implications are hard to foresee. At the 2016 congress of the Royal College of Nursing (RCN) it was stated that the use of data, information and technology were no longer specialist issues, rather every nurse should be an 'e-nurse', able to use technology to maximum effect for patients, service users and carers (RCN, 2018). To achieve this, training need to be responsive and support the future workforce in using new technologies

Digital skills required in the sector

The health and social care sector includes a wide range of roles and types of work, but only four occupations (care workers, nurses, nursing auxiliaries and doctors) account for over 40 per cent of the workforce. There are also large, non-clinical occupations as receptionists, and managers of GP practices and care homes (Howat et al., 2015). The skill levels and the 'digital intensity' of occupations in the sector vary a great deal: in the US, nearly 20 per cent of all ICT-related positions are in the health and social care sector but the least 'digitally intensive' among the most often advertised jobs is also in this sector: only 5 per cent of online job advertisements for personal care aides mention computer skills (Beblavý et al., 2016).

Digital skills that are specific to occupations in the health and social care sector were highlighted in a study of middle-skill occupations in the US (Burning Glass Technologies, 2017). Specific digital skills are required to work, for example, as a radiology or laboratory technician, using specialist equipment, but also as a medical secretary and claims specialist working with patient data (Burning Glass Technologies, 2017). A report by Skills for Care, the workplace development body for the adult social care workforce in England identifies three broad groups of digital skills: basic or generic digital skills; intermediate or digital champion skills and specialist skills that require understanding specific care and support focused digital technologies (2014). In their review of evidence on the use of digital technologies in the social care sector Dunn and Braddell (2014) found four main types of use: assistive technologies, mainly for older people or for people with learning disabilities; using online sources to provide information to people using services; learning and research; and records management.

Another important digital skill in healthcare settings is digital leadership (Maguire et al., 2018). A key finding of a report that discusses successful digital transformation projects in the UK health sector, such as the introduction of digital records systems is that a combination of clinical and IT perspectives is necessary for success. Some case studies highlight that investing in the digital skills of clinicians enabled hospitals to get the most out of the new digital systems and save time and money that would have been spent on external IT consultants, as it is clear from the following quote:

Had to develop their in-house capability to better support change and save money. […] So, upskilling all of my team, being able to understand the [digital] product well enough – we work quite closely with the vendors […] to understand […] the scope of what it can do and how it can achieve that.

(Digital change manager, quoted in Maguire et al., 2018, p 68)

Research conducted as part of HEE's Technology Enhanced Learning (TEL) Programme identified a lack of emphasis on digital literacy in job descriptions across the NHS and that professional bodies make minimal reference to digital literacy in their codes of practice (Kennedy & Scott, 2016).

A 'digital readiness indicator for health and social care' has been developed in the *Building a Digital Ready Workforce Programme* (BDRW), a cross-organisational programme between Health Education England (HEE) and NHS Digital that is part of the Government's *Digital Transformation Portfolio* (DTP)[23]. The DTP sets out how the government and national health and care organisations aim to use information technology to improve health and social care services in England. The indicator has two main domains, being digitally willing and being digitally able, with skills included in the second domain (as shown in Figure 1).[24] Skills are seen as a subset within a broader categorisation of digital capabilities which include attitudes, skills and behaviours, capabilities described fully in a more detailed, developmental framework for the health and care sector in the UK.

A developmental framework, the *Health and Care Digital Capabilities Framework* (2018)[25] is also used in the health care sector in the UK. The aim of the framework is to support all working in health and care to be confident in their understanding of what digital literacy means and the digital capabilities that are increasingly required of all. It is based on the Jisc digital capabilities framework, presented in Appendix B Table 1 and has been further

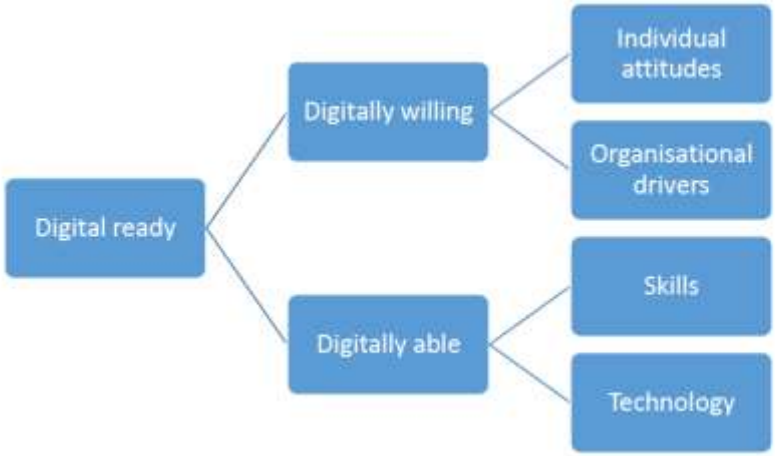
[23] More information about the DTP is available online: https://www.gov.uk/government/groups/personalised-health-and-care-2020.

[24] The framework is based on the result of an online consultation. NHS Digital and NHS England commissioned the organisation Clever Together to host a three-week national online workshop to explore the needs and experiences of people working in the system who have digital expertise, including informaticians, IT professionals, and clinical staff. The workshop took place between 22 November and 13 December 2017, with 1,061 participants.

[25] This framework was developed by the BDRW and HEE's Technology Enhanced Learning (TEL) Programmes, both of which have dedicated digital literacy workstreams (for more details see HEE (2018): https://www.hee.nhs.uk/our-work/building-digital-ready-workforce).

developed with levels of digital capability now described. The main focus of the framework is to fully articulate, those digital capabilities that are vital if health and care is to fully exploit new and emerging technologies to provide the best care.

Figure 1: **Digital readiness indicator for health and social care (Source: NHS England, 2018)**



Different organisations are using the framework to support their own work, for example, the RCN's endorsement of the framework is linked to their profile on what 'digital professionalism' should be. Capabilities included in the framework can also be mapped against the Nursing and Midwifery Council (NMC) code and so also supports the revalidation process. The domains of the HEE Digital Capabilities Framework are presented in Figure 2.

Current levels of digital skills in the sector

Although the UK is seen as a leader in generating ideas for digital healthcare solutions, it is less successful at implementing them in clinical practice. A report by Deloitte (2015, cited in Ecorys UK, 2016) argued that this is partly due to two factors: a shortage of technical and managerial skills within the healthcare system and that many patients lack the basic digital skills needed to access and utilise the digital technologies. The report also highlighted a lack of skills in health analytics which would be crucial to manage 'big data'. The Good Things Foundation, in partnership with NHS England (NHSE), identified that one of the potential barriers to the implementation and sustainability of their Widening Digital Participation programme was the uneven level of digital literacy of frontline healthcare professionals and more widely in the social care sector (Good Things Foundation & NHSE, 2015:p28).

Figure 2 The domains of the Health and care digital capabilities framework (Source: Health Education England, 2018)

A recent consultation with nurses about digital skills (RCN, 2018)[26] found that day-to-day problems with basic technology and the lack of time to engage with new technologies are the most important barriers to improving nurses' digital skills: "*If staff haven't time to take a break, use the bathroom and are struggling to deliver patient care, they will find it difficult to engage with and learn new systems"* (RCN, 2018, p 7). Contributors to the consultation agreed that there was a need to train and support nurses, and some suggested that digital skills training should become a mandatory requirement, complemented by more human-centred design and allowing staff more time to familiarise themselves with technology. It was also highlighted that undergraduate nursing students were not trained in health informatics, partly because universities cannot access systems in hospitals where they place their students.

A survey on the use of digital technology in community nursing (The Queen's Nursing Institute (QNI), 2018)[27] aimed to map the use of healthcare information technology and

[26] Between 25 January and 23 February 2018, the RCN convened a four-week national online consultation and series of real-world focus groups, facilitated by Clever Together. 896 people participated, of these, 365 people were active contributors, offering 2,122 ideas, comments and votes. Alongside these contributions, feedback captured in five focus groups in Belfast, Cardiff, Edinburgh, Leeds and London was translated into 331 ideas, comments and votes in the online consultation, enabling interaction between these online and real-world contributors, and allowing us to undertake a single analysis of all contributions.

[27] This report is based on a survey of over 500 nurses working in the community.

skills and attitudes within community nursing. Just over a fifth (21%) of respondents stated that having an understanding and confidence in using IT contributes to their working efficiently. The lack of training in the use of technology was a problem, as the following quote demonstrates: "T*here are lots of assumptions on people's skills rather than support in teaching and developing"* (The Queen's Nursing Institute, 2018, p 31). The nurses participating in the survey reported using 67 differently named IT systems; and while 74 per cent of nurses find that IT systems are a more reliable way of working than paper-based systems, almost a third (29%) of community nurses are still working largely with paper based systems. A number of respondents said that the introduction of new IT systems had resulted in an increased workload and placed more time pressure onto nurses. Importantly, some respondents felt that the demands of IT systems reduced the amount of time they can spend with patients.

Developing digital skills in the sector

In their study of digital transformation projects that introduced electronic medical records (EMR) systems in care homes in the US, Avgar et al. (2018) found that the work practices and employment relations had a strong influence on how successful the projects were.[28] Nursing homes that used work practices that promoted discretion, teamwork and communication quickly adapted to the new systems and needed relatively little external technical support (from the vendors supplying the systems). In particular, management allowing staff to experiment with the new system and setting up peer-support arrangements were very important to the success of the new systems. Having freedom to experiment with the new technology systems facilitated the learning of frontline workers. The study found that for frontline workers, who are relatively low skilled, freedom to experiment with the system – to engage in trial-and-error learning - was more beneficial than formal training. In contrast, formal training was found to be more important in the learning for staff in higher skilled occupations, for example care home managers (2018, p

[28] The study is based on the analysis of a data from the programme evaluation conducted in the state of New York in which a single vendor was selected to provide electronic medical records (EMR) systems to 15 client nursing homes from 2007–2008. Nursing homes were chosen to minimize heterogeneity along dimensions such as resident mix, so the research setting offered an opportunity to study EMR implementation in a relatively controlled setting. Measures of workplace organisation at nursing homes, collected immediately prior to implementation, were developed through surveys of 962 employees from the in-sample nursing homes.

647). Appointing 'technology champions' who could assist other frontline staff with use of the new technology was also beneficial. These champions added a layer of peer support to the learning experience.

The findings of this academic study from the US support the conclusions of a report commissioned by HEE (2017). Drawing on five case studies, the HEE report identifies nine key factors that contribute to successfully developing a digitally literate workforce (pp 4-5). These factors can be summarised under three broad categories. First, leadership and strategy are vital. Leaders can encourage staff to develop their digital capabilities and they can provide opportunities and resources, such as time, to support that development. Secondly, an open and trusting organisational culture, with an ethos of sharing control over digital working is also key to developing digital capabilities. Thirdly, different methods of learning and skills development need to be adopted, including informal and social learning, such as peer support from digital champions is important. Digital champions were found to promote learning, and the report argues that simply recognising and rewarding staff who offer ad hoc support to others (informal and 'spontaneous' digital champions) is also effective. Members of the RWG have noted that BDRW is currently testing different methodologies for developing digital champions in the health and care sector.

In the health and social care sector the development of digital capabilities of frontline staff cannot be viewed in isolation from the capabilities of patients and service users. Medical and care professionals can play a key role in supporting patients' access to digital information. NHS Digital has produced a guide to digital inclusion to help local health and care organisations to actively promote digital inclusion in their communities (NHS Digital, 2018). NHS Digital and the Good Things Foundation also run the *Widening Digital Participation programme*, which has enabled thousands of people in England to use digital services and tools that support their health and care (Good Things Foundation, 2017).

3.5. Case study two – Culture and creative industries

The Creative industries have their origin in individual creativity, skills and talent. The Creative industries contributed over 5 per cent in gross value added (GVA) of the UK economy in 2016, which is comparable to that of the Construction sector. Between 2010 and 2016, the GVA of the creative industries grew by 45 per cent, faster than any other sector of the UK economy. Cultural organisations and practitioners contributed just under a third of the GVA generated by the Creative Industries (DCMS, 2018). In this case study the focus is on two sectors within the creative industries: the culture sector, with most evidence from the museums sectors, and the digital marketing sector.[29]

The digital transformation of the creative industries has changed the character of the sector. Cultural organisations use technology in many areas of their business, from audience outreach through to e-commerce. In digital and social media marketing the opportunities provided from an increased reliance on data analytics have led to a shift in how advertising is bought, sold and created (Bond, 2015, cited in Ecorys UK, 2016). The impact of digital technology on marketing is so strong that the relationship between 'traditional' and 'digital marketing' is debated, with some defining digital marketing as a sub branch of marketing but others viewing it as an independent field of activity (Royle and Laing, 2013).[30]

Digital skills required in the sector

Current evidence on skills demand in the culture sector can be derived from the analysis of job descriptions, which indicates a growing demand for digital skills and competencies. An analysis of job descriptions for curators in the US library and museum sector highlighted the need for technical skills (such as understanding software, web mark-up languages, relational databases, digital repositories) and digital knowledge (understanding metadata) (Jeonghyun, Warga, & Moen, 2013).

[29] Creative industries is defined to encompass publishing, media, architecture, art craft and design, fashion, advertising, public relations, and computer games and software (DMCS, 2001, cited in Royle and Laing, 2013) The *Culture is digital* report (DCMS, 2018) defined cultural organisations as those from the performing arts, visual arts, heritage, museums, archives, libraries, film and making connections with the wider creative industries. Digital and social media marketing as a potential case study sector was recommended by the RWG.

[30] In this case study digital marketing is defined as "the use of digital technologies to create an integrated, targeted and measurable communication which helps to acquire and retain customers while building deeper relationships with them" (Royle and Laing 2013, p 65).

Evidence on skills demand is also reflected in the changing job roles in the sector. For example, in the museum sector traditional audio-visual roles now include the installation and maintenance of more complex digital interactives and curatorial roles have changed to include the production of digital content, engagement in social media, curation of digital-born objects and digital preservation (Barnes et al., 2018). The required digital skills and competencies in museum roles include, for example, social media skills (Garibaldi, 2015); knowledge of social tagging (Owens, 2013); manipulation of digital images (Schroer, 2012); blogging (Verboom & Arora, 2013); understanding of Intellectual Property Rights (IPR) (Tsolis et al., 2011); designing and using 3D technology (Liritzis et al., 2015); and designing and using virtual and augmented reality (Donghui et al., 2017). A typology of skills and competencies, including digital skills that are deployed by museum professionals is shown in Box 5.

In addition to digital skills being included in many job roles, specialist digital roles have also emerged in the cultural industries, for example: digital content creator, digital programme staff, digital learning staff, digital curators, digital collections staff and digital developers (Barnes et al., 2018, pp 14-15). A training and development officer interviewed in the *One by One* study[31] emphasised that candidates for the digital team are expected to present a reasonably detailed skill set that is not just technical, but also includes experience of digital activity, such as for example: "*doing social media on behalf of an organisation and, you know, following brand guidelines, and making sure things are adhering to a consistent tone" (Training and development officer, cited in Barnes et al. 2018, p 24).*

Turning to digital marketing, the evidence also highlights that digital transformation has led to changes in the skills requirements: in addition to creative talent, marketers also need to know the technologies, how to read the data and how to market accordingly (Hale, 2015 cited in Ecorys UK, 2016). Royle and Laing (2013) found that digital marketing skills[32] included website construction; maximising the potential of social media such as Facebook and Twitter; Search Engine Optimisation (SEO); mobile applications; customer conversion

[31] One by One (2017-2020) is a research project which aims to help UK museums to better define, improve, measure and embed the digital literacy of their staff and volunteers in all roles and at all levels. It is funded by the Arts and Humanities Research Council (AHRC) and is led by and is led by the University of Leicester in partnership with Culture24. This evidence brief includes evidence from Phase 1 of the One by One study.

[32] The term 'digital marketing skills' is used by Royle and Laing (2013) to refer to the knowledge and awareness of digital marketing and its applications in the creative industries.

and knowledge of digital analytics for evaluating the effectiveness of digital approaches are among the most important digital marketing skills.

Box 5: **Digital skills in the UK museum sector (Source: Barnes et al., 2018)**

Domain-dependent skills – specialist skills (select, collect, organise, interpret, conserve, present, re-present) and knowledge specific to museology or the role within the museum.

Generic skills – communication, management, information processing, team working, research, planning, interpersonal, presentation, creativity, design.

Technical skills – email, word processing, spreadsheets, presentation software, basic html, file transfer protocol (FTP), JavaScript (and other programming languages), web design, web publishing, running websites, app development, database management, photography, 3D scanning, 3D modelling software, photo editing software, open source software, file sharing software, time lapse camera use, work with analytical equipment such as X-ray fluorescence.

Digital skills – management and manipulation of digital and moving images, ability to understand web analytics and social media data, writing online content, assessing and managing online information, online communication, photogrammetry, live streaming, use of different operating systems.

Specific digital skills – blogging, CMS Mimsy XG, Adlib, Facebook, Instagram, Tumblr, Twitter, MailChimp, 3D image sharing websites (Sketchpad, Sketchup), design programmes (InDesign), Periscope, Raspberry Pi, Spotify, Photoshop, Audience Finder, Inkscape, Adobe Creative Suite, Dropbox, Event Brite, WordPress, Snapchat, Curo 3D, CAD/CAM, Google+, Hootesuite, Buffer, TweetDeck.

Looking at what skills will be required in the future, there is a prediction that employment in the creative industries in the UK will grow. However, there is also expected to be a 'hollowing out' – in other words, the need for intermediate skills is predicted to decrease and demand for both high–and low-level skills is predicted to increase (Williams et al., 2012, cited in Ecorys UK, 2016).

A Harvard Business Review report stated that marketing organizations will need a new blend of talent. Expertise in areas such as television, digital and e-commerce will give way to what have been called 'thinkers,' 'feelers,' and 'doers.' 'Think' marketers are defined as those who excel at data analysis and modelling, while "feel" marketers are experts in customer behaviour and interactions, especially online. Finally, 'do' marketers focus on creating content and managing projects (Dholakia, 2015).

Current levels of digital skills in the sector

The *One by One* study found that few museum staff had specific digitally-related qualifications, instead, most had either developed digital skills within their current role or previously, in another role or a job elsewhere:

> *I think the museum […] relies on the digital skills that people bring with them, you know, and so we get good at things possibly by accident, or just because one person has those skills, and what happens when that person leaves.*
>
> *(HR manager, cited in Barnes et al. 2018, p 24).*

There is also evidence of skills challenges (skills gaps and shortages) in the culture sector. The *Digital Culture Survey* shows that over a third of museums in England feel that they do not have the skills to meet their digital aspirations (Nesta and Arts Council England, 2017). The survey also highlighted regional variations in the digital skills organisations can draw on, and found that London has the highest number of 'digital leaders', while organisations outside London were less confident in their digital skills (pp 33 and 40). The *Culture is Digital* report points to 'particular skills gaps around intellectual property and data analysis' (DCMS, 2018). It is also recognised that the digital literacy of the museum workforce continues to impede the adoption of technology within the sector (New Media Consortium (NMC), 2015; 2016). Interviewees in the *One by One* study noted basic digital skills shortages within the case study museums:

> *The biggest problem is not digital media skills, it's just bog-standard digital skills […there is the] assumption that everybody knows how to use computers. People don't know how to use a computer. […] We, as an organisation, have forgotten people need to be shown how to use it sensibly.*

(IT manager, cited in Barnes et al. 2018, p 27).

Recruitment into digital specialist roles is considered challenging: managers of the case reported not being able to offer attractive salaries. Attracting applicants with highly sought skills, knowledge and expertise, such as web development and film production, is particularly difficult.

Focusing on digital marketing skills in the UK communication and creative industries, Royle and Laing (2013) identified the key skills gap as the ability to integrate digital marketing approaches with established marketing practice. Other skills challenges included a lack of specific technical skills, such as search engine optimisation skills (SEO), mobile applications knowledge, 3d video expertise, using blogs and online discussion groups.

Developing digital skills in the sector

There are a number of examples across the culture sector of how digital skills and competencies are being developed. Evidence from Australia examined the development of digital capabilities across the galleries, libraries, archive and museums sector noting that much could be learnt and shared from across the fields (Goss, 2016). The *One by One* study found that while case study museums recognised the need to upskill and reskill in terms of digital, there was little evidence of formal or planned training around digital skills. Instead, digital skills development tended to be informal; for example, staff learning on the job, or staff supporting each other and sharing skills. Formal training is sometimes provided when new digital systems are implemented or a clear skills need is identified. Skills needs are typically identified in annual development reviews. Some interviewees in UK museums described how staff had lobbied for a particular type of skills development:

> *This year they are rolling our photography training to curators. […] Curators have been asking for this training for years; it was spurred on when our collections went digital.*
>
> *(Curator, cited in Barnes et al. 2018, p 27).*

Formal digital skills development practices included regular training opportunities such as drop-in sessions. These are often considered to be more useful and accessible than longer courses that are run a few times a year. However, across the UK museum sector digital skills

and competencies are primarily developed through peer learning. Professional networks are particularly important to small museums and the representatives of these museums highlighted that the general openness within the sector was very important for developing the digital skills of their staff. The *Culture is digital* report found that digital leadership from executive leaders and trustees was of key importance to the development of digital skills, and meaningful change happens when the senior leadership recognises the transformational role that technology can play in supporting the development of their organisation.

3.6. Case study three – Financial services

Digital transformation in the financial services industry has been driven by external technology firms 'disrupting' the traditional business models. The innovation of these firms created new customer demand for financial technology, forcing traditional financial services to compete in this market. Traditional banks increasingly have to remodel their operations to compete with Financial Technology (fintech) firms. While the digital 'disruption' is argued to have been very expensive for the sector, with UK banks spending billions of pounds every year on technology to keep up with the latest developments, it has also led to positives outcomes. There is now greater co-operation between traditional financial services and technology firms (Ecorys UK, 2016), for example, the Bank of England launched a *Fintech Accelerator* (in 2016) to develop partnerships with firms working on new technology (HM Treasury, 2018).

A report prepared for the House of Commons Committee on Exiting the European Union (2017) argues that fintech is not a sub-sector of financial services, rather, it is a label applied to firms operating across the sector, which harness new technology. Increasingly, fintech is seen as an industrial sector in its own right: the 2017 *UK Fintech Census* showed that this newly minted sector employs 76,500 people and this is projected to grow to more than 100,000 by 2030 (EY, 2017). Because almost half (42 per cent) of its workers come from outside the UK, fintech is highly exposed to post-Brexit changes in the immigration regime (Crosswell, 2018).

Other effects of digitalisation in the Financial services industry include the impact of Artificial Intelligence on branches of high street banks. Traditional jobs, such as loan officers and mortgage brokers are likely be automated in the near future (Frey and Osborne, 2013).

Furthermore, a report by EY (2016b) demonstrates that robots have started to enter wealth management, a domain of financial services where personal relationships between clients and banking staff were thought to be vital for business. However, some private banking clients of an Asian bank are now served by robots and interact with the bank through enhanced online platforms.

Digital skills required in the sector

According to a survey of executives and employees (Oxford Economics, 2017), which included 500 financial services managers, 41 per cent of executives rate digital proficiency as the most important quality for a manager of the future to possess. Building soft skills and leadership capabilities was seen just as important as keeping up with technology. In an influential study, Autor (2014) argues that many jobs require flexibility, judgement and common sense and will be difficult to automate. Examples of jobs in the Financial services sector that are likely to remain filled by humans include: research analyst, call centre staff and high-net-worth personal advisors (EY, 2016b). In these roles, digital and interpersonal skills will continue to be intertwined and these roles will be vital to how banks structure their workforce, and hire, remunerate and train their staff. Box 6 presents more detail about these roles.

A study commissioned by the Treasury (EY, 2016a) found that three main types of skills are critical to workers succeeding in fintech: technical skills, financial service expertise (this includes the skills required to understand financial service markets, business models and regulations) and entrepreneurial skills. Finally, the recruitment firm Hays has published a series of blog posts discussing what skills financial services professionals need to remain employable and what occupations promise the best career prospects in in the digital world of financial services (Piesse, 2017 and 2018). Occupations which are likely to remain stable include cybersecurity specialists, wealth managers, data specialists and 'innovation officers' and specialisms in legal, compliance and risk areas of financial services. The skills and knowledge required in these occupations include cybersecurity and crypto currencies.

Current levels of digital skills in the sector

There are concerns about skills shortages limiting the expansion of the fintech industry. According to a report by the Government Office for Science (2015), in 2015, 45 per cent of technology business leaders reported a skill shortage. Skills shortages affect regulatory and

compliance staff, particularly software, analytics and regulatory and compliance specialists. The skills shortages are predicted to worsen as the business areas of regulation and compliance are becoming increasingly analytical, leading to the rise in demand for these specialist skills.

Box 6: Occupations in the financial services sector which are hard to automate (Source: EY, 2016b, p 12)

Research analyst. The ability of machines to advance clients' thinking, rather than report on the facts remains limited at least in the near future. Analysts have the advantage over machines that they can form relationships with leaders of the companies they cover, speaking with them and interpreting the nuances of their comments. While the mechanics of data analysis can be automated, the role requires a degree of human interaction and judgement that cannot (yet) be as effectively achieved by machines.

Personal advisors. While the 'mass affluent' may have their wealth managed by robot advisors, high- and ultra-high-net-worth clients are likely to expect dedicated personal advisors.

Call centre employees. There is already some automation in bank call centres and employees have scripts to help them solve problems faster, customers would become very frustrated if these employees were only able to stick to the script (as machines would be). To provide good quality service in this role, a problem solving capability and engagement with clients is required.

The EY Report (2016a) compared the fintech ecosystems of seven regions: the UK, California, New York, Germany, Singapore, Hong Kong and Australia[33] and found that the availability of financial services and entrepreneurial talent in the UK is strong and expected to remain so. The report argues that UK has an unrivalled lead in financial expertise, and entrepreneurial and leadership skills are also readily available in the UK, second only to the US. Entrepreneurial talent is found to be 'strong' in the UK and in Australia, however, in the UK, it is challenging to find entrepreneurs with the required mix of leadership and technical skills. Lastly, the study found that the talent pipeline was weakest for technical talent, with

[33] These regions were selected on the basis of the reputation and size of their fintech sectors.

concerns about future technical talent shortages being most pronounced in the UK (and in New York and Australia, which have considerably lower shares of science and technology graduates). An interviewee in the UK explained that *"One of our biggest challenges for tomorrow is our tech skills agenda, and ensuring we have sufficient technical skills"* (Fintech hub, UK, cited in EY, 2016a, p 33).

In 2017, 58 per cent of respondents to the *Fintech Census* said that attracting qualified and suitable staff was among their top three challenges. The shortage of coding and software skills was reported as a particular concern (EY, 2018).

A recent opinion piece for Forbes (Marria, 2018) argues that the skills gaps described above persist for two main reasons: firstly, the majority of the existing workforce does not have the skill set required to work with technologies used in the financial services sector. This is exacerbated by the fast pace of innovation, which makes it difficult for (potential) workers to learn how to operate the latest iteration of any given technology and identify what skills and knowledge employers require. Secondly, it is argued that not enough young people with the right skill set are attracted to the financial services industry, when they can also find positions at more recognisable companies, such as Google or Facebook (Marria, 2018).

Developing digital skills in the sector

Developing digital skills is thought to be a priority for Financial Services firms (Oxford Economics, 2017). Firms in the traditional financial services are under pressure to compete with fintech companies but there are other pressures, including demographic ones. EY's Global Banking Outlook (2016b) stated that by 2025, 'millennials' will make up 72 per cent of the global workforce. Because this generation is typically more digitally capable but also more diverse than previous generations, banks need to change the way they hire, motivate, reward and develop their staff.

The UK Government has published a *Fintech Sector Strategy* to ensure that the UK remains the best place in the world for Fintech. The Strategy includes policies that aim to support firms in finding employees with the required skills in the long (supporting the development of digital skills in schools) and the short term (providing additional visas for 'exceptional talent' (HM Treasury, 2018).

A report by the Government Office for Science (2015) argues that it will be important to have strategies to inspire and re-skill the workforce displaced by automation in the Financial

services sector and ensure a supply of skilled workers to fill new and different jobs. The innovators of the future will be the brightest minds, often educated in advanced mathematics, engineering and computer science. To develop the required skills, training in these disciplines is needed, combined with a broad range of business skills, including product and service design, marketing, sales, communications, entrepreneurship and accountancy. To put these principles into practice, the *Connect with work* programme has been launched to help the sector find and recruit individuals with the right skills and attitude to work at fintech firms (HM Treasury, 2018).

Start-up firms' requirements for coding and engineering skills and product and sales skills highlight the importance of working with education, sector and government bodies to ensure that the UK is developing the STEM skills that fintech firms require (EY, 2017).

3.7. Conceptualising success in the workplace

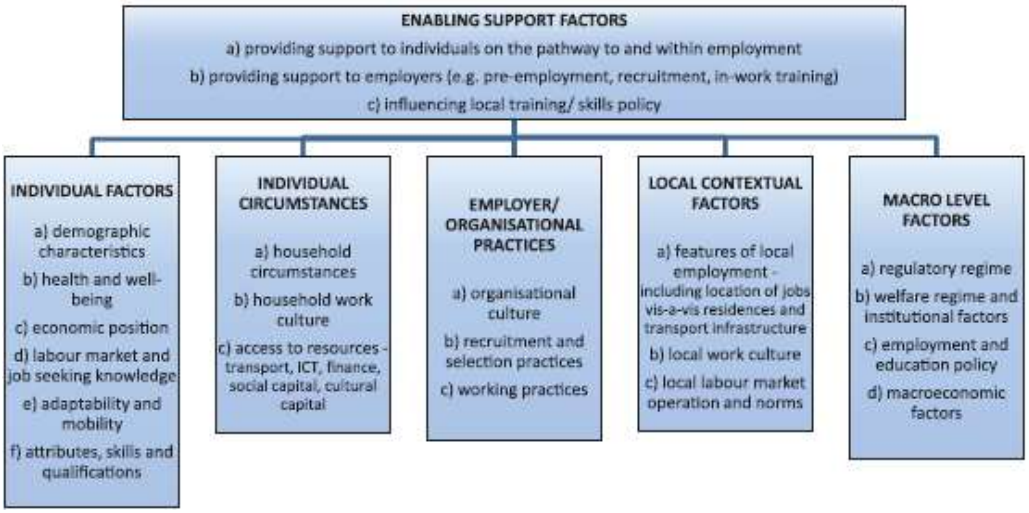
This section addresses the question of how to conceptualise 'success' for workers in the labour market and what are the links between success and workers' digital skills? The concept of employability is a good starting point to this discussion. Employability is commonly defined as the combination of factors and processes that enable people to progress toward or find employment, to remain employed, and to advance in the workplace (Houston, 2005). As people enhance their skills, develop experience, and become more competitive job applicants, their employability improves. Because the concept of employability emphasizes an individual's skills and skill development, it represents both a conceptual and policy shift away from earlier, collective workforce approaches, such as full employment (Garrido et al., 2012).

McQuaid and Lindsay (2005) set out an employability framework which made a distinction between individual factors, personal circumstances and external factors, and in the context of the increased pervasiveness of using ICT, Green and colleagues (2013) created an extended employability framework. The remaining part of this subsection discusses the evidence organised around this framework, presented in Figure 3.

The employability framework has one overarching row relating to enabling support factors (labour market intermediaries from the public, private and voluntary sectors) and five columns. The five columns represent: individual factors (including skills, and more specifically, digital skills, qualifications and attributes); individual circumstances; employer

and organisational practices; local contextual factors, such as the quantity, quality and location of jobs, the characteristics of the local work culture and features of local employment; and in the final column, macro level factors, including employment law, the national welfare regime and other institutional factors, employment, education and training policy and macroeconomic factors.

Figure 3: Employability framework (Source: Green, 2017)



Starting with the enabling support factors, careers information and guidance services, as well as the services of Jobcentre Plus are increasingly offered online, which means more flexibility for clients who are digitally literate and have access to broadband and digital devices (digitally included clients), but poses challenges to the digitally excluded (Duncan et al., 2011; House of Commons, 2016b; Rust, 2014). There is evidence that certain groups of clients need additional support before they can confidently use digital services and that some support is given by Jobcentre Plus (JCP) and non-governmental organisations (NGOs) working in this field.[34] In a recent discussion in the House of Commons Work and Pensions Committee, some of the leading NGOs in the field called for a 'digital skills assessment' for all JCP clients to identify what support they need before they are referred to online resources such as Universal Jobmatch (House of Commons, 2016b). While reviewing the evidence on what works in this field is beyond the scope of this evidence brief, it is safe to state that the accumulated experience of those organisations which provide digital skills

[34] These NGOs include the Good Things Foundation (formerly known as Tinder Foundation), the Citizens Advice Bureau and the Social Tech Trust (formerly known as the Nominet Trust).

training and support to people who are trying to access employment-related services and secure employment could inform the UK government's planned digital retraining programme.

Looking at individual factors in the first column of the employability framework, the International Labour Organisation (ILO) definition of employability skills includes a combination of digital and other 21st century skills and highlights the role they play in making workers adaptable to changing circumstances, reinforcing the arguments about the right 'mix' of digital, 21st century and basic cognitive skills, that was already mentioned in section 3.1:

> *Individuals are most employable when they have broad-based education and training, basic and portable high-level skills, including teamwork, problem solving, information and communications technology (ICT) and communication and language skills. This combination of skills enables them to adapt to changes in the world of work.*
>
> *(Brewer, 2013, p iii)*

Considering both skills and individual circumstances (included in the second column of the employability framework), research by the Nominet Trust has found that poor literacy and numeracy prevent young people from using digital technology and living in a low income household could prevent access to broadband. It adds that the experience of unemployment, directly or in the household, affects young people's motivation to "develop digital skills through formal training programmes" (Nominet Trust, 2017, p 3).

Evidence about digital inclusion activity in Sunderland in northeast England suggests that those working in manual and routine jobs perceived technology to have less impact on their employment and employability than residents in managerial and professional and in intermediate groups (Clayton and Macdonald, 2013).

Turning to the third column of the digital employability framework and focusing on workplaces, it is clear that as employers' recruitment and selection strategies are increasingly web-based, workers need digital competencies to search and apply for jobs (as reflected in the digital skills frameworks discussed in Section 3.1). However, beyond searching and applying for jobs, the employability of low-skilled workers may not benefit a great deal from digital skills, for example, day labourers with digital skills are only more employable if a potential employer values those skills (Garrido et al., 2012).

New types of work are also enabled by digital technologies and a body of evidence focuses on how employer and organisational practices are fundamentally shaped by digital technology. In particular, platform work represents a major change in the relationship between employers and employees (see, for example Balaram, 2018). Platform work is defined as work providing services via online platforms, where the worker and the client are matched digitally, payment is conducted digitally via the platform and the work is location-independent, web-based or work is performed on-location (Pesole et al., 2018).

Some of this research is concerned with employee experiences (Broughton et al., 2018; Pesole et al., 2018), including evidence on the challenges platform workers face in developing their skills (Barnes et al., 2015). Members of the RWG also emphasised that for worker in stable employment it is easier to learn new digital skills, while those in casual employment face difficulties. Making a more general point, RWG members argued against adopting an idealised vision of workplaces where all employees benefit from workplace learning and resources.

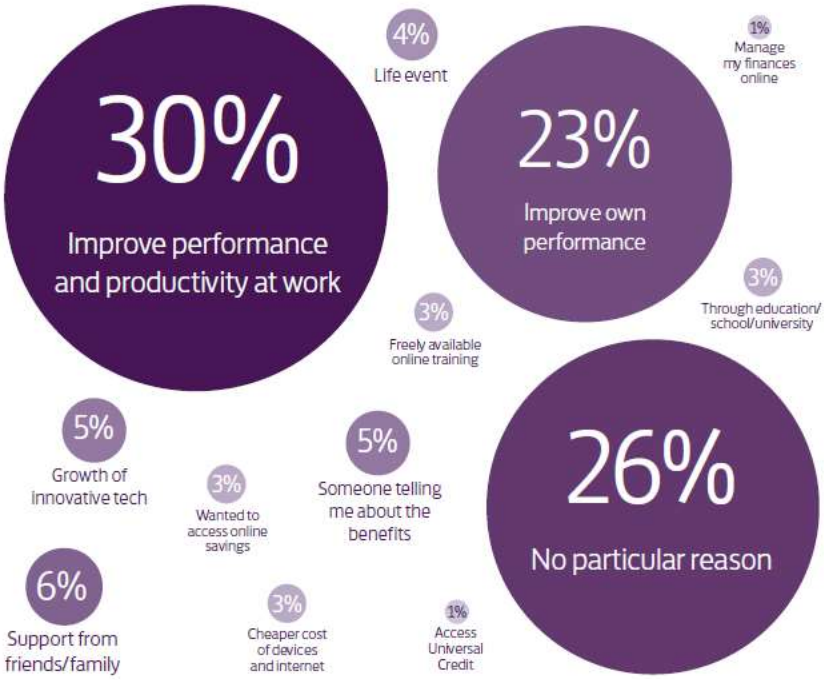
In the UK, a survey that informed the Consumer Digital Index 2018 shows that only a small proportion (14 per cent) of those who use the internet for work feel that their digital skills have improved through work (Lloyds Bank, 2018, p 25). The most important catalyst for adults to improve their digital skills is work: a third (30%) of those who said that their digital skills had improved in the year prior to the survey, said that the motivation for doing so was to 'improve performance and productivity at work' (see Figure 4). However, only a fraction, 6 per cent of this group received digital upskilling in the workplace (Lloyds Bank, 2018, p 25).[35]

The role of work organisations in training and upskilling their employees is also emphasised in research by the UK Digital Skills Taskforce (2014, p 100). The report quotes a manager from Network Rail, who described the somewhat unexpected challenges they faced when trying to recruit from existing staff into new job roles that required some digital skills. A number of different training approaches (from classroom-based teaching to mentoring) were necessary to enable staff take up the new positions. Closely related to the

[35] Information about workplace upskilling comes from telephone interviews with 2,700 adults who were selected from a UK representative sample of one million consumers aged 18 and older. The interviews allowed responses to be combined and compared with data based on 12 months of transactional behaviour that provides a longitudinal view to understand if or how people shifted their financial or digital capability over the year prior to the survey (Lloyds Bank, 2018, p 9).

responsibility of employers in developing the digital skills of their staff, members of the RWG argued that workers' motivation to learn new skills and to reskill is a key question and that the body of research on motivation should be reviewed in more detail. This evidence should also take into account the views of employees, who may resist learning new digital skills at work in an attempt to stop the intensification of work.

Figure 4 ***'If you have improved your digital skills in the past year – what was your motivation to do so?'*** **(Source: Lloyds Bank, 2018, p 25).**



Turning to local contextual and macro level factors that have an effect on employability (included in the fourth and fifth columns), research highlights the effect of local labour market conditions on the chances of workers to succeed in the workplace (Frey and Osborne, 2014 and Berger and Frey, 2016a). For example, it is argued that in the wake of the 1980s computer revolution in the US some 'skilled cities' adopted technology in ways that created new jobs for more skilled workers. In contrast, cities that specialised in routine or manual work, such as Cleveland and Detroit, did not benefit from the computer revolution and experienced decline in their local economies (Berger and Frey, 2016). These different patterns emerged as a result of local, city-level contextual factors. Finally, focusing on the regulatory and policy framework (macro level factors) of employability, evidence includes a recent report by the World Bank, which discusses the impact of macro-level

factors on individual workers. Acknowledging the impact of technology development on jobs, the report calls for national labour market policies which facilitate "easy and secure transition from one job to another as demands change" (Ridao-Cano and Bodewig, 2018, p. 11). Evaluating the current employment and social welfare policy in the UK, the report finds that macro level factors make it very difficult for workers to move from one job to another.

4. Gaps in the evidence base

This section of the evidence brief addresses the research question: What are the gaps in the publicly available evidence about the general digital skills workers need to succeed in the labour market? Evidence gaps identified by the research team and those identified by members of the Research Working Group are outlined and a number of research ideas, which were developed at the meeting of the Research Working Group on September 25th, 2018 are summarised in Boxes 7 – 10 in the remaining part of this section.

Box 7: Research project 1: Proposed research on digital skills and job quality

Proposed research on digital skills and job quality

The project aims to explore, from an employee perspective potential links between employees' digital skills and job satisfaction. Job quality needs to be conceptualised in relation to organisational skills, technological skills and social skills (among others) in key industrial sectors. Members of the RWG proposed the research question: 'What are the links between job quality and employee digital skills?' and recommended that existing databases should be searched for evidence on this question. They proposed that qualitative research methods should be used, because these can reveal details about people's everyday life experience. The team of RWG members who have developed this research idea expect that some of the challenges workers face in developing digital skills in the workplace are posed by managers and a lack of supportive organisational culture.

The first gap identified by the research team is that there is relatively little evidence about how digital skills are deployed in workplaces: most of the evidence focuses on digital skills requirements at the stage of recruitment (for example data derived from online job

advertisements and the analysis of skills shortages.[36] Further, there is limited evidence about the deployment of digital skills from the perspective of workers. Members of the RWG made two important comments in response to these findings: firstly, they noted that there is evidence about the effects of information overload related to technology and these findings about 'techno stress' would go some way towards filling this evidence gap . Secondly, a report, written in response to the Taylor Review of modern working practices (2017) was mentioned. This report includes eighteen 'priority measures' of job quality, designed to form the basis for a new national set of metrics. Some of these metrics, especially the 'use of skills' indicator may be relevant to future research on digital skills in workplaces (Irvine et al., 2018). The first research idea from the Research Working Group, presented in Box 7, also focuses on the deployment of digital skills in the workplace from the perspective of the workers.

It is clear from the reviewed evidence and the discussion at the Research Working Group meeting that improving the digital skills of workers with low levels of educational qualifications is of key importance, as these jobs are likely to be lost as a result of technological change. RWG members emphasised that these workers may come from disadvantaged groups and some of them have negative experiences with formal training, and research into what supports their engagement in learning is of key importance. It was suggested that relevant evidence could be collected from staff at Jobcentre Plus and NGOs which provide support to job seekers in accessing online employment services, and from those receiving the support (for example job seekers and participants of the Work and Health Programme).

[36] An important exception is a brief review of recent literature by Wallace Stephens (2018).

Box 8: Research project 2: Proposed research on motivation and behavioural change

Proposed research on motivation and behavioural change

The aim of this research project is two-fold: to understand why people do or do not improve their digital skills and capabilities and attempt to improve the current situation. The starting point is that high-level personal digital skills may not transfer to the workplace. The research must consider the context, which may encourage and support learning, such as social networks and culture, including support from friends and families.

The main research questions this project aims to address are: What are the drivers and inhibitors that influence people? What does and doesn't work in people's personal lives and at work over the short, medium and long term? How personal and work spheres of working lives are linked?

There are a number of key considerations in developing the research proposal in full: firstly, which population to focus on (considering: demographics, employment status, industrial sectors, geographical regions, work roles, types of work organisations, forms of employment and the needs of vulnerable groups) and secondly, how to ensure that the skills/capabilities the study measures will be relevant in the future?

Suggested research methods include conducting large-scale, self-reported surveys, in which the questions need to build on existing knowledge in this field. The other proposed research method is to conduct 'behavioural' market research, for example, a marketing approach that would explore people's immediate responses to an intervention. The third research method is ethnography, to find out what interventions are most effective in the long term, for example, assessing which messages from the senior staff at a workplace are most effective at fostering employee engagement. Finally, the research design also includes 'trial interventions' (matched control), in other words, determining at least roughly matched regions would be important. The proposed project would focus on a maximum of three industrial sectors, and questions of quality must be balanced with those of quantity of information.

This ambitious research project is likely to face challenges, including the tension between productivity and net overall benefit from improving digital skills.

The motivation to learn new digital skills was also highlighted as in important factor in skills learning and development – members of the Research Working Group outlined a research project idea, presented in Box 8, which focuses on this aspect of skills development.
The second evidence gap was identified by members of the RWG who felt that the links between digital skills and productivity are not well researched. They have created a research outline (Research project 3, presented in Box 9) to address this gap and added that regional level data would be particularly useful.

Box 9: Research project 3: Proposed research on digital skills and productivity

Proposed research on digital skills and productivity

The proposed research project aims to explore how digital skills are deployed at the workplace level, thus the proposed research questions are: How do we use digital skills to be more productive? How are digital skills deployed (at work)?
Research in this area is of key importance: productivity growth is closely linked to innovation and research into productivity is likely to lead to more general findings, beyond that of deploying digital skills (for example in the area of innovation).
A potential approach to studying this problem is to ask employers about their 'most productive' or 'most valuable' employees.
The suggested research methodology is a mixed method study in workplaces, including employee surveys, qualitative interviews with employees and management and participant observation. It is important to note that there is a long history of influential case studies conducted in workplaces (for example, the case study in the Toyota automotive sector in the 1990s).
When selecting case study organisations, a number of factors need to be considered, such as the industrial sector, size, ownership, product market strategy, because these factors are associated with the level of productivity.
The greatest challenge to this research project is gaining access to workplaces and the team considered ideas such as gaining access through management consultancies.

The final research project outline which was developed by members of the Research Working Group in response to the preliminary findings of this evidence aims to develop a

new classification of digital and complementary skills and explore how it may help the identification of current and future skills needs. This research outline is presented in Box 10.

Box 10: Research project 4: Proposed research on the classification of digital and complementary skills and the identification of current and future skills needs

Proposed research on the classification of digital and complementary skills and the identification of current and future skills needs

Existing forms of digital skills classification (including apprenticeship standards, T-levels qualifications, frameworks outlined in the report by Ecorys UK, 2016 and the Essential Digital Skills Framework) are used to assess and measure skills shortages, enable self-diagnosis and progression, create consistency, enable signposting services, curriculum development and industry body recommendations.

Currently, there is a 'cottage industry' of digital skills frameworks development and it is unlikely that there is a gap or need for a new framework. In contrast, there is a need to assess what we are measuring and why, when we measure digital skills. In other words, what problems does having a framework solve?

There may be an evidence gap on the comparative use and impact of different frameworks and there is also more to understand on how frameworks are built and updated. Thinking through the use and value of digital skills frameworks led the group to the following research questions:

What are the pathways for progression in the digital economy? In particular: how are pathways identified, represented, communicated? Are they fit for purpose? What are the barriers to progression (for example, age, resources, motivation, time)? Where are the 'pain-points' which prevent progression or lead to shortages in the digital economy (for example, information asymmetries). What about the gap between training and employment?

The proposed research methods include mapping skills and employment, to generate pathways from education to employment and for changing careers. This can be achieved through the use of longitudinal labour market data, data from the Labour Force Survey, other large scale surveys as well as data from Linked-In and qualitative analysis and case studies.

Finally, the research team suggested that existing evidence on digital skills, such as the types of skills in demand, data on skills shortages at local and regional level should be gathered and made more easily accessible.

5. Conclusions

This evidence brief is based on a review of evidence that was conducted to address the policy question: '*What digital skills do adults need to succeed in the workplace now and in the next 10 years?*' This policy question was translated into the following research questions: How are general digital skills for the workforce defined and conceptualised? What are the links between workers' general digital skills and success in the labour market? What types of general digital skills do workers need to succeed in the workplace now and in the next ten years, taking into account the effect of digitalisation on the labour market? What types of general digital skills do workers with lower, medium and high level skills and those in different occupations and industries need? Finally, the review also aimed to identify gaps in the evidence. To answer these questions, a systematic evidence review was conducted and the emerging findings were discussed at a meeting of the Digital Skills and Inclusion Research Working Group. The comments and research ideas from the meeting have been incorporated into this evidence brief.

In the first part of the conclusion the key findings are summarised. Starting with the definitions of general digital skills for the workforce, the evidence review has found that although much of the relevant literature discusses 'digital skills', this term is used as a shorthand to mean, among others skills, knowledge, behaviours, attitudes, competencies, capabilities, and character traits. Secondly, current frameworks for digital skills include a handful of key areas of skills and competencies, namely Information and data literacy, Digital communication and collaboration, Digital content creation, Digital safety, Digital identity and Awareness of digital rights at different levels of proficiency. Thirdly, in addition to ICT-related technical skills, digital skills also include non-technical, so-called '21st century skills', which can be grouped under a cognitive, intrapersonal and interpersonal domain. While there is a trend in the academic and practitioner literature to create comprehensive frameworks for digital skills, others scholars are critical of the attempts to give a general definition of 'digital skills' and call for more context-specific definitions, which clearly identify the group of people who need the skills, the context in which they need to use the

skills and the timeframe in which these skills are relevant. Finally, some of the most cutting edge research that looks at online vacancies information makes demand for digital skills measurable by effectively defining them as the ability to use certain software and applications, such as the Microsoft Office suite and carry out certain tasks, such as 3D printing. The review has found that it is difficult to establish the boundary between essential and more specialised digital skills for the general workforce and identify a list of digital skills beyond the essential level. Descriptions of digital competence as a 'T-shaped skill set', in which individuals possess depth in one area and good knowledge across many other areas are insightful.

The second and third research questions, looking at the types of general digital skills that workers need to succeed in the workplace now and in the next ten years are perhaps the most important ones addressed in this evidence brief. The main finding is that basic or essential digital skills (such as using a desktop computer) are needed in almost all occupations in the European Union, including about a third of plant machine operators and in elementary occupations. The analysis of online vacancy data (in the US and the UK) has also revealed that essential digital skills are required across low-, medium- and high-skilled occupations, and the used of productivity software are required for medium- and high-skilled occupations. Indeed, the use of Microsoft Office software is argued to be an 'entry ticket' to medium- and high-skilled jobs. There are also 'clusters' more specialist digital skills, such as digital design, Customer Relations Management (CRM) or machining technology, which are not necessarily advanced digital, but 'specialist' in the sense that they are essential in some occupations.

Most of the evidence about the future demand for general digital skills points at 21st century skills, especially interpersonal skills and cognitive competencies and learning strategies and argue that occupations where workers use digital skills creatively and to solve problems (for example engineering) are likely to grow, while occupation where digital skills are used for routine tasks (such as in HR occupations) are likely to decline. As for the drivers of change, most research evidence focuses on the effect of automation on future occupations and a number of recent studies loosely agree that about 30 per cent of jobs will be significantly affected, but disagree whether jobs will be fully automated or there will be a major change in task composition.

The final research question addressed in this evidence brief is about succeeding in the workplace: How can it be conceptualised and what are the links between digital skills and

success? As most of this evidence brief focuses on the individual worker and their skills and competencies, Section 3.2 is a very important counterpoint: it includes evidence about contextual factors, beyond the control of the individual that also shape success in the workplace. The concept of employability is useful here and the employability framework presented in Section 3.2 includes individual circumstances, workplace-, local- and macro-level factors. Most evidence focuses on labour market entry and the challenges facing lower-skilled workers. There is also a growing body of evidence about platform working, including from the perspective of the workers themselves, but there is relatively little evidence about how digital skills are deployed in the workplaces.

The evidence review and the Research Working Group also identified gaps in the evidence base. Perhaps the most important gap concerns information about digital skills from workplaces and from the perspective of workers. Research with lower-skilled workers, who are the most likely to face new digital skills requirements in the context of increasing automation would be particularly important. We hope that the research ideas developed by the Research Working Group and presented in Section 4 of this evidence brief will be useful in motivating the research and practitioner communities.

The evidence review has a number of limitations. As with all reviews, it is only based on publicly available literature which may exclude research currently underway and within this context the fast-changing context of studying digital skills this could be important. The resources allocated to this brief mean that only a selected number of databases could be searched. However, a range of evidence from academic and grey literature has been reviewed and included in the evidence brief, which provides a substantive overview of the current definitions, frameworks and debates in response to the research question.

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Appendices

Appendix A

Appendix A Table 1: Keyword search terms

Search 1		
Keyword 1	**Keyword 2**	**Keyword 3**
digital skills	workplace	future
digital literacy	workforce	2030
digital literacies	labour market	2020
IT skills	employment	forecast
ICT skills	employee	projection
technical skills	economy	
technology	business	
21st century skills	worker	
digital revolution	staff	
digital transformation	recruitment	
IT training	hiring	
ICT training		
Search 2		
Keyword 1	**Keyword 2**	**Keyword 3**
digital technology	skills	future
technology implementation	skills demand	2030
4th digital revolution	skills supply	2020
	skills gaps	forecast
	skills development	projection

Appendix B

Appendix B Table 1: Digital skills/competencies/literacies/capabilities frameworks

Reference	Main areas of digital skills included in the framework
Tech Partnership/HM Government Essential digital skills framework (2018)	Essential Digital Skills for life and work include five categories: 1) communicating, 2) handling information and content, 3) transacting, 4) problem solving and 5) being safe and legal online.
Core Skills for Work Developmental Framework Australia (2013)[37]	The Core Skills for Work Developmental Framework describes a set of non-technical skills, knowledge and understandings that underpin successful participation in work. Cluster 3 'Get work done' includes a skill area entitled 'Work in a digital world.' There are four focus areas within the skill area: Use technologies, Connect with others, Access, organise and present information and Manage risk. The framework has five proficiency levels ranging from a 'novice performer' through a 'capable performer' to an 'expert performer'. 'Work in a digital world' refers to the capacity to connect to other people, information and contexts for work-related purposes using digital systems and technology. It involves understanding concepts and language associated with the digital world and the capacity to understand and work with accepted etiquette and risks associated with online environments.
Digital Capability Framework (Jisc, 2016)	The framework is the output of a research project and the terminology has shifted from 'digital literacy' to 'literacies' and then to 'digital capabilities' – reflecting the development of scholarship during the lifetime of the project. Digital literacies are defined as: those *capabilities which fit an individual for living, learning and working in a digital society. Digital literacy* looks beyond functional IT skills to describe a richer set of *digital* behaviours, practices and identities. The most recent version of the framework includes six elements: ICT proficiency; information data and media literacies; digital creation, problem solving and innovation; digital communication, collaboration and participation; digital learning and development; and digital identity and

[37] Australian Government, 2013, Core skills for work developmental framework.

	wellbeing. These are further divided into 15 sub-elements recognising a combination of functional skills, critical use, creative production, participation, development, and self-actualising (Jisc, 2016; cited in Beetham, 2017).[38]
Health Education England's Digital Capabilities Framework (2018)[39]	The framework builds on research (particularly that of Jisc and Helen Beetham) and stakeholder engagement to provide levels of digital capabilities for all health and care staff within six domains. The framework describes digital literacy as 'those capabilities that fit an individual for living, working, learning, participating and thriving in a digital society'. The six domains outlined in the framework are: digital identity, wellbeing, safety and security; data, information and content; communication, collaboration and participation; technical proficiency; teaching, learning and self-development; creation, innovation and research.
European Digital Competence Framework for Citizens 2.0 (2016)[40] and its updated version, known as DigComp 2.1 (2017)[41]	The DigComp framework is a general, high level description of a set of competences that are seen as relevant for users of digital technology. The framework identifies 21 competences in five areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving, across 4x2 proficiency levels - each of the four levels (foundation, intermediate, advanced and highly specialised) are divided into two sub-levels.

[38] Beetham, H., 2017, Digital capability framework: an update.

[39] HEE, 2018, Digital capabilities framework.

[40] Vuorikari, Punie, Carretero Gomez, & Van den Brande, 2016, European digital competence framework for citizens 2.0

[41] Carretero, Vuorikari & Punie, 2017, DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use.

Appendix B Table 2: Classifications of digital skills, competencies and literacies

Reference	Definitions and main areas of digital skills included in the classification
Ecorys UK (2016)[42]	Three main categories of digital skills: **basic digital literacy skills, digital skills for the general workforce and digital skills for the ICT professions**. The first two categories are relevant to the policy question addressed in this Evidence Brief. **Basic digital literacy skills** are grouped in four categories: Understanding digital information and communication (literacy, numeracy, writing, communication skills and understanding the basic legal and ethical framework that applies to the use of ICTs); IT management (functional skills, such as backing up and deleting data, installing software and creating passwords); Managing information (online and offline) and Digital communication. **Digital skills for the general workforce**: all of category 1, and Information management and processing (such as spreadsheets, word processors, databases, presentations); Safety and security and Sector-specific digital skills (for example 3D printing, CAD, digital marketing, but also automated milking on farms).
OECD (2016)[43]	The framework does not refer to digital skills, but **ICT-related skills,** which are grouped into three categories: ● **ICT generic skills**: to use ICT technologies for professional purposes. ● **ICT specialist skills:** to programme, develop applications and manage networks. ● **ICT complementary skills:** to perform new tasks associated to the use of ICTs at work (e.g.: information-processing, self-direction, problem-solving and communication). ● **Foundation skills**: Foundation skills refer to the literacy and numeracy proficiency, which are usually developed in early years. In EU Member States the level of ICT generic skills is measured by the OECD Survey of Adult Skills (PIAAC).
UNESCO Broadband Commission for Sustainable Development (2017)[44]	The Commission defines digital skills as a "combination of behaviours, expertise, know-how, work habits, character traits, dispositions and critical understandings" which are on a "continuum from basic functional skills to higher level, specialist skills" (Broadband Commission for Sustainable Development, 2017, p.4).

[42] Ecorys UK, 2016. Digital skills for the UK economy.

[43] OECD, 2016. Skills for a digital world: working party on measurement and analysis of the digital economy.

[44] Broadband Commission for Sustainable Development, 2017, Working group on education: Digital skills for life and work.

	Three categories of digital skills: 1) Basic functional digital skills (accessing and engaging with digital technologies); 2) Generic digital skills (using digital technologies in meaningful and beneficial ways); 3) Higher level skills: (using digital technology in empowering and transformative ways).
European Skills / Competences, qualifications and occupations (ESCO) (2017)[45]	ESCO lists digital skills, competences and knowledge and links them with occupations. Skills and competence areas: ICT safety, 2) digital data processing, 3) digital content creation, 4) problem-solving with digital tools and 5) digital communication and collaboration. ESCO includes 550 different ITC skills, including 'transversal ICT skills', which are similar to 21st century skills.

[45] Digital competencies, ESCO classification. https://ec.europa.eu/esco/portal/skill.

Appendix B Table 3: Definitions of digital skills based on online job advertisements

Reference	Definitions
Beblavý et al.(2016)[46]	The study defined three levels of IT/digital skills: Basic/general digital skills, for example 'computer skills', 'internet' and 'e-mail'. Intermediate digital skills include five categories based on 'productivity software skills' (word processing, spreadsheets, Power Point, office packages and SAP). Advanced digital skills, these were divided into nine categories: customer relationships management (CRM); databases and data management; data analysis and statistics, programming and programming languages; digital media and web design; desktop publishing, Content Management Software (CMS); social media and blogging and search engine analysis (SEO).
Djumalieva and Sleeman (2018)[47]	Djumalieva and Sleeman analysed online job advertisements and the study defined 'digital skills' to include employer requirements including knowledge of specific (e.g. Maya) as well as (e.g. 3D printing).
Burning Glass (2019)[48]	Two categories of digital skills are defined: Baseline digital skills: productivity software skills Advanced digital skills: this category includes seven clusters of digital skills: Programming skills, Computer and networking support, Data analysis, Digital design, Customer Relations Management (CRM), Digital marketing and Machining technology.

[46] Beblavý, M., B. Fabo and K. Lenaerts, 2016, Demand for digital skills in the US labour market: the IT skills pyramid.

[47] Djumalieva, J. and C. Sleeman, 2018, Which digital skills do you really need?

[48] Burning Glass Technologies, 2019, No longer optional: Employer demand for digital skills.