OECD publishing

OECD DIGITAL ECONOMY PAPERS
No. 250

SKILLS FOR A DIGITAL WORLD

2016 MINISTERIAL MEETING ON THE DIGITAL ECONOMY

BACKGROUND REPORT



2016 MINISTERIAL MEETING
THE DIGITAL ECONOMY:
INNOVATION, GROWTH
AND SOCIAL PROSPERITY

OECD
BETTER POLICIES FOR BETTER LIVES

FOREWORD

This report sets the scene for the discussion of Panel 4.2 “Skills for a Digital World” of the OECD Ministerial Meeting on the Digital Economy, 21-23 June 2016, Cancún (Mexico). It provides new evidence on the effects of digital technologies on the demand for skills and discusses key policies to foster skills development for the digital economy.

The report was prepared by Michele Rimini and Vincenzo Spiezia, OECD, for the Working Party on Measurement and Analysis of the Digital Economy (MADE). It was approved and declassified by the Committee on Digital Economy Policy on 13 May 2016 and prepared for publication by the OECD Secretariat.

Note to Delegations:
This document is also available on OLIS under reference code:
DSTI/ICCP/IIS(2015)10/FINAL

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

© OECD 2016

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for commercial use and translation rights should be submitted to rights@oecd.org.

TABLE OF CONTENTS

FOREWORD 2

EXECUTIVE SUMMARY 4

SECTION 1. WHAT SKILLS FOR THE DIGITAL ECONOMY? 6

ICT generic skills 6
ICT specialist skills 7
ICT complementary skills 9
Foundation skills 11

SECTION 2. THE OECD SKILLS STRATEGY: A FOCUS ON THE DIGITAL ECONOMY 13

2.1 Developing Relevant Skills for the Digital Economy 14
Strengthening foundation skills 14
Good practices at the school level 15
Good practices at the national level 16
Good policy practices for the promotion of digital literacies 17
2.2. Activating Skills in the Digital Economy 20
Active labour markets policies for the digital economy 20
Skills Assessment and Anticipation Exercises for the Digital Economy 22
2.3 Putting Digital Skills to Effective Use 23
Workforce training for the digital economy 24
Age biased technological change, workforce training and training obsolescence 25
Supporting workforce training and digital leadership in SMEs 25
Governing skills systems for the digital economy 27
Building effective multi-stakeholder partnerships 29

SECTION 3. LEVERAGING DIGITAL TECHNOLOGIES FOR BETTER SKILLS 30

Digital technologies facilitate personalised learning 30
Digital technologies foster collaborative learning 31
Digital technologies reduce time and space barriers 33
Digital technologies are changing expectations on the teaching profession 35
Policies that address teachers' professional development needs in ICT 36
ICTs to support professional learning communities 38
Massive Open Online Courses (MOOCs) for Lifelong Learning 38
Data driven innovation in teaching and learning 41
Digital technologies and the labour market 44

CONCLUSION 49

NOTES 50

REFERENCES 51

EXECUTIVE SUMMARY

The pervasiveness of digital technologies in daily life is fundamentally changing the way individuals access and elaborate knowledge. Individuals have to process complex information, think systematically and take decisions weighting different forms of evidence. They also have to continuously update their skills to match rapid technical change at the workplace. More fundamentally, in order to seize the new opportunities that digital technologies are opening in many areas, individuals have to develop the right set of skills to make a meaningful use of these technologies.

Increasing use of digital technologies at work is raising the demand for new skills along three lines: ICT specialist skills to programme, develop applications and manage networks; ICT generic skills to use such technologies for professional purposes; and 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, digital literacies as well as social and emotional skills are crucial to enable effective use of digital technologies by all individuals in their daily lives.

To ensure that individuals can engage in digital activities and adapt rapidly to new and unexpected occupations and skills needs, a stronger emphasis has to be placed in promoting strong levels of foundation skills, digital literacies, higher order thinking competencies as well as social and emotional skills.

These changes in the demand for skills present two major challenges to skills development systems, including formal education, training and the recognition of skills acquired through non-formal learning. First, while there is awareness that the skills profile of citizens and workers will be very different than in the past, the skills of the future are difficult to identify with certainty due fast technological changes. The second challenge is to ensure that, once changes in skills have been identified, skills development systems adjust sufficiently fast to match new skills demands.

While raising the demand for new skills, digital technologies are also creating new opportunities for skills development. Massive Online Open Courses (MOOCs) and Open Educational Resources (OER) modify learning methods and give access to quality resources to a larger population over more flexible hours. The use of digital technologies in formal education and vocational training has the potential to improve learning, although the outcomes depend on the capacity to link these tools to effective pedagogy. Big data analytics can also complement labour market information systems with a more timely and precise monitoring of changing skills demand to adapt skills development and activation policies.

Lastly, the increase in the quantity of data that are collected on education and labour markets on a daily basis through online courses, administrative records and online job vacancies, and their exploitation through data analytics can open endless avenues for research and innovation in education and training and helps to better inform policy decisions.

In spite of their potential, these initiatives have, thus far, remained a niche. Barriers to their adoption include limits on learners and teachers/trainers' capacity to take advantage of digital technologies; concerns about the quality of online education; and the lack of recognition for learning outcomes. Policies to overcome these barriers and to ensure consistency and quality, especially in an international marketplace, are key to grasping the learning opportunities created by these tools.

The OECD has developed a comprehensive Skills Strategy that helps countries identify the strengths and weaknesses of their national skills systems, benchmark them internationally, and develop policies that can transform better skills into better jobs, economic growth and social inclusion. The OECD Skills Strategy provides a useful approach to address the opportunities and challenges for skill development in

the digital economy. This approach consists of three main steps. First, identify more precisely the kind of skills required in the digital economy, through the definition of an agreed framework for digital literacy, further cross-country analysis of existing datasets and the development of new surveys. Second, examine how these changes may translate into curriculum reform, teacher training and professional development. Third, leverage ICTs to improve the access to and the quality of education and training, e.g.: through online courses, new learning tools at school and adequate recognition of skills acquired through informal learning.

SECTION 1. WHAT SKILLS FOR THE DIGITAL ECONOMY?

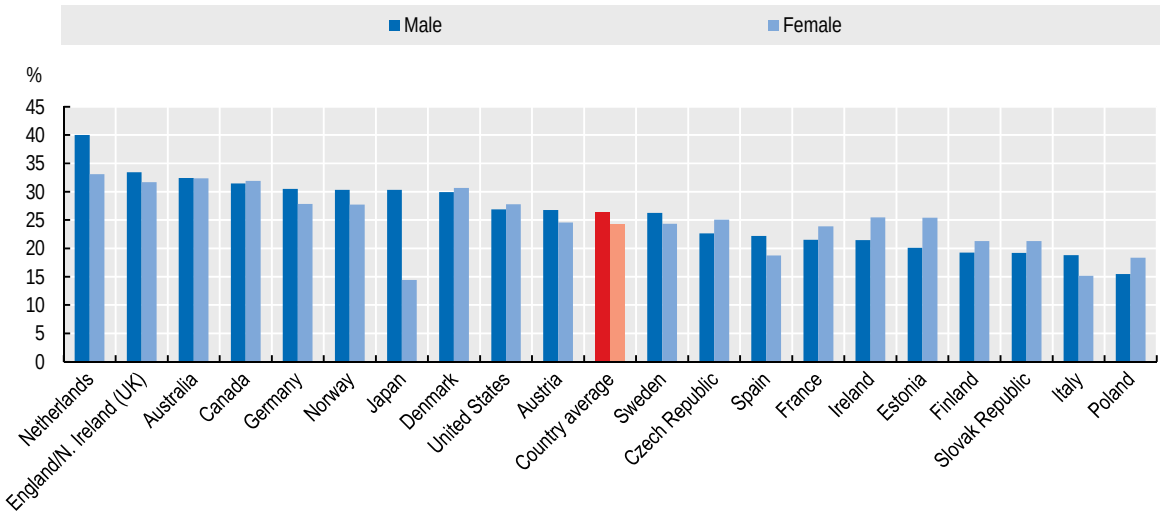
Increasing use of digital technologies at work is raising the demand for new skills along three lines. First, workers across an increasing range of occupations need to acquire generic ICT skills to be able to use such technologies in their daily work, e.g.: access information online or use software. Second, the production of ICT products and services – software, web pages, e-commerce, cloud and big data – requires ICT specialist skills to programme, develop applications and manage networks. Third, the use of ICTs is changing the way work is carried out and raising the demand for ICT-complementary skills, e.g.: the capability to process complex information, communicate with co-workers and clients, solve problems, plan in advance and adjust quickly. Last but not least, the attainment of sound levels of foundation skills constitutes a prerequisite for the proficient development of ICT generic, specific and complementary skills.

ICT generic skills

OECD analysis (OECD, 2016) shows that the demand for ICT generic skills, as measured by the OECD Survey of Adult Skills (PIAAC), has increased in a large majority of countries. Yet, the frequency of ICT use at work continues to differ significantly across them (Figure 1). Furthermore, in half of the countries surveyed by PIAAC, women tend to use ICT at work less than men.

Figure 1. Daily users of office software at work, by gender, 2012

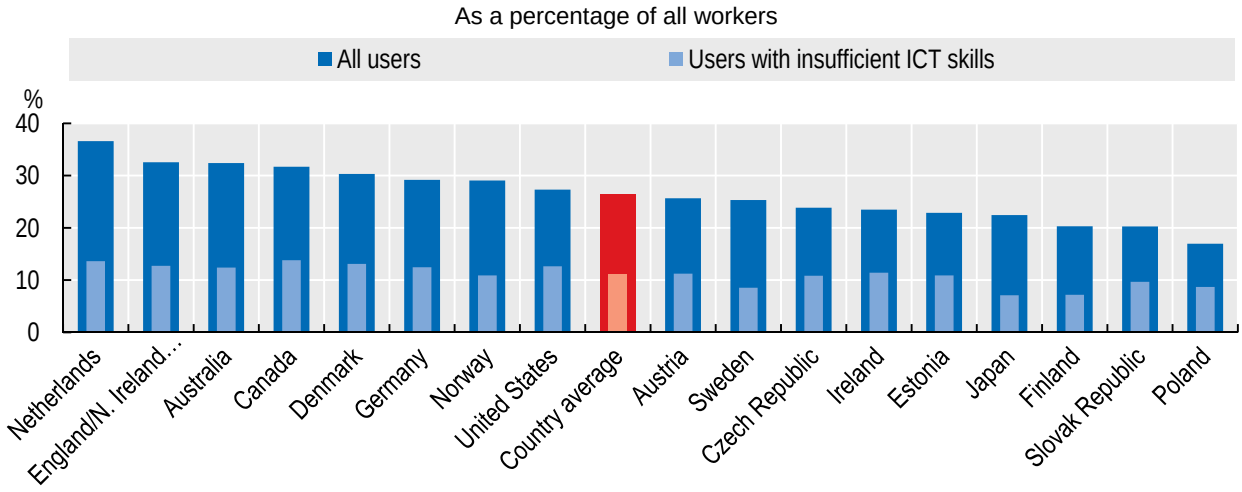
As a percentage of all workers



Source: OECD, based on PIAAC.

The analysis also compares the demand for ICT generic skills and the supply of these skills in the workforce, as measured by the PIAAC assessment of ICT skills. Many workers use ICTs regularly without adequate ICT skills: on average, over 40% of workers using office software every day do not seem to have sufficient skills to use them effectively according to the assessment (Figure 2).

Figure 2. Daily users of office software at work, by ICT skills



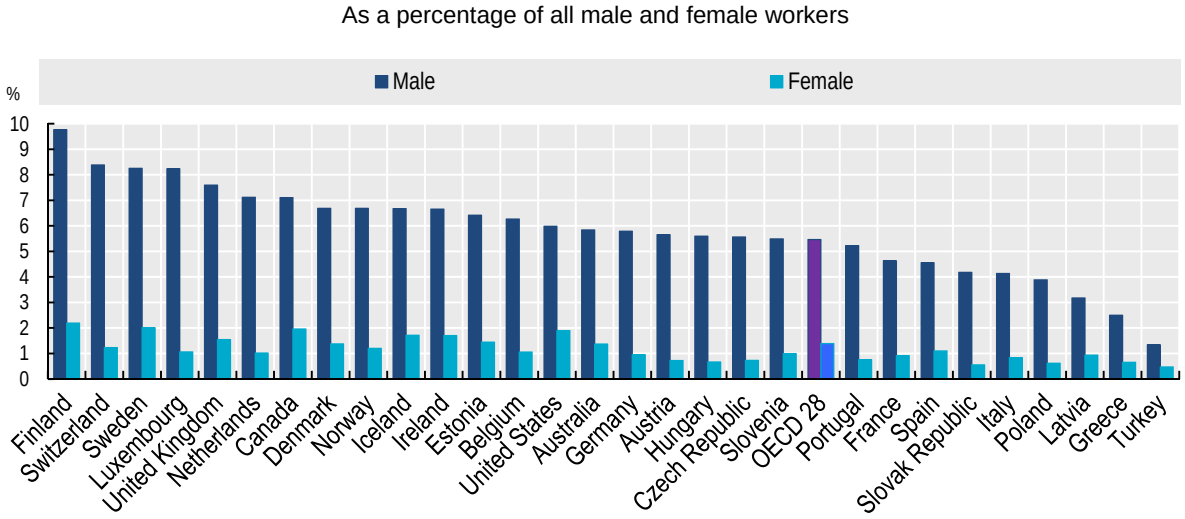
Source: OECD (2016).

ICT specialist skills

ICT specialists have been among the most dynamic occupations in recent years and several forecasts suggest that the demand for ICT professionals will grow even faster in a near future. In 2014, ICT specialists accounted for 3.6% of all workers in OECD countries. This figure hides large differences between men and women. While 5.5% of male workers in OECD countries are ICT specialists, this proportion is just 1.4% for female workers (Figure 3).

Some forecasts predict a significant shortage of ICT professionals (EC, 2014; OECD 2014c) over the next 5 to 15 years. These forecasts rely on a scenario-based approach which, by its very nature, is hard to validate. Unfortunately, available statistics do not permit to address these issues thoroughly.

Figure 3. ICT specialists by gender, 2014

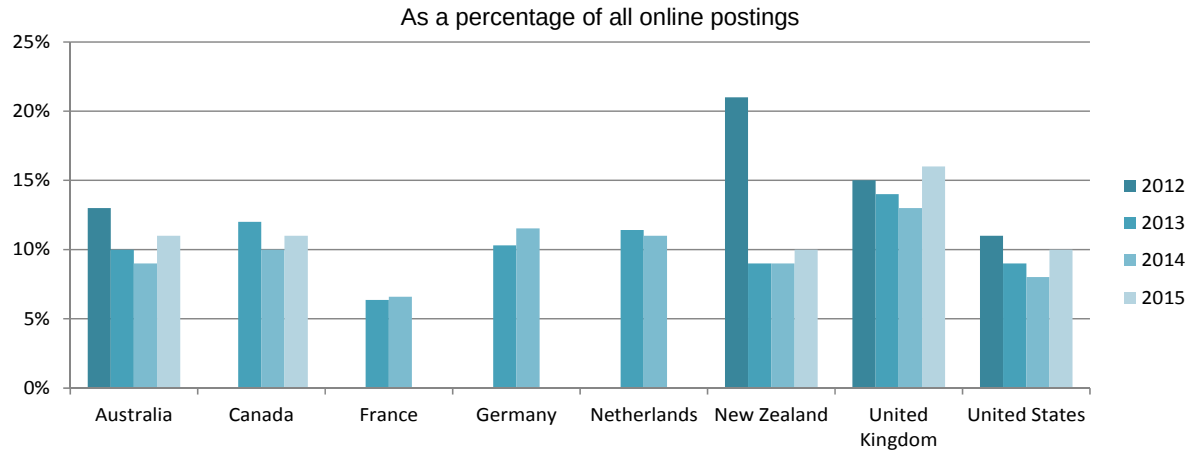


Source: OECD, based on Australian, Canadian and European labour force surveys and United States Current Population Survey, April 2016.

Official statistics on wages and job vacancies are mostly available at the level of industries, not occupations. In ICT services, wages have been growing in line with productivity growth over for 15 years while vacancy rates have remained stable or even decreased since 2007 (OECD, 2016).

The share of online vacancies for ICT specialists has also remained stable in most countries for which data are available since 2012 (Figure 4). Median vacancy duration, i.e.: the number of days necessary to fill an online vacancy for ICT specialists was just 32 days in France, Germany and the Netherlands in 2014.

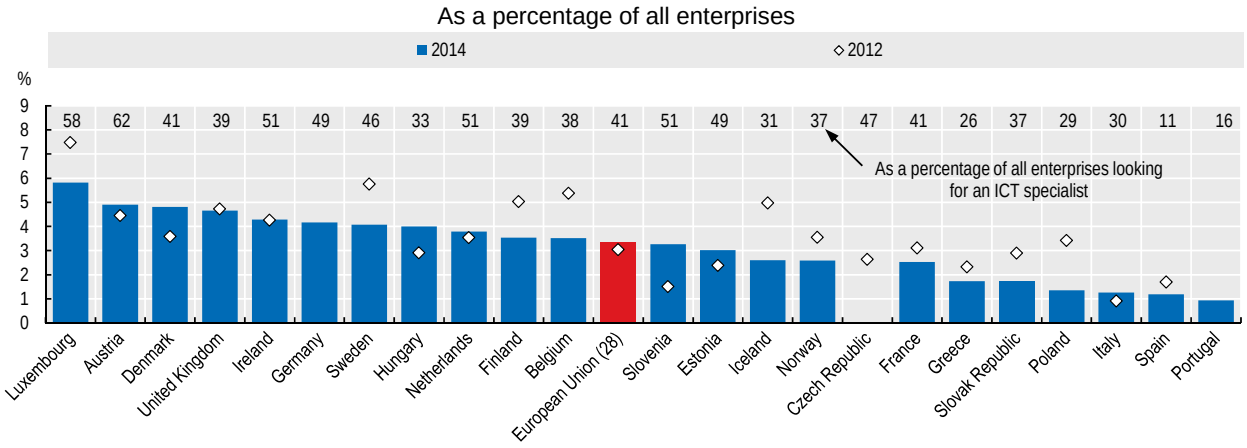
Figure 4. ICT online job postings (2012-2015)



Source: OECD (2015x), based on BurningGlass (www.burning-glass.com) and Jobfeed (www.textkernel.com).

Employers' surveys provide complementary information about potential skills shortages. In the European Union, 41% of enterprises looking for an ICT specialist report having difficulties to fill the vacancies. However, only a small share of enterprises (14%) wants to hire one. Therefore, the percentage of enterprises reporting hard-to-fill vacancies for ICT specialists is only about 3% and has not changed from 2012 to 2014 (Figure 5). Business surveys in Australia and New Zealand as well as other international surveys report similar findings (OECD, 2016).

Figure 5. Enterprises that reported hard-to-fill vacancies for ICT specialists, 2012 and 2014



Source: OECD (2016).

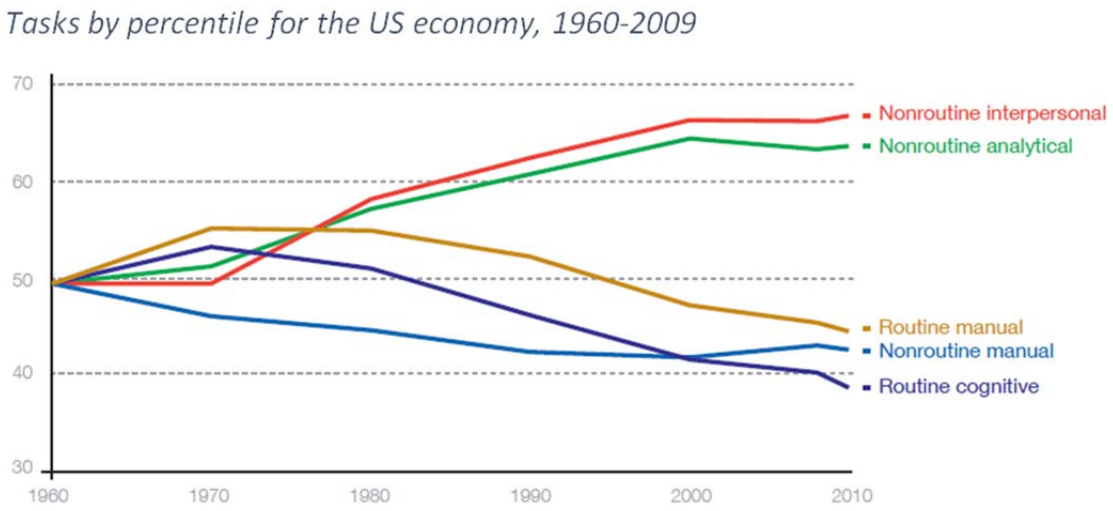
As available statistics do not permit to fully address these questions, the development of better measures – based on both official statistics and online vacancies – is an important step for future work.

ICT complementary skills

The diffusion of ICT at the workplace is not only raising the demand for ICT specialist and generic skills. It is also changing the way work is carried out and raising the demand for ICT- complementary skills. These are skills that are not related to the capability to use the technology effectively but to carry out the work within the new environment shaped by ICTs, i.e.: a "technology-rich environment". For instance, higher frequency of information made available by ICTs calls for better capability to plan in advance and to adjust quickly. Organisations characterised by horizontal work enabled by ICTs call for more cooperation across teams and stronger leadership. Wider diffusion of information among a larger number of workers increases the importance of management and coordination. The sales skills required in face-to-face commercial transaction are not the same as those involved in an anonymous e-commerce sale.

A significant strand of literature (Author, Levy and Murnane 2003; Van Reenen, 2011; Michaels *et al.*, 2014) argues that digital technologies are replacing workers in performing routine tasks and increasing demand for non-routine ones (Figure 6). Such shifts in the relative importance of tasks at the workplace raise questions on what skills workers should develop to meet new requirements at work.

Figure 6. The changing nature of work



Source: Levy, Frank and Richard J. Murnane (2013). "Dancing with robots: Human skills for computerized work." Third Way NEXT.

Developing skills policies based on trends in task demands, however, has its own risks due to rapid tasks and skills obsolescence (OECD, 2013a). The insights of the educational research community on the definition and development of 21st century skills are important to bridge the gap between a task-based approach and good practice examples. Yet, further research is required to map ICT tasks to the 21st century skills.

The educational research community has pointed out the profound transformation from industrial to knowledge-based economies and societies, whereby knowledge becomes central and needs to be continuously regenerated by learning (Dumont and Istance, 2010). Students should prepare themselves for jobs that do not yet exist, technologies that have not been yet invented and problems that are not yet recognised as such (*ibid.*).

Workers in the digital economy should be able to generate and process complex information; think systematically and critically; take decisions weighing different forms of evidence; ask meaningful questions about different subjects; be adaptable and flexible to new information; be creative; and be able to

identify and solve real-world problems (Dumont and Istance, 2010, p. 23). These requirements do not create a demand for new skills but rather increase the importance of some human competences that have been valuable for many centuries (National Research Council, 2012).

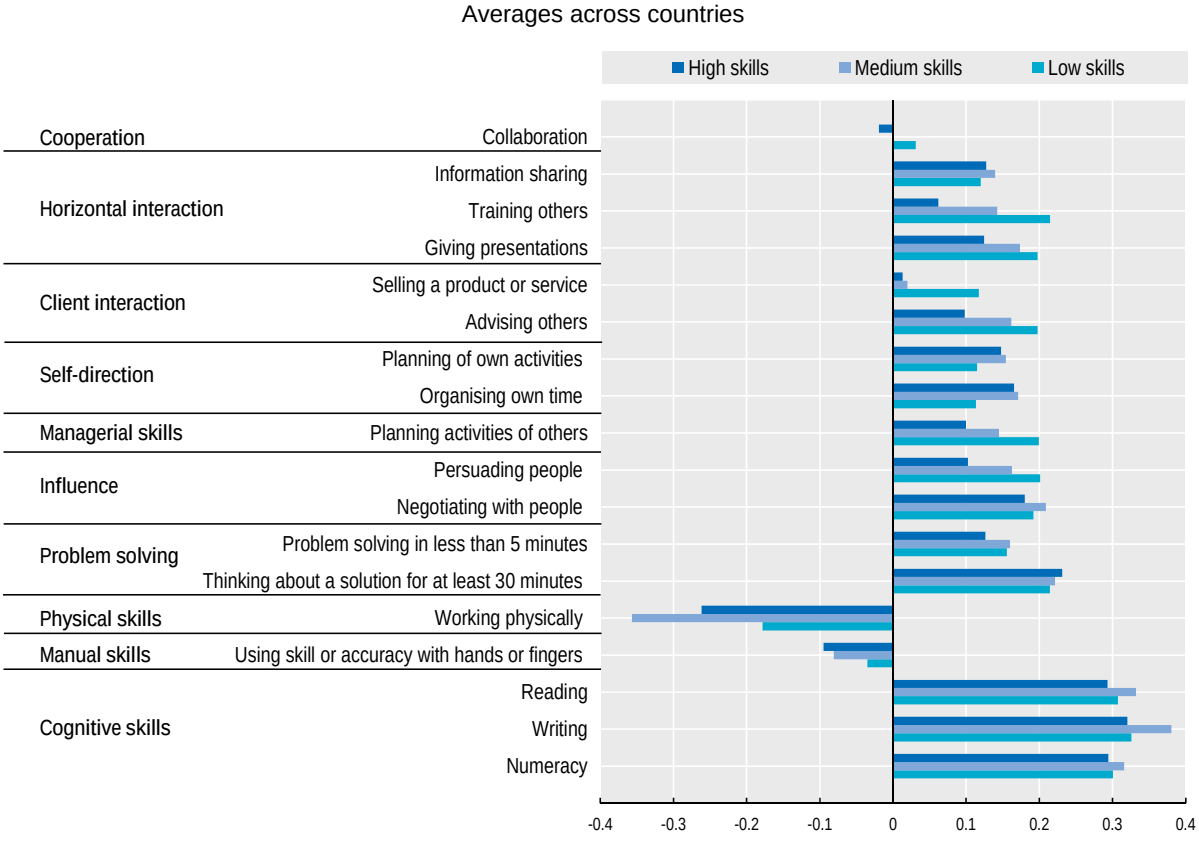
While the process of identification of 21st century skills is still ongoing, researchers have developed broad classifications that can be partially linked to a task-based approach. In particular, the National Research Council in the United States has identified three broad domains: a ***cognitive*** domain, including cognitive processes, knowledge and creativity; an ***intrapersonal*** domain, including intellectual openness, work ethics and self-confidence; and an ***interpersonal*** domain, including teamwork, collaboration and leadership. Interestingly, this classification corresponds to another strand of work by the OECD aimed at identifying what skills are crucial for social progress and well-being (OECD, 2015i). According to this classification, next to ***cognitive*** skills children should be able to develop ***social*** and ***emotional*** skills, sometimes also referred to as "soft skills". Social and emotional skills include working with others, managing emotions and achieving goals.

The research literature argues that those are not endowments that children are born with, but rather a set of malleable characteristics that can be developed and improved in an appropriate learning environment (ibid.). Moreover, social and emotional skills should be developed alongside 21st century skills as they contribute directly to their development. As an example, critical thinking combines a cognitive component - the ability to reflect on information, with an emotional part – being open to unconventional thoughts (OECD, 2015i). As an additional layer of complexity, skills such as creativity and social skills are difficult to measure and consensus is yet to be reached on how they should best be fostered in formal education (OECD, 2015i, 2015l).

OECD research also shows that higher use of ICT at work is associated with tasks that require more interaction with co-workers and clients, more problem solving and less physical work (Figure 7). As ICTs are reshaping business models and firms' organisation, the skills required to perform these tasks become more important.

Changes in the tasks set associated to increasing use of ICTs tend to be larger for people in low-skill occupations than for those in middle and high-skill occupations. Therefore, the need for re-skilling is likely to be bigger for those people that educational and training systems have more trouble to reach.

Figure 7. Correlations between daily use of ICTs at work and other tasks - by skill level



Source: OECD (2016), Figure 14b.

Foundation skills

According to the results of the Programme for International Students Assessment (PISA) and the Survey of Adult Skills (PIAAC), ***sound levels of foundation skills*** are a prerequisite for the development of the skills demanded in the digital economy. Foundation skills refer to the literacy and numeracy proficiency of students and adults, which are usually developed in early years (OECD, 2015j), most often before entering compulsory education.

The PISA survey measures digital literacies as the ability to "evaluate information from several sources, assessing the credibility and utility of what is written using self-established criteria as well as the ability to solve tasks that require the reader to locate information, related to an unfamiliar context, in the presence of ambiguity and without explicit directions"(OECD, 2015k, p. 91). In other words, digital literacy can be seen as the ability to read and navigate autonomously digital content.

Evidence shows that the performance of 15 years old students in digital literacy is positively correlated with their performance in reading (ibid.). At the same time further analyses of the browsing behaviour of students reveal that among students of similar reading performance, the extent to which their behaviour conforms to targeted navigation ("think before you click") is associated with differences in digital reading performance. This reinforces the idea that navigational skills have more to do with the ability to regulate and monitor cognitive processes or with spatial reasoning, than with mere technical aspect of browsing.

The importance of foundation skills as a basis for the development of digital literacies is further illustrated by the results of PIAAC in problem solving in technology-rich environments. The PIAAC results reveal a positive association between problem-solving performance and literacy and numeracy. On average across OECD countries, 83% of adults who are highly proficient in literacy (Level 4 or 5 in the assessment) are also highly proficient (Level 2 or 3) in problem solving in technology-rich environments (OECD, 2015a). While these high correlation levels may be partially explained by the nature of the analysed tasks in the problem solving assessment, they still reveal a preponderance of literacy and numeracy in serving as foundations for the development and acquisition of higher order cognitive skills. Both PISA and PIAAC findings confirm the importance of foundation skills as a basis for the acquisition of the skills that are and will increasingly be required in the digital economy.

In today's societies even simple interactions and transactions tend to require writing and reading, rather than speaking and listening only – e.g. asking information from a help-desk, making a professional appointment, sharing information with team members, etc. (OECD, 2015a). Therefore, reading and writing skills become increasingly relevant to fully grasp the benefits of technology rich societies.

Finally, foundation skills are a fundamental pre-requisite for lifelong learning. Pursing this idea, in 2006 Norway launched the Programme for Basic Competencies in Working Life (BKA) with the aim of strengthening literacy, numeracy and ICT skills among the adult population (OECD, 2014b).

SECTION 2. THE OECD SKILLS STRATEGY: A FOCUS ON THE DIGITAL ECONOMY

The changes in the demand for skills driven by the digital economy present two major challenges to skills development. First, while there is awareness that the skills profile of citizens and workers will be very different than in the past, the skills of the future are difficult to identify with certainty due fast technological change in the digital economy. The second challenge is to ensure that, once changes in skills have been identified, skills development systems adjust sufficiently fast to match new skills demands.

The OECD has developed a comprehensive Skills Strategy that helps countries identify the strengths and weaknesses of their national skills systems, benchmark them internationally, and develop policies that can transform better skills into better jobs, economic growth and social inclusion. The Skills Strategy supports countries in adopting a systematic and comprehensive approach to skills policies that can:

- *Prioritise investment of scarce resources*: Since developing new skills is a costly and long-term endeavour, skills policies need to be designed so that these investments reap the greatest economic and social benefits.

- *Combine short- and long-term considerations*: Effective skills policies are needed to respond to structural and cyclical challenges, such as rising unemployment when economies contract or acute skills shortages when sectors boom, and to ensure longer-term strategic planning for the skills that are needed to foster a competitive edge and support required structural changes.

- *Build a case for lifelong learning*: By seeing skills as a tool to be honed over an individual's lifetime, a strategic approach allows countries to assess the impact of different kinds of learning – from early childhood education through formal schooling to formal and informal learning later on – with the aim of balancing the allocation of resources to maximise economic and social outcomes.

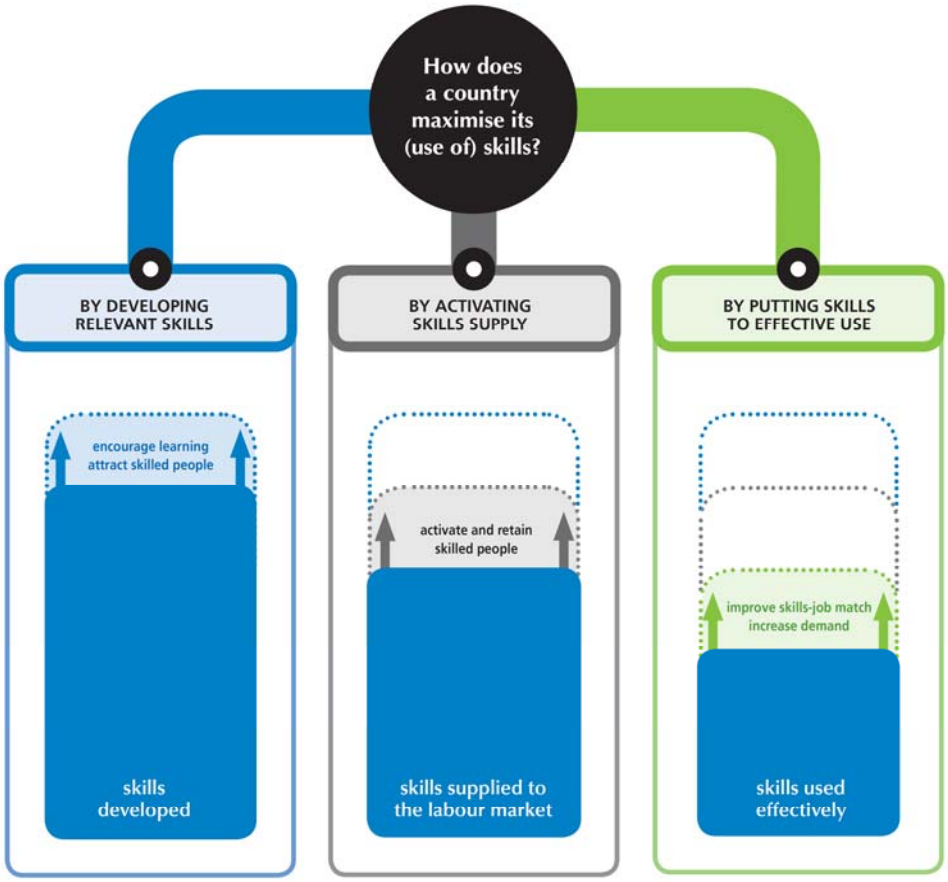
- *Foster a whole-of-government approach*: If skills are to be developed over a lifetime, then a broad range of policy fields are implicated, including education, science, technology and innovation, industry, employment, economic development, migration and public finance. Aligning policies among these diverse fields helps policy makers to identify policy trade-offs that may be required and avoid duplication of efforts and ensure efficiency. This may prove challenging in national skills development systems where responsibility are shared across sub-national levels of government, such as cities, regions and states.

- *Align the perspectives of different levels of government*: With major geographical variations in the supply of and the demand for skills within countries, there is a strong rationale for considering skills policies at the local level. This would help countries to align national aspirations with local needs.

- *Include all relevant stakeholders*: Designing effective skills policies requires more than co-ordinating different sectors of public administration and aligning different levels of government: a broad range of nongovernmental actors, including employers, professional and industry associations and chambers of commerce, trade unions, education and training institutions and, of course, individuals must also be involved.

The Skills Strategy is built around three main policy levers: developing relevant skills; activating skills supply; and putting skills to effective use (Figure 8). These three levers provide a useful approach to address the opportunities and challenges for skill development in the digital economy.

Figure 8. The OECD Skills Strategy



Source: OECD (2012)

2.1 Developing relevant skills for the digital economy

Empowering individuals with the relevant skills for the digital world is key for them to fully participate in today's and tomorrow's economic, social and cultural life. The evolving nature of the digital economy requires individuals to rapidly adjust to shifts in skills demands and technology. A greater emphasis should be placed in ensuring that individuals are equipped with strong foundation skills, higher order thinking competencies as well as social and emotional skills to respond to greater levels of uncertainty. In addition, digital literacy is essential to ensure inclusion in the digital economy and society.

Strengthening foundation skills

Improving foundation skills has been a major goal of educational reforms across many OECD countries. The key objective behind these reforms was to ensure that **all** students leave compulsory education with **good** levels of foundation skills. Several initiatives have targeted the promotion of Early Childhood Education and Care (ECEC) as a means to give a better start to children entering the schooling system (OECD, 2015c). Poland, for instance, developed a national strategy in 2013 to bring participation

rates in ECEC (52% for 3-year-olds and 66% of 4-year-olds) closer to the OECD average (74% and 97%, respectively). Australia deployed a National Early Childhood National Development Strategy (2009), which raised ECEC participation rate in the year before school to 81% in 2012.

Over the past few years (2008-2014), many OECD countries have also started addressing these issues from the perspective of *fairness* (ensuring that personal or social circumstances do not hinder achieving educational potential) and *inclusion* (allowing each student to reach a minimum level of foundation skills), which has resulted in policies targeting early school leaving and dropout rates, grade repetition, early tracking and student selection (ibid.)

International research shows that participation in ECEC programmes can have a significant positive impact on educational quality and equity outcomes. According to PISA, ECEC programmes help to improve mathematics performances, even after controlling for differences in socioeconomic status (OECD, 2013c).

Further policies aiming to strengthen foundation skills for all students have been centred on three actions: to reduce students' drop-out rates, to avoid grade repetition and to limit early tracking and student selection (OECD, 2015c). Efforts to reduce students' drop-out are part of the European Commission 2020 strategic framework for Education and Training, with an ad-hoc working group on early school leaving (European Commission, 2013b). Previous policy experiences show that reduction of early school leaving goes hand by hand with grade repetition avoidance.

Helping each student to achieve a minimal threshold of foundation skills may mitigate the impact of socioeconomic status on digital literacies as " what people do with media is more important than the technologies and connectivity available to them"(OECD 2015d, p. 135). Indeed, proficient use of new media still largely depends on individuals' levels of foundation skills as well as the social and cultural factor influencing their use (Livingstone and Helsper, 2007).

With an evolving definition of 21st century skills, OECD countries have experimented different innovative practices in teaching and learning. The objectives of such experimentations have been broad in scope but generally focused on a few underlying principles: the development of adaptive competencies (OECD, 2010b) and the promotion of collaborative learning, with a particular attention to problem solving (OECD, 2014c). Educational research has also undertaken evaluations of the benefit from the exposure to a broader curriculum and the revision of teaching practices through metacognitive pedagogies (Mevarech, Z., Kramarski, 2014) as well as of the role of problem-based learning in fostering problem solving skills (Hoidn and Karkkainen, 2014).

Good practices at the school level

The complete mapping of 21st century skills onto learning objectives is a rare event, even in the most innovative schools across the OECD area. The OECD Innovative Learning Environments project Universe case inventory (OECD 2012) takes stock of an impressive number of innovative schools having introduced some 21st century competencies in their curriculum. Some schools, e.g.: the North Union Local Schools in Ohio, United States, and the schools in the "Call Them Emotions" project in Switzerland, centre their pedagogies in the development of critical thinking together with social and emotional skills. Others, like those in the Community of Learners Network in British Columbia, Canada, place collaborative learning as a key distinctive feature of their pedagogical model (ibid.).

North Union Local Schools has initiated a Comprehensive Educational Academic Advancement Programme which aims to meet the educational wishes of all students. Students are encouraged to take a more challenging middle and high school academic course load to be better prepared to compete in the 21st

Century and to develop social and critical thinking skills. All students have the autonomy to develop an individualised learning plan that meets their needs. A variety of advancement options are offered to these secondary students, including: credit flexibility, flexible scheduling and extended school day options, on-line and correspondence course offerings, dual enrolment and post-secondary educational options.

Swiss schools participating in the "Call Them Emotions project" focus on the promotion of life skills and socio-emotional competencies, critical thinking and active involvement of the child. All activities are followed by a discussion where facilitators ask children to share their understanding and evaluate their learning. In addition, personal learning can be displayed trough paintings, role playing, oral communication, and handcrafts (when appropriate). Formative feedback is granted, through discussions with children and an analysis of the life experiences that children endure out of school.

Community of Learners Network Nanaimo Ladysmith is a 'mini-network' within the larger Network of Performance Based Schools in British Columbia. The Network involves intensive collaboration on applying inquiry methods. Flowing out of the Community of Learners foundation, there is an implicit understanding in this learning environment that learning is a socially constructed process. Collaborative learning is used to build in emotional safety and accountability for the learning. The project relies on an extensive use of peer coaching/partner talk, multi-aged peer coaching, jigsaw structures and collaborative inquiry projects (OECD 2012).

Additional pedagogical methods worth noting were developed by the Mevo'ot a Negev school in Israel and the Lok Sin Tong Leung Wong Wai Fong Memorial School in Hong Kong where an attempt was made to encompass most of the previously discussed 21st century skills.

At Mevo'ot a Negev, skills such as problem solving, collaboration, teamwork and communication are at the core of instruction. The core learning process is projects-based learning, wherein learners carry out projects in the frame of an extensive study unit around a specific problem; learners gather information, find answers to questions and present their conclusions. Students divide into workgroups of 3-4 and then examine, according to their choice, a topic or a sub-topic from the wider subject. During the project and at the end of it they submit a public presentations on the subject learned in order to shed light on the insights and understanding they have reached and which constitute the basis for the teacher`s evaluation (OECD 2015n).

Good practices at the national level

At the level of national development skills systems, very few countries have developed strategies to foster the acquisition of 21st century skills in formal education. However, the development of some skills, such as critical thinking problem-solving, is entering the educational policy debate.

In the late 1990s, the Japanese government reformed the Course of Study, its national curriculum standard to improve students' engagement and motivation. The key rationale behind this reform was to strengthen students' ability to think critically and creatively, and to identify and solve problems independently. The new curricula reduced the content load by about 30% to leave space to deeper learning through classroom activities emphasising introspection independent decision making, and problem-solving skills. The reform also allocated more time for elective offerings and introduced a new class period in all schools, called "Integrated Learning". In these classes, students engage in cross-curricular projects related to the understanding of environmental, social welfare and health issues. Those classes provide them with opportunities to practice observation and experimentation and to discover multiple solutions to problems as well as draw connections to their own lives (OECD, 2014c).

Likewise, in 1997 Singapore launched a project to promote a sharper focus on developing thinking skills which subsequently lead to revision in the curriculum with national examinations adjusted to give greater importance to the assessment of higher-order thinking and problem solving skills. In 2009, Singapore identified the most relevant 21st century competencies. Those were critical and inventive thinking; communication, collaboration and information skills; and civic literacy, global awareness and cross-cultural skills. The 21st century competencies framework now guides the development of the national curriculum as well as school-based programmes to nurture these competencies. Interestingly, this curriculum reform was accompanied by a wider effort across schools to harness ICT for teaching and learning. Provisions from three waves of the ICT Masterplan since 1997 have enabled teachers to use ICT tools that help students learn and work independently and collaboratively (OECD, 2014c).

A comparable effort to mainstreaming 21st century skills into national curriculum is taking place at the regional level in Alberta, Canada. The starting point is somewhat different and reflects a collaborative bottom up-policy design exercise. With a series of province-wide consultations starting in 2009, the government developed a curriculum redesign project to include 21st century skills. Albertans voiced the need for a transformation of the education system in order to help students engage in a rapidly changing knowledge-based society. In this context, a framework for student learning was developed that identifies critical thinking, problem solving and decision making as key cross-curriculum competencies (Alberta Education, 2013a, 2013b in OECD 2014c).

This involved, for example, developing the confidence and skills in students to solve different types of problems, which could be assigned to the domain of emotional competencies (OECD, 2015i); stimulating the use of multiple approaches to solving problems; and modelling students' ability to transfer knowledge and experience gained in the past to solve problems and make decisions in the future. Proposals for further collaborative curriculum development are under review and the new curriculum is expected to be launched by 2016 (OECD, 2014c).

Good policy practices for the promotion of digital literacies

In a context of rapid technological progress not all citizens are likely to be able to keep pace with such developments. As discussed in Section 1, there is evidence that large segment of the working population may lack both generic and specialist ICT skills.

In many OECD countries, the promotion of digital literacies falls primarily in the hand of national education ministries, which determine the extent to which ICT skills are included in the curriculum. The introduction of ICT in curricula may be the result of broader national digital strategies as in the case of Sweden and Spain, more recently. National digital strategies may take a different approach in engaging young people with ICTs, as the example of the Informatik Biber competition in Germany shows.

In Sweden, education for ICT is integrated in curricula as a learning outcome: "every pupil, on completing primary and lower secondary school, must be able to use modern technology as a tool for knowledge-seeking, communication, creation and learning". The new Schools Act from 2011 introduced new/revised syllabuses and a new curriculum for Swedish primary and lower secondary schools. The upper secondary school has also acquired new syllabuses, and a new qualification descriptor has been introduced for teacher and preschool teacher training programmes. The latest initiative ICT for everyone a Digital Agenda for Sweden in 2011 reiterated that "Everyone of working age must have good digital skills to be employable or be able to start up and run businesses"(Empirica, 2014b).

In the United States the Obama administration has recently launched the Computer Science for All Initiative to give all students across the country the chance to learn computer science (CS) in school. The initiative will provide USD 4 billion in funding for states, and USD 100 million directly for districts in his

forthcoming Budget to increase access to K-12 CS by training teachers, expanding access to high-quality instructional materials, and building effective regional partnerships. The initiative will also be supported by the private sector with more than MSU 60 million in new philanthropic investments from companies such as Google, Microsoft, Oracle and Salesforce.org. Last but not least, the initiative also recognises that students must be equipped with strong computational thinking skills and the ability to solve complex problems.(White House 2016)In Germany, the national digital agenda, Digital Germany 2015, aims to promote ICT studies and career opportunities through the organisation of nation-wide ICT and engineering related competitions. A notable example of this policy includes the yearly organisation of a national computer science contest for school children called Informatik-Biber (2014). The competition is aimed at students in grades 5-13 (age 10 to 15-16) and is held annually in November since 2007. It is funded by the German Federal Ministry of Education and Research. It seeks to raise the interest of young students in computer science, without requiring prior knowledge. In 2013 a total of 206,430 students took part in the competition (IVI and Empirica, 2014).

Some OECD countries have implemented a number of policies to promote digital literacy and inclusion for specific groups of the population who may lag behind (e.g. older people and women) to ensure that access and use of digital technologies benefits all segments of the population equally.. Good practice examples in this regard can be found in Norway (Box 1) and Portugal.

In Portugal, under the "National Strategy for Digital Inclusion and Literacy", the "ICT and Society Network" promotes digital inclusion and literacy of the population at large. The "ICT and Society Network" is a multi-stakeholder national platform with more than 500 members that mobilises regions, cities, municipalities, companies, government, academia, private sector, non-governmental organisations, the media, educators, and citizens, for a pro-active participation in reducing the digital divide, namely the population that never used the Internet.

Box 1. The national programme for digital inclusion in Norway

Access and internet use in Norway is among the highest across OECD countries. According to the Norwegian Media Barometer 2015, 87 percent of those aged between 9 and 79 use the Internet during the course of a day. Use is highest (99 percent) among younger users between 16-24 years old, while 52 percent of those aged 67-79 use the internet any given day. According to the national statistics, weekly Internet use has also increased from 52 percent in 2010 to 62 percent in 2013 in this segment of the population. This development suggests that many older Norwegians keep up with modern digital life and see the advantages of using new digital tools.

With these encouraging statistics Norway recently launched a more ambitious two years national programme which aims at significantly reduce the number of citizen who are not familiar with digital technologies regardless of age, gender, education, residence and participation in the workforce.

The programme is run by the Ministry of Local Government and Modernisation and enjoys the collaboration of big players in the ICT industry. Thus far the programme has developed web based resources for educators and trainers in digital competence. The programme arranges collaborative regional conferences across the country, to ensure close collaboration and the sharing of resources between regional and national contributors. In addition, a magazine is being developed to inspire elderly non-digital citizens to get involved in the digital world. Different grants are being established to help develop local and regional educational initiatives. Plans are also on their way to develop national indicators of digital competence and digital inclusion.

Source: Note from the Ministry of Local Government and Modernisation Department for national ICT policy and Public sector reform (2016)

The issue of gender disparity in technology access and use raise concerns, especially in countries such as Sweden where the gender perspective is one key pillar for policy action. A major concern among

Swedish policy makers is the low female participation rate in the IT industry, which is the result of lower enrolment rates in IT related academic courses for young women. As an illustration, in 2013 only 24 percent of women enrolled in IT related academic training, in comparison with 18 percent in 2003. Moreover, forecasts from the Swedish Statistical Office (SCB) indicate that the percentage of women with a technical qualifications in roles such as data specialists run the risk of being less than 20% by the year 2030.

Gender disparities in ICT related academic and professional careers are driven by a multitude of factors including social and cultural norms, self-beliefs, anxiety and risk aversion which all play a role at very early stages in life. According to the PISA study on average across OECD countries, less than 5% of girls contemplate pursuing a career in engineering and computing. In virtually all countries, the number of boys thinking of a career in computing or engineering exceeds the number of girls contemplating such a career. In addition, PISA and other studies find that girls have less belief in their own abilities in mathematics and science, and are plagued with greater anxiety towards mathematics, than boys – even when they perform just as well as boys (OECD 2015p).

To challenge current beliefs, cultural and social norms hindering women participation in ICT related careers the Swedish government has placed an emphasis at primary school level to support girls' interest in natural science mathematics and technological subjects. Moreover, a revision of the college level technology programme will take into account the experiences of both men and women, and will challenge current misconceptions and stigmas on women who choose technology as core subject. As an illustration, the KomTek a municipal technology and entrepreneurial school, has been designed according to a "gender-aware pedagogy" and has received support from the European Social Fund. Last but not least, future awareness campaigns will also seek to address preconceptions about women in ICT careers, most notably those associating women with careers to the "soft parts" of ICT (e.g. communication) than "hard parts" (e.g. technology).

The European Commission has been at the forefront of policy initiatives action in addressing ICT-related skills issues. In 2007, the Communication "e skills for the 21st Century" set the basis for its policy action aiming to respond to the growing demand for highly-skilled ICT practitioners and to achieve digital literacy for all citizens (European Commission, 2007).

The Communication has been followed by the institution of a broader **EU-eSkills strategy** which is bearing a number of positive outcomes in the area of ICT skills development. The initiatives that stemmed from the implementation of the e-skills strategy were financed by the Competitiveness and Innovation Framework Programme (CIP), while the initiatives for 2014-2020 focus on small and medium enterprises (SMEs) under the umbrella of the programme for the Competitiveness of Enterprises and Small and Medium-sized Enterprises (COSME). Future actions are planned to address the critical need for e-leadership skills the focus on the promotion of professionalism for ICT practitioners; focus on the creation of a larger talent pool of entrepreneurs, business leaders, managers and advanced users with a focus on the strategic use of new information and communication technologies (European Commission, 2016).

Current initiatives are the "Opening-up Education" initiative to modernise education for the digital age, the "e-Skills for jobs" awareness raising campaign on ICT professional jobs. The Grand Coalition for Digital Jobs is a cross-European multi-stakeholder partnership that facilitates collaboration among businesses, education providers, and public and private actors to reduce skills gaps by increasing the number of training programmes and making the most of the job opportunities offered by digitisation in Europe. So far, this initiative has been successful in attracting around 60 stakeholder pledges offering training, apprenticeships, placements and carrying out awareness raising activities to encourage young people to study and pursue careers in ICT. It has also raised political awareness and support for these

issues. In 13 Member States, national coalitions have been set up and more are planned. Some Member States have also produced digital skills strategies.

The EU-eSkills Strategy has undergone a number of evaluations to monitor progress by each Member State. In the period 2009-2013 the action focused on three pillars: digital literacy, professionalism for ICT practitioners and e-leadership. The largest number of activities were registered in the cluster of professionalism for ICT practitioners (Empirica, 2014a). In contrast, activities related to e-leadership, including support for the acquisition of digital leadership skills among entrepreneurs, , were less frequent.

2.2. Activating skills in the digital economy

Rapid population ageing, high rates of youth unemployment and increasing dependency ratios raise great concerns for the financial sustainability of social security systems and for intergenerational cohesion.

To respond to such challenges, OECD governments have put in place a number of initiatives to facilitate labour market activation of young people Not in Education, Employment or Training (NEETs), and older workers who have spent a long period in unemployment. The rationales behind these policy interventions are to confront immediate employment challenges through Active Labour Market Policies (ALMPs) and reduce the risk of future skills imbalances through the use of forecasting instruments such as Skills Assessment and Anticipation Exercises.

Active labour markets policies for the digital economy

According to the latest research (OECD, 2015f), the following three elements are fundamental to smooth reinsertion into the labour market: **motivation**, **employability** and **opportunities** for training or employment. Among the instruments available policy-makers to tackle long-term unemployment, recent efforts have been placed on the implementation of Active Labour Market Policies (ALMPs). ALMPs can raise job seekers' **motivations** by linking unemployment benefits to search efforts, improve **employability** by providing counselling and training, and increase **opportunities** through job matching services (OECD, 2015f).

Recent evidence suggests that ALMPs are increasingly diverse in nature, and their effectiveness depends on a tailored approach to individual needs. Among ALMPs, job-search assistance and training programmes are regarded as the most effective measures, , the former by helping job seekers to find a job and keep it, the latter by upgrading skills of weaker target groups (European Commission, 2013a).

The diffusion of ICTs at work and the increase in the demand for ICT specialist, generic and complementary skills have triggered a reflexion about the type of skills that ALMPs should help to develop. For instance, the Austrian Ministry of Labour created a Special Committee on New Skills to address this question (OECD, 2015e). In Portugal the "Digital Employability Strategy and Action Plan 2015-2020" was launched by the Portuguese Coalition for Digital Jobs.

At the European level, policy-makers have called for urgent action to support NEETs in their transition to work, which translated into the adoption of a Youth Guarantee. The Youth Guarantee's objective is ensure that all young people aged under 25 receive a good-quality offer of employment, continued education, apprenticeship or traineeship within four months of becoming unemployed or leaving formal education (European Commission, 2015b). Many Member States of the European Union have taken steps to turn this European call into reality especially in regions where youth unemployment rates exceed 25%. In Spain, the Youth Guarantee included a focus on the development of ICT skills (Box 2).

Box 2. EU youth guarantee programme-fostering ICT skills? The Spanish case

Among the countries mostly hit by youth unemployment, Spain has been particularly adamant in adopting the Youth Guarantee Scheme. It established a National Youth Guarantee Programme (Law 18/2014) between 2013 and 2016 with a financial support of approximately 3.5 billion from the European Union (Espana, 2013).

Through the programme the Spanish government put an emphasis on the role of ICTs in promoting economic and social growth as well as on the importance of ICT skills for **employability**. The design plan of the initiative is particularly concerned with "ensuring that efforts to improve talents and skills include ICT or digital training and raise the category of vocational knowledge and skills, guaranteeing that study courses and ICT certifications are in line with comparable international standards". In addition, it puts greater importance on the role of ICTs in improving access and integration into the job market of young people with disabilities or who have greater difficulties of access (ibid.).

The commitment towards ICTs is reiterated by national legislation. The Spanish Public Employment Service launched a call for proposals with a total budget of almost €42 million for professional training activities and training in ICT and language courses to be developed at the national level for young people registered in the Youth Guarantee system (European Commission, 2015a).

The not-for-profit sector has been growing and increasingly engaged in training provision and labour market integration initiatives. These initiatives are often launched by social enterprises with the support of philanthropies, the European Social Fund and, in some cases, direct government co-sponsorship. The rationale behind these interventions may stem from the need of an immediate response to skills gaps within a specific sector requiring ICT specialist skills or, from a broader commitment to ICTs skills as generic skills for **employability**, in the spirit of activating the supply of skills of disadvantaged groups in the labour market.

The projects "e-skills for Women" in Luxembourg and Interface3 in Belgium are examples of this ambition. They both target unemployed women from disadvantaged backgrounds and with the aim to improve their employability through ICT training.

The **e-skills for women** project is centred on French speaking women aged 18-55 and consist of a series of workshops where participants receive technical training on languages for web maintenance as well as core competencies training on teamwork, personal branding and effective communication. Participants are identified with the help of ADEM (*Administration de L'Empoi*), the national employment agency.

The **Interface3** programme offers a more comprehensive approach: IT technical training is supported by mentoring and coaching on soft skills and core competencies, as well as French language courses for foreigners (Interface3, 2014). The targets of the programme are young (18-30) unemployed women in the Brussels-Capital region, where the combination of fast growth in youth population and low-skills migration has contributed to increase unemployment rate to over 20% (ibid.).

In Ireland, Fast Track into Information Technology Ltd (FIT) works to the re-integration of long-term unemployed into the labour market through ICT skills training (Box 3).

Box 3. Fast track to information technology (FIT), Ireland

Fast Track Into Information Technology Ltd (FIT) is an industry-led charity that works in close collaboration with Irish government departments, national education and training agencies, local development and community-based organisations. FIT provides ICT skills training at different level (at entry, intermediate and expert levels) to ensure it outreaches to various segments of the Irish population. Central to FIT's mission is the re-integration of the long-term unemployed into the labour market through ICT transversal skills training that allows graduates to enter multiple sectors of work including, but not limited to, the IT sector.

From a Skills Audit that it conducted in 2014 among some of the largest, but also small and medium sized companies, FIT argues that 75% of immediate vacancies are for employees able to exercise skills at the competent and entry levels, compared to 25% at the expert level (FIT, 2016). Qualifications for those competent and entry-level opportunities can be acquired through formal vocational training. In addition, FIT reported that transition rates of FIT graduates into employment or further education is at 70%

As a result, FIT launched its ICT Professional Associate apprenticeship style pilot programme offering a two-year education based on 6 months of in-school training and 18 months of work-based learning. FIT works hand-in-hand with some of the largest employers in Ireland to ensure that its programmes are up-to-date with the skills demanded by the labour market. With over two thirds of participants coming from an unemployed or long-term unemployed background, in its first year the ICT Professional Associate programme showed very promising graduate outcomes in terms of transition from education to the workplace, or to further education.

Source: Fast Track into Information Technology (2016), Skills Audit 2014, http://fit.ie/about/skills-audit/

Skills assessment and anticipation exercises for the digital economy

The ability to assess and anticipate skill needs has become a prominent policy concern across OECD and partner countries. Skills mismatch may lead to longer period of unemployment for job seekers and lower productivity in firms while skills shortage may hamper economic growth. A number of employment plans aim to address this challenge by promoting the collection and use of information on the demand and supply of skills, the transportability of educational and occupational credentials, the up-skilling or reskilling of new, unemployed and displaced workers and the promotion of geographical mobility (OECD, 2015e).

However, skills assessment and anticipation (SAA) exercises are instrumental to broader strategies that tackle skills shortages as they present some limitations. Time constraints within the policy cycle may restrict the policy relevance of the exercise to specific categories of education and training programmes, most notably those with long training periods, restricted entry requirements, and particular geographical mobility. In addition, a great level of coordination across stakeholders is required to ensure that the data collection and use of skills information happens smoothly, given the highly complex nature of some of the data-sources (ibid.). Finally, particular care is required in handling results. As noted earlier, skills assessment and anticipation exercises do not attempt to predict the future with certainty or precision but rather aim to be used as tools to help prepare or plan for future scenarios. As such, they should be seen as a contribution to skills development policies and not as the exclusive input for workforce planning techniques.

The OECD (OECD, 2015e) in collaboration with the European Centre for the Development of Vocational Training (CEDEFOP), the European Training Foundation (ETF) and the International Labour Organisation (ILO) has recently carried out a survey on the use of SSA exercises in its member countries. The survey aims to identify effective strategies for improving skills governance and turning qualitative and quantitative information on skill needs into relevant policy actions.

The survey shows that 29 out of 34 participating countries undertake some type of SAA exercises However, important difference exists in the coverage of skills, the time span and frequency, the geographic coverage as well as the methodology used. The latter varies from the approach of the Denmark Rational

Agent Economic Model (DREAM), based on computable general equilibrium model that can forecast future skills needs over a 50-year horizon, to the approach taken by Industry Skills Councils in Australia where current skill needs are identified assessed drawing from interviews or focus groups.

Skills assessment and anticipation exercises are being extensively used by public and social organisations alike to inform policy design and action in the areas of labour markets and education. More specifically, in the area of labour market policy SAAs are mainly used to revise design, and allocate re-training and on the job training programmes as well as to inform the development of apprenticeship programmes. In the realm of education policy the widest use of SAAs is made with reference to course provision and funding decisions from upper-secondary education as well as for the update and revision of competencies frameworks and curricula. In contrast, in Australia, New Zealand and Sweden, skills assessment and anticipation information is used to place occupations in high demand on special shortage lists. Workers with skills required in those occupations do not have to be sponsored by an employer when applying for a permanent visa (OECD, 2015e).

In a number of countries - Austria, Belgium, Canada, Denmark, France, Hungary, Ireland, Italy, Norway, Portugal and Turkey - SAA programmes explicitly look at skills needs in the digital economy. Skills needs are assessed in relation to changes in occupational structure, e.g. re-allocation of workers towards ICT-intensive sectors, and in the skill requirements within occupations, e.g. increased use of ICT at work (OECD, 2015e).

In Canada, occupations related to the digital economy are assessed as part of the Canadian Occupational Projection System (COPS). In addition, the Canadian Sectorial Initiative Programme monitors the development of skills with an impact on the productivity of the ICT sector, such as measures of job readiness and career paths in STEM, and produces 5-year forecasts of ICT occupations.

Ireland, Austria and Norway have started policy level reflections on future skills needs. Ireland established an Expert Group on Future Skills Needs that carried out a study on the future skills needs of the digital media industry and was later included in the Ireland Action Plan for jobs (2014-2018). In Austria, the national Public Employment Service established the **Standing Committee on New Skills** to anticipate qualifications required in the medium term and take measures accordingly. Norway has commissioned a study to forecast future supply and demand for advanced ICT competences up to 2030. The study recommends the establishment of a regular monitoring system of supply and demand of advanced ICT skills.

2.3 Putting digital skills to effective use

Effective use of skills in the workplace is a key engine for labour productivity and economic growth. Research based on the OECD Survey of Adult Skills (PIAAC) shows that the average use of reading and writing skills explains a considerable share (50% and 44% respectively) of the variation in labour productivity across countries (Quintini, 2014). As a result, lifelong learning, workplace training and continuous professional development are key to ensure that skills are fully utilised and do not depreciate overtime.

Effective use of skills is a key challenge among OECD countries both for young people and older workers. Evidence shows that young people entering the workplace make the least use of information processing skills, including ICT skills, in comparison with prime age workers (Quintini, 2014, p. 30).

This evidence is at odds with the general opinion that young people are naturally well versed in online skills (the myth of the digital native), as young people do not naturally or automatically acquire digital literacies (Livingstone and Haddon et al., 2014). Instead, the evidence points at ICT skills acquisition through use (OECD, 2015a). Indeed, there is a two-way relationship between proficiency in information processing skills and the use of those skills: proficiency facilitates practice and practice reinforces proficiency (OECD, 2013c).

The underlying mechanism of skills depreciation due to under or non-utilisation mirrors the same principle, in that the skills stock of an individual deteriorates if not used - the so called "use it or lose it" effect (OECD, 2015b). In addition, the diffusion of new digital technologies in the workplace makes the skills related to previous technologies obsolete (IVI and Empirica, 2014).

This is of particular concern for elderly workers. Evidence suggests the elderly workers use problem-solving skills less and are more likely to witness the obsolescence of some of their skills due to rapid technological change (Schneider, 2005). This is not only limited to ICT skills but apply to a wider set of skills (Behaghel, Caroli, and Roger 2014; OECD, 2015j). As a consequence, elderly workers are more likely to experience long periods of unemployment, with severe effects on their health and well-being.

Workforce training for the digital economy

Mostly based on longitudinal datasets, several studies have documented the positive impact of workplace or on-the-job training on individual labour market outcomes respective to wages, job security and productivity at the firm level (OECD, 2015b). Training is often advocated as an appropriate policy response to cope with the rapid pace of technological change that characterises the digital economy.

Training is believed to address skills obsolescence and depreciation and help ensure that the workforce is resilient in an ever-changing environment. However, challenges remain vis-à-vis the training participation gap that exists in most countries between the less-qualified and the more-qualified, prime age and older workers, those in large and small and medium enterprises.

While workplace training emerges as key policy lever to maximise skills utilisation and ensure that skills do not depreciate over time, an analysis of existing practices at firm level show that firms themselves have great incentives to provide employees with continuous professional training if they want to innovate and remain competitive in the market. Learning organisations adapt and compete through learning and are more likely to innovate (Box 4).

Box 4. Innovative workplaces

In an effort to understand which working organisations leave their employees greater room to innovate and, as a result, generate higher levels of innovation, an OECD study (OECD 2010c) looked at the European Working Conditions (EWC) survey to understand the most prevalent forms of work organisation across the EU to determine which of them could be defined as "learning organisations" as per their likelihood of being conducive to greater levels of learning for the employee and the organisation itself.

The results show that organisations that rely on the expertise of individual professionals and fuse them in creative project teams to create innovative projects on behalf of their clients, the so called "operating adhocracy" (Lam 2005), are most likely to provide their employees with continuous professional development and training programmes. In addition, organisations that delegate problem solving activities to a wide range of employees could be more successful in both upgrading the competencies of workers and in transforming ideas into new products and processes (OECD 2010c, 51). Interestingly, learning organisation across the 27 EU Member States are a widespread phenomenon as 67% of firms in the EWC survey are characterised by high levels of autonomy in work combined with high levels of learning, problem-solving and task complexity.

Source: OECD (2010), Innovative Workplaces: Making Better Use of Skills within Organisations, OECD Publishing. http://dx.doi.org/9789264095687-en

Age biased technological change, workforce training and training obsolescence

The rapid pace of technological change combined with the long period out of formal education place older workers in a particular need to update their knowledge and skills (OECD, 2015b). Continuous training becomes therefore a key instrument to address older workers' employability.

The empirical evidence shows firm-level training increases the share of older workers in employment and reduces their turnover (Behaghel, Caroli, and Roger, 2014). However, these effects do not seem large enough to compensate for the negative age bias associated with ICT sand innovative work practices (ibid.).

In terms of access to training about new technologies, elderly workers in low-skill occupations, e.g.: clerks and blue-collar workers, seem to have less opportunities (Behaghel and Greenan, 2012) than elderly workers with higher skills.

In ICT-intensive industries, the challenge of age-biased technological change is compounded with faster obsolescence of ICT specialist skills. In response to such a challenge, some countries, like the Netherlands, have already devised policies for the re and up-skilling of the older population in the IT sector although measures of impact are not yet available (Box 5).

Box 5. The technology pact 2020 in the Netherlands

One of the main objectives of The Technology Pact 2020 in the Netherlands is to retain technology workers in the ICT sector, and find alternative jobs for those workers with technology backgrounds that have been marginalised or are at risk of being marginalised.

The Technology Pact 2020 has begun to deliver measures to re-skill technology workers and up-skill young and unemployed technology workers. In 2013, industry partners from the technology sector signed an agreement, whereby they established sector plans for the second half of 2013 with the aim of reducing the outflow of young workers and recently unemployed by providing them with opportunities as qualified technicians through training and by upgrading their skills.

The Technology Pact 2020 has also established another national measure to boost training and re-skilling schemes for redundant technology workers aimed at finding them alternative jobs and providing them with professional mobility.

Source: adapted from: IVI, and Empirica. 2014. E-Skills: The International Dimension and the Impact of Globalisation (Final Report). http://eprints.maynoothuniversity.ie/5559/1/CT_e_Skills_report.pdf.

Supporting workforce training and digital leadership in SMEs

Ensuring adequate training is particular important for small and medium enterprises (SMEs). On the one hand, SMEs lack sufficient resources to develop training programmes; on the other, training providers have not sufficiently developed training content specific to the needs of SMEs. Some countries have favoured the creation of multi-stakeholder consortia at the sector, local or industry level to share training costs for the workforce.

Government intervention is also justified by the existence of market failures, as free-riding and competition may reduce firms' incentives to co-operate and invest in training (OECD, 2013d). Korea has addressed the issue of SMEs workforce training with direct funding from the national Employment Insurance Fund. Ireland has taken a similar approach with its state-funded initiative Skillnets (Box 6).

Box 6. Training programmes for existing workers and SMEs

Korea

All training programmes for existing workers in Korea are financed through the Employment Insurance Fund. Most programmes comprise subsidies paid to employers who provide skills development programmes for their employees. The government refunds training expenses to insured employers when they provide, either directly or through outsourced providers, vocational training authorised by the Ministry of Education and Labour. A subsidy can also be paid to cover training costs and minimum wage when an employer offers training leave to employees with one or more years of service.

There are also a number of programmes to encourage SMEs to provide training to their employees. SMEs can be reimbursed for all or part of the training costs for their employees who take part in authorised training programmes to improve performance of "core tasks", such as sales, marketing, production and quality management, human resources and organisation management.

There is also support for groups setting up a "training consortium" to help provide vocational training to SME workers. The government subsidises training expenses and facility and equipment expenses to the consortium, which could be comprised of companies, employers' federations, universities or other training providers. Around 250 000 employees from 120 000 SMEs participated in the consortium project in 2011, a very small proportion of all SME employees in Korea.

Ireland

Ireland Skillnets was established in 1999 to promote and facilitate workplace training and upskilling by SMEs. It is the largest organisation supporting workplace training in Ireland. In 2011, it had 70 operational networks through which it trained over 40 000 people for a total expenditure of EUR 25 million. It is a state-funded, enterprise-led body that co-invests with enterprises, particularly SMEs, when they co-operate in networks to identify and deliver training suited to their workforces. A network of SMEs, which are mostly sectorial or regional, is guided by a steering group of the local enterprise representatives. The steering group gives strategic direction and guidance to a network manager who co-ordinates all operational activity leading to the delivery of an agreed training plan with learning interventions suited for the member company workforces. The national programme is coordinated by Skillnets Ltd., who contract with all networks and provide programme support and monitoring to ensure the delivery of agreed quantitative and qualitative target outputs. In 2011, 30 of these networks were located in Dublin, but were predominantly sectorial networks with a national remit and company membership. 25% of all Skillnets member companies and 33% of trainees were Dublin-based.

Sources: OECD (2014), Employment and Skills Strategies in Ireland, OECD Reviews on Local Job Creation, OECD Publishing. http://dx.doi.org/10.1787/9789264207912-en and OECD (2013), Korea: Improving the Re-employment Prospects of Displaced Workers, Back to Work, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264189225-en

Recognising the role of SMEs in driving economic activity in Europe, in 2013 the European Commission launched the e-Leadership Initiative (IVI and Empirica, 2014) to foster ICT skills among business leaders and promote e-leadership and digital entrepreneurship. The initiative seeks to equip business leaders in SMEs with the right skills to lead multidisciplinary teams, develop new business models and exploit new business opportunities through digital technologies.

As part of e-Leadership Initiative, the LEAD programme focuses on the development of business skills for SMEs and start-ups who seek to exploit the business opportunities created by new technologies. The programme accompanies business leaders in designing, developing and deploying new digital services in areas such as cloud computing, mobile and social technologies as well as big data (Empirica 2015).

Governing skills systems for the digital economy

As digital inclusion is becoming less dependent on access to technologies and more on knowledge and skills, digital skills have been recognised as key competence across OECD countries. Lack of agreement on the definition of digital skills prevents alignment and coordination among stakeholders. Reaching a common understanding on the definitions of digital skills is therefore a pre-requisite to effectively design and implement skills policies for the digital world. A common understanding can facilitate policy coordination across governance levels and may help managing private sector involvement in the design of digital skills policies.

DIGCOMP, the EU framework for developing and understanding digital competence in Europe, provides insights on what digital competences are, and what skills, knowledge and attitudes they may be associated with (Box 7). The framework consists of five dimensions, based on findings from research, case studies and multi-stakeholder consultations.

Box 7. Areas of competence, DIGCOMP Framework

The areas of digital competence captured in the DIGCOMP Framework are as follows:

Information: identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose.

Communication: communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness.

Content creation: create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media output and programming; deal with and apply intellectual property rights and licences.

Safety: personal protection, data protection, digital identity protection, security measures, safe and sustainable use.

Problem-solving: identify digital needs and resources, make informed decisions on most appropriate tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update own and other's competence.

Source: European Commission (2013), DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe, Luxembourg: Publications Office of the European Union

Several EU countries have integrated the DIGCOMP framework across different policy areas. In the United Kingdom, for instance, Go ON UK, the UK's digital skills charity working closely with the Cabinet Office and the Government's Digital Service, has revised its definition of Basic Digital Skills based on that of DIGCOMP (Go on UK 2015). At the heart of Go ON UK's concern is to ensure that everyone in the country achieves the same minimum standard of digital literacy. Seeking alignment between Go ON UK's and the DIGCOMP framework has thus been seen as paramount to the conception of a reliable, common measurement framework through which levels of digital skills can be determined.

As part of its Digital Agenda, Italy is evaluating the official adoption of DIGCOMP as an end user competence (Agenzia per l'Italia Digitale 2015). The Agency for Digital Italy (AGID) is responsible for achieving the objectives of the Italian Digital Agenda (developed in line with the European Digital Agenda) and coordinating activities across the state, regional and local levels. One of its strategic axes of

work is to support the dissemination of digital literacy initiatives, including promoting the use of innovative teaching technologies.

A number of regional initiatives have emerged in Spain. Within the framework of the Digital Agenda for the Basque Country, the Government of the region launched Ikanos, a digital competency project, whose main objective is to promote the adoption of DIGCOMP, new ways of learning and innovative certification systems (Ikanos 2015). Ikanos implemented a free online testing tool and assessment reporting on individual's level of digital skills for employability based on DIGCOMP. In Navarra, the Department of Education chose to use DIGCOMP as a key reference for strategic planning and wider policy support. In Extremadura, the focus has been on teachers and supporting the implementation of a Teachers Competence Portfolio based on DIGCOMP.

Despite giving rise to several initiatives scattered across the country, the DIGCOMP framework has led the Spanish Ministry of Education to develop an overarching teacher digital competence framework to provide guidance on areas of improvement vis-à-vis teaching methods, evaluation and accreditation processes in line with the EU framework. However, significant research remains to be done to observe best practice models, share guidance and avoid inadequate approaches to its implementation.

The engagement of the private sector in the implementation of national and international skills development frameworks is crucial to ensuring that workers will benefit from the opportunity to improve their digital skills. Several country examples show that meeting this aim often requires the creation or identification of an institutional body that takes on stakeholder gathering, advocacy (awareness building) and advisory functions both for the public and private sector (IVI and Empirica 2014). The Netherlands provide an interesting case of the public and private sector coming together in a Working Group to advocate the use of ICT skills frameworks.

Box 8. Promoting the use of ICT competence frameworks to the industry

In 2011, the Netherlands established a Working Group of which the principal function is to raise awareness on the European e-Competence Framework (e-CF) and promote its use in the Netherlands. The Ministry of Economic Affairs is one of its founders and contributes to the implementation of the e-CF mainly through the Working Group.

The e-CF Working Group brings together a wide range of partners from the government, private sector and education spheres. It is part of the Digitally Skilled and Digitally Safe Programme, a joint initiative by the Dutch government and private sector actors, which has identified the large-scale adoption of the e-CF by the Dutch ICT-labour market as a key priority. In November 2013, 21 Dutch organisations signed a covenant to agree on the use of the e-CF in their recruitment and training activities.

In 2012, the Dutch government decided to integrate the European e-Competence Framework at the core of its public sector iStrategy. A central element of the iStrategy was set as the implementation of a Quality Framework for Information Management with a view to improve internal and external labour market policy and personnel planning in ICT.

The Quality Framework specified the required levels of knowledge and competence for all ICT-related job categories and levels in order to harmonise the descriptions of the ICT career profiles within the Dutch public sector. According to the iStrategy, the Quality Framework was introduced in 2012 for all matching and training operations, and in 2013 a full range of training courses was made available for senior government staff.

The Dutch government and Nederland ICT, a trade association of over 550 ICT companies in the Netherlands totalling 250,000 employees, signed a cooperation agreement in 2012 to optimise the collaboration between the public and the private sector. The agreement highlights the importance of retaining and improving ICT talent in the Netherlands, and both parties agreed to use the Quality Framework for Information Management within the public and private sector.

Source: IVI and Empirica (2014), e-Skills: the International Dimension and the Impact of Globalisation, Luxembourg: Publications Office of the European Union

Building effective multi-stakeholder partnerships

Governments, training providers, employers and social organisations all play a part in the skills development system. Multi-stakeholders partnerships not only contribute to build capacity but also to promote a more inclusive and targeted approach to skills development. Such partnerships encourage training provision that is more responsive to labour market needs, familiarise employers with vocational programmes and qualifications and help vocational trainers to keep up-to-date (OECD, 2014d).

Sector skills councils have been established in several OECD countries (e.g. Ireland, Norway, Portugal) with the ambition to bring labour market research and skills demand forecasting to light and provide strategic advice on building skills through education and training and private sector involvement. While some countries such as Canada (Box 9) have progressed in establishing ICT sector skills council, mores systematic use of this approach may help reducing the imbalances in ICT specific skills demand and supply.

Box 9. The Canadian ICT sector skills council (ICTC)

The Information and Communications Technology Council (ICTC) is a not-for-profit national centre of expertise for the digital economy. With the mission of strengthening Canada's digital advantage in the global economy the ICTC aims at fostering innovative Canadian industries through a talented and diverse digital workforce. The main focus areas of the ICTC are research and policy advice on ICT labour market trends and ICT labour market intelligence as well as workforce solutions for the ICT industry to manage digital talent across the country.

The research activities focus on providing real-time monitoring and forecasting of Canada's ICT workforce requirements and trends, impacting the ICT sector and other sectors of the economy. In particular ICTC provides labour market's monthly, quarterly and yearly snapshots of trends in the ICT sector as well as an outlook for the Canadian workforce across 15 ICT occupations on a municipal and provincial level. Moreover, further research activities investigate the impact of new trends such as automation and robotics on the overall economy.

ICTC's engagement in workforce solutions seeks to help Canadian businesses to access the right talent with the right skills needed by providing targeted solutions for recruiting, retaining and integrating women, aboriginals, youth and internationally educated professionals into ICT workforce. In addition, the e-talent portal (www.etalentcanada.ca) provides real time job insights on a provincial and municipal level as well as research, skills forecasts, wages, demographics and available educational programmes.

Further initiatives pertain to the domain of digital competencies with online self-assessment tools and programmes supporting the development of digital skills for non-IT professionals. In addition ICTC developed an ICT competency profile where ICT stakeholders can customise job profiles according to the national standards of knowledge skills and abilities.

As a multi-stakeholder platform the ICTC includes large network of industry, educational institutions, and policy makers representing the digital economy in Canada.

Sources: ICTC(2016) Information and Communications Technology Council Annual Report 2014-2015 available at http://www.ictc-ctic.ca/annual-reports-2/ and www.ictc-ctic.ca

SECTION 3. LEVERAGING DIGITAL TECHNOLOGIES FOR BETTER SKILLS

Digital technologies have fundamentally changed the way individuals access information and elaborate knowledge. While raising the demand for new skills, they also create new opportunities for education and training. This section examines the opportunities that digital technologies can open for formal education and training as well as for informal and lifelong learning.

The pervasiveness of digital technologies in today's lives has fed growing expectations on their benefits for education and raises questions as to the reasons why these benefits have not yet fully materialised. Paraphrasing Solow's so-called "productivity paradox", one can see computers everywhere but in learning outcomes. The debate in the educational community is vivid. Many voices claim that ICTs bring up a generational change of unprecedented nature, with far-reaching implications for education. Others argue that digital media and connectivity has far more negative effects on the education of young people than positive ones (OECD, 2012a).

The educational literature provides some insights as to why technology has failed on its promises in radically improving education, pointing to weaknesses in knowledge management processes, teachers training and incentives mechanisms (OECD, 2010a). At the same time, a growing body of research is addressing these issues and providing evidence for the positive effects of ICTs in opening new forms of learning for the 21st century.

Digital technologies facilitate personalised learning

Educational literature has identified learners' prior knowledge as a key factor for effective learning. Student-centred learning has then become a paradigm for new forms of learning, which are also facilitated by the introduction of technology in the classroom.

The "flipped classroom" approach provides a clear illustration of how technology can build on learners' previous knowledge. In the flipped classroom direct instruction is partially replaced by video lectures that can be played anytime and anywhere. The learner can thus decide when to stop or rewind the lecture and focus on what he ignores or finds harder to harder to understand.

The classroom is "flipped" in the sense that the lecture builds up on a learner' previous knowledge and teachers focus on his/her doubts, concerns and misunderstandings. Time for teaching assumes a different connotation as time is freed up from frontal instruction and mainly dedicated to interactive group learning activities (Lowell Bishop and Verleger, 2013). This additional time can be used for more innovative pedagogies, including project-based and inquiry-based learning which foster the development of problem-solving and critical thinking skills.

As the flipped classroom approach is still in its infancy, there is a lot of experimentation and uncertainty surrounding its applicability across a wider range of subjects and effectiveness in addressing students' needs on an equal basis. Recent evidence on the use of the Khan Academy (Box 10) suggests that video lectures have been used for multiple purposes of which some go beyond flipping the classroom.

More specifically, Khan Academy resources were used as: a) an intervention for students who had fallen behind their grade-level peers; b) an enrichment activity for advanced students, allowing them to explore topics above their grade level; c) an accountability tool allowing close monitoring of student progress on problem sets; d) a highly integrated supplemental practice activity, reinforcing skills recently introduced in the classroom (Murphy et al., 2014).

Box 10. Freely available online resources for classroom instruction. The Khan Academy

Khan Academy is a non-profit organisation that aims to provide a free world-class education to all, anywhere in the world through educational videos released under a Creative Commons BY-NC-SA license, now backed up by a learning analytics platform on its own website. Khan Academy offers more than 6 000 instructional videos and 100 000 practice problems covering the subject areas of mathematics, biology, physics, chemistry, economics and finance, among others.

It is in the process of developing structured learning paths following the example of the already existing Algebra Mission. These predetermined paths are expected to facilitate more effective learning. The platform currently reaches more than 10 million students per month and has 350 000 registered teachers from across the world. The Khan Academy employs approximately 60 full-time and between approximately 40 to 70 part-time employees.

Khan Academy was founded after Salman Khan who, whilst trying to combine his fulltime job in the finance industry with his commitment to helping his cousins in India with mathematics tutoring, decided to place his lessons on YouTube. The organisation was incorporated in 2008 as a not-for-profit enterprise and was initially financed through the founder's savings. It later received a donation from a private investor and then larger philanthropic grants in 2010 from Google (USD 2 million) and the Bill and Melinda Gates Foundation (USD 1.5 million), which facilitated the setting up of a functioning organisation. The translation and adaptation of Khan Academy's content into Spanish was funded by a large grant of the Carlos Slim Foundation in 2013 (Dolan, 2013).

Adapted from: Orr, D., M. Rimini and D. Van Damme (2015), Open Educational Resources: A Catalyst for Innovation, Educational Research and Innovation, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264247543-en

Digital technologies help improve the quality and responsiveness of the teacher-student interactions. Video lectures and similar technologies are particularly well suited for the use of real time formative assessments, a system of interactive assessment of student progress and understanding. ICTs enable instantaneous interaction and feedback between students and teachers. The immediate feedback it provides allows teachers to personalise their instruction to the needs of individual students or to specific groups of students (Kärkkäinen and Vincent-Lancrin, 2013).

Real-time assessments are often used as part of personalised learning experiences. "*So Ms Cadwell, in her own web browser, pulls up a dashboard where Khan Academy's software presents, through the internet, the data the children are producing at that instant. She can view information for the entire class or any individual pupil. Just then she sees two fields, representing modules, turning from green to red, one for Andrea, the other for Asia. Ms Cadwell sees that Andrea is struggling with exponents, Asia with fractions. "Instead of having to guess where my students have gaps, I can see it, at that moment, and I walk over to that one student," says Ms Cadwell, as she arrives at Asia's chair"* (Economist, 2011).

Digital technologies foster collaborative learning

Recent findings from cognitive theories suggest that learning is a social process, whereby knowledge construction by an individual occurs throughout processes of interaction, negotiation and co-operation (De Corte, 2010). Neuroscience also shows that the human brain is primed for such interactions and that, while self-study and personal discovery remain valuable, learning increasingly depends on interacting with others (OECD, 2010b).

Digital technologies media facilitate learning through interaction and participation more than passive consumption of information or knowledge (Ananiadou and Claro, 2009). In technology-enabled learning environments, students work together (in groups) and/or interact with each other to enhance their learning with the help of various technologies, often with facilitation from the teacher. When combined with other learning approaches, technology-enabled collaboration can contribute to project, problem-based learning or

supplement face-to-face learning. Technology-enabled collaboration models may include in-built assessment features which may also take into account team performance and/or collaborative activity (Kärkkäinen and Vincent-Lancrin, 2013).

Collaboration through technologies can thus foster a wide array of skills needed for the digital economy. Those include flexibility, cultural diversity, group work and interaction as well as higher order thinking skills by posing more complex and challenging questions than the ones that are asked during face-to-face interactions (ibid.). However, co-operative approaches still remain at the margins of school activity, despite longstanding understanding of their benefits and significant evidence of their value (OECD, 2010b).

Collaborative learning approaches are often experimented classes within the same school. A remarkable example is provided by the Canadian Elementary Connected Classrooms project in British Columbia (OECD, 2015n). In this pilot project three mixed-age classrooms (covering school grades 4 to 7) from three elementary schools participate in videoconferencing, online collaborative work, online literature circles, and exchange of student-created multimedia content.

Weekly videoconferences of the three classes are delivered by teachers focusing on their expertise and interest and also manage a complementing online forum. Learners and facilitators interact through verbal questions and sharing, sharing smart board work, and engaging in online forums and chat rooms together. Moodle - a free and open-source software learning management system - has become a powerful communication and sharing tool; students frequently message each other and their teachers, and engage deeply in discussion forums. Participants also communicate by sharing the multimedia content created by students and facilitators at each site (videos, photography, Prezis, multimedia presentations, etc.).While learners mostly work with partners or groups at their home sites during videoconferences, many opportunities exist for learners to collaborate and discuss during the project (Halbert and Kase 2013).

The Melbourne Royal Children Hospital in Australia offers an interesting example of the use of technology for collaborative learning. The Hospital works in collaboration with young people, families and schools to ensure that hospitalised children remains engaged in education and connected to their school community throughout their recovery.

The pedagogies are focused on real-world complex problems and collaborative inquiry is facilitated and encouraged through the use of shared learning spaces and ICTs. As example of collaborative learning within the RCH is the Trans-Tasman Project where a number of students from different age groups across the hospital worked together to gain an understanding of how the Christchurch (New Zealand) earthquake affected the young people in that region. Assisted by the RCH Education Institute teachers, young people across the hospital connected with a school in Christchurch which was affected by the earthquakes. These students created a blog to facilitate input, voice and decision making about the project with the aim of raising funds through the development and selling of wrist bands to benefit those affected (Zazryn et al., 2012).

Online gaming has also proved to be a useful tool to fostering collaborative learning (Statista, 2015). In educational gaming, students play with video games, interact with simulations or engage with virtual worlds. In some cases, educational gaming may include collaborative project-based learning experiences where students themselves become game designers and content producers (Kärkkäinen and Vincent-Lancrin, 2013). For instance, the City Academy Norwich has used its Eco-Virtual Environment (EVE) project to “engage students in an immersive virtual world to develop their collaborative skills, communication skills and understanding of global energy challenges” (Box 11).

Box 11. Eco-Virtual Environment (EVE) of City Academy Norwich, the United Kingdom

The Eco-Virtual Environment (EVE) project of the City Academy Norwich, United Kingdom, is a virtual world simulation focusing on environmental challenges. Students participate in the virtual world as part of a team and as creators of learning materials. In the EVE project "students are presented with an island that has growing energy demands". They are then required to "specialise and collaborate in order to design an energy network", while their "decisions will have real-time feedback in terms of power, finance and environment". The real-time feedback will then guide students' further decisions. With the teacher "in the driving seat", the simulation is meant to be organic and flexible. In terms of technology, the EVE project "looks and feels like a high-end computer game".

Initial testing of the EVE project has suggested some positive impact on student communication and problem solving, although the impact on student learning is still to be further investigated

Adapted from: Kärkkäinen, K. and S. Vincent-Lancrin (2013), "Sparking Innovation in STEM Education with Technology and Collaboration: A Case Study of the HP Catalyst Initiative", OECD Education Working Papers, No. 91, OECD Publishing. http://dx.doi.org/10.1787/5k480sj9k442-en.

Digital technologies reduce time and space barriers

The use of digital technologies is often regarded as a way to facilitate and increase access to educational resources. However, while Internet penetration in OECD countries has reached high rates (OECD, 2014e) opportunities to level up access to education are yet to be fully exploited.

Virtual science laboratories have been flourishing in several OECD countries to provide virtual access to real research facilities or to create virtual environments for research. The use of online laboratories only requires access to the Internet and allows learners to access more experimental equipment than what a single school can generally afford. In addition, virtual laboratories allow students to modify the condition of the experiment and verify the results in line with the learning goals established by the teachers. The use of online laboratories can be at least as effective in terms of learning as the use of on-site physical equipment, and many resources are freely available on the web (Kärkkäinen and Vincent-Lancrin, 2013).

The iLab Network remote laboratory platform in Northwestern University provides an illustration of the benefits of virtual laboratories. The iLab remote laboratories include student materials and assessments and allow students to access experiments from any place at any time. As an example, the Radioactivity iLab enables students to "remotely control a Geiger counter to measure radiation being emitted from a sample of radioactive strontium-90" – with the actual laboratory equipment being located in the University of Queensland in Australia. Its objective is "to allow students to observe and experimentally derive the inverse square law". Students' skills in experimental design and data analysis are meant to be developed with the help of an online "lab journal" providing them with "instructions, readings, and meta-cognitive prompts". The Radioactivity iLab experience is asynchronous – meaning that students' experiments are executed when the equipment "becomes available" (ibid).

Licensing regimes of the hosting platforms may provide a further layer of flexibility and adaptability to the use of the virtual laboratory. With open licensing regimes, such as those granted to Open Educational Resources and Open Software, available materials can be re-used, remixed and even redesigned for different purposes. In this way, the benefit of using virtual laboratories can spread to a very large community of users. These solutions raise high interest in countries like India, where fast demographic growth is putting pressure on physical educational resources.

Another interesting example of virtual laboratory is the PhET interactive simulation environment at the University of Colorado, which provides students with virtual access to equipment unavailable at their local institution. The simulation environment consists of interactive, research-based simulations of physical

phenomena for elementary through to university students. The simulations have open licenses and are presented as individual exploratory environments rather than courses, so that each computer simulation can be easily integrated into various classroom activities and adjusted to the local learning context. The National Science Foundation in the United States reported that PhET simulations have been used over 60 million times and are available in 65 languages with 22 full website translations (Ferrante, 2012). The geographical and institutional reach of this initiative constitutes a remarkable example of how place constraints can be overcome using digital technology and open licensing regimes (Orr, D., Rimini, M., Van Damme D. 2015).

Digital technologies contribute to redefining some structuring characteristics of education: students' proximity with one another and their teachers as well as the materials used. By removing the constraint of place and time ICTs can help address the needs of those students at risk of exclusion from formal education. The examples of Escola Móvel in Portugal and the Open College in Australia (Box 12) illustrate how virtual classrooms and distance learning can address the educational needs of those who are unable to attend regular classroom instruction. Similarly, digital technologies extend the reach of Higher Education Institutions to groups who will be otherwise unserved. As an illustration the University of Saskatchewan's College of Nursing in Northern Canada provides a program of study targeted to Indigenous students who are predominantly located in remote areas. The College uses a Learn Where You Live approach with the objective to make nursing education closer to Indigenous communities. Using Remote Presence (RP) technologies, the College provides students with access to highly qualified faculty, regardless of where they are located. RP allows for real-time, interactive medical care between two places, such as a patient and a nurse in one city, and a doctor in another.

Box 12. Distance schools

Escola Móvel in Portugal

Escola Móvel is a distance learning project which gives children and adolescents (aged 10-17, from grades 5 to 12) permanent access to a virtual, national curriculum-oriented learning environment. This project has been designed and developed by the Portuguese Ministry of Education, and initially it sought to respond to the needs of students from families of showmen and circus artists and workers who would have to change schools throughout the year - about 30 schools a year - as a result of their families' professional activities, leading to high dropout and failure rates.

In the course of 4 years this project has been broadened to include teenage mothers and students over 15 who have repeatedly failed to complete compulsory education. Curriculum design, instruction and assessment are adjusted to the students' specific interests and learning needs. Escola Móvel seeks to prepare students for the challenges of the digital age by combining the use of technology with the development of different literacies - basic (language and numeracy), scientific, visual, artistic, multicultural - through the subject areas. The development of metacognitive and interpersonal skills occurs both within virtual interactions (online chats and forums in subjects/subject areas, tutoring and cross-curricular areas) and face-to-face interactions (four attendance weeks a year and individual tutoring).

In school year 2007-2008, 95 students attended Escola Móvel, out of which 82 concluded the school year with a success rate of 91,5% (including results in Portuguese and Mathematics national examinations). The remaining 13 students redirected their options to professional courses and training.

Open access college in Australia

The Open Access College is a government distance education institution offering all levels of school education to learners who are unable to attend a local school or access the curriculum in their own school. These students may live in a remote location; experience medical or psychological health issues; be restricted in their choice of curriculum; come from families who travel or are based overseas as a result of work commitments; be currently incarcerated in a penal institution; or, have been excluded from their local school.

The organisation of learning at the Open Access College shows innovative learning methods to cater for distance education learners at the Middle School level. Those methods include:

- Formalised half-hour long telephone or online Centra sessions with individuals or small groups conducted up to 7 times per week.
- Specialised resource materials provided for individual and group work in the form of on line integrated learning programs, internet research guides, and customised/personalised learning materials such as DVDs, CDs and activity kits.
- Face-to face workshops, mini schools, visits from teachers, camps and excursions.

Sources: OECD (2013), Innovative Learning Environments, Educational Research and Innovation, OECD Publishing. http://dx.doi.org/10.1787/9789264203488-en

Digital technologies are changing expectations on the teaching profession

Teachers and pedagogical leaders play a pivotal role in facilitating the integration of digital technologies into the classroom. Evidence from the latest round of PISA shows that most of the variation in ICTs use during mathematics instruction depends on teachers or student-specific factors rather than on school policies (OECD, 2015e). In addition, the use of computers during mathematics instruction is the result the national curricular approach to the subject, whereby an applied approach to mathematics instruction is more likely to lead to higher levels of computer use (ibid.).

Interestingly, PISA findings suggest a positive correlation between the quality of pedagogical practices and the use of ICTs in mathematics instruction. Students who use ICTs during mathematics lessons tend to describe their teachers as using effective instructional strategies and behaviours, such as structuring practices (e.g. setting clear goals, asking questions to verify understanding), student-oriented practices (e.g. giving different work to students who have difficulties or who can advance faster, having students work in small groups), formative assessment (e.g. giving feedback on strengths and weaknesses), and cognitive activation (e.g. giving problems that require students to apply what they have learned to new contexts and/or giving problems that can be solved in several different ways). As a result, teachers who embed in their practices pedagogies to foster deeper learning and the acquisition of 21st century skills are more likely to use ICT for those purposes (OECD, 2015k).

According to the survey on the teaching profession (TALIS), the use of ICT for project or class work is less frequent than for other teaching practices. On average, only 37% of teachers report frequent use of practices involving ICT (OECD, 2014f). The use of technologies in the classroom may be hindered by two factors: a shortage in ICT-related school materials and the lack of adequate teacher professional development.

Between approximately 30% and 40% of principals surveyed in TALIS report that lack of ICT infrastructure hinders the capability of their school to provide quality instruction to, at least, some extent. According to the same survey, over 56% of teachers report moderate or high professional development needs with regard to the use of new technologies in the workplace. The co-presence of these two elements, adequate materials and sufficient training is essential for the successful mainstreaming of ICT in the classroom. While the growing availability of cheaper technology is likely to address the issue of ICT-related materials shortages, it cannot automatically address the challenges of teacher professional development.

As discussed in the literature, skilful teachers are a prerequisite for the implementation of a challenging curriculum that stimulates higher order learning (Darling-Hammond and Post, 2000) and the development of 21st century skills. New instructional technologies can help, but three decades of research have shown that technology alone does not facilitate new forms of learning. Digitally savvy teachers remain critical to seize the learning opportunities created by new technologies (Atkins, Roberts, and Higdon, 2013).

Policies that address teachers' professional development needs in ICT

In-service training for teachers is considered as a professional duty in about a half of all European countries, but, in practice, it is optional in many of them. Teachers' involvement in professional development greatly varies across countries in content, methods and duration (OECD, 2014f). Therefore, integrating ICT training into teachers' professional development becomes a more challenging task, unless it is part of a broader effort to promote ICTs in schools.

Strategies of this kind have been implemented in a few OECD countries, including Chile, Korea, Italy and Spain. For example, as part of the Italian National Plan for Digital Schools in 2012, INDIRE, the national board for educational research and teacher development supported a digital school plan with dedicated training offers and resources for self-training. In addition, France, developed a new competencies framework for ICT skills for teachers called C2i2e, which will ultimately lead all new hires to gain ICT proficiency within 3 years after integrating the profession (Box 13).

Box 13. Policies to promote teachers' ICT professional development

Providing training resources, the case of Italy

INDIRE (formerly known as ANSAS) develops content for teachers' professional development with the aim of stimulating innovation in teaching and learning, of bridging the distinction between formal, non-formal and informal learning environments, and, in a lifelong learning perspective, of reducing the distance between pedagogical practices and everyday life" (ANSAS 2012)

INDIRE has a rich resource bank for professional development related to the use of ICT in schools, including over 1 400 text or multimedia resources (of which over 10 hours of video tutorials), many of which introduce subject-specific uses of ICT. Training is often in blended (face-to-face and online) mode, combining preparatory face-to-face sessions with online activities and materials that are specific to subjects and grade-levels but also linked to curricular contents and distance tutoring.

From school-year 2012-2013, INDIRE enriched its training offer with the new DIDATEC training. DIDATEC supports teachers in integrating ICT in subject pedagogy, and will be initially offered at base and advanced level in four southern regions (Campania, Calabria, Puglia, Sicilia). These regions are part of the *Programma Formativo Nazionale 2007-2013* that is supported by regional cohesion funds from the European Union. The aim of the DIDATEC training is to strengthen ICT skills among teachers to improve the quality of teaching and learning (ANSAS 2012)

Teaching workforce - mastering of ICT competences

Since 2010, France is looking to formalise ICT skills training for all its teachers and training professionals via the creation of a certificate on the use of digital technologies and the Internet (*Certificat et internet de l'enseignement supérieur de niveau 2 "enseignant"*, C2i2e).

The C2i2e certificate validates professional competences in the pedagogical use of basic numerical technologies and technology tools, which are today recognised as central to the exercise of their functions. The training leading to the acquisition of the C2i2e certificate is open to all people studying towards a degree in the teaching profession, as well as any postgraduate student (*Bac +5*) and already established teachers and trainers.

Some of the skills targeted include the use of digital tools for research purposes, to foster team work and encourage student networks, to improve pedagogical methods and ensure the effective evaluation and monitoring of students' ICT skills competences in school.

Obtaining the certificate is not a pre-requisite to the successful completion of one's teaching degree. However, the Ministry of Education is expecting that all teaching student candidates and graduated teachers obtain the certificate within three years of graduating, thus aiming for its future teaching workforce to become a master of ICTs.

Sources: https://c2i.education.fr/spip.php?article216 and_Avvisati, F. et al. (2013), "Review of the Italian strategy for digital schools", OECD Education Working Papers, No. 90, OECD Publishing, Paris, http://dx.doi.org/10.1787/5k487ntdbr44-en.

Alternative measures to promote ICT professional development for teachers include non-monetary incentives. As an example, fellowship programmes such as those pioneered in the United Kingdom can provide recognition for lead teachers in ICT without introducing permanent and formal leadership positions. In addition, state funded competitions such as the Chilean ENLACES can provide incentives to teachers to reflect and elaborate strategies on how to best integrate ICT in teaching processes. Likewise, prizes have been awarded to innovative teachers who integrate ICTs into their daily practices. Those prizes have often been supported by with large private institutions such as the Telefonica Foundation and Intel (OECD, 2012b).

ICTs to support professional learning communities

Alongside professional development in a formal setting, establishing communities of practice among teachers can help them improve their teaching practice and overcome individual challenges (Vieluf et. al. , 2012).The rapid expansion of ICTs and social media has allowed teachers to gather into virtual and physical professional learning communities. In these communities, teachers can share access to learning materials, learn about good practices in teaching and learning, have the videos of their classes observed and commented by colleagues as well as exchange ideas on online forums according to their field of expertise.

Some of these communities function as proper social networks for teachers. **Edmodo** is one of those social learning platform where educators are able to manage their classrooms and assessments and share lessons and tips with each other. Similarly, **edWeb.net** is a professional social and learning network for educators, decision-makers, and influencers. EdWeb can be used to create a personal learning network or professional learning community to make it easier to collaborate, share ideas. In addition, the platform provides free professional learning programmes and personalised training. Other platforms such as **Edutopia** have an explicit goal to showcase evidence- and practitioner-based learning strategies that empower teachers to improve education through teaching 21st century skills such as critical thinking, problem solving, communication and collaborative learning.[1]

Perhaps the most comprehensive and diffused teachers' platform is TES, the world's largest online community of teachers with 7.9 million registered users[2]. TES provides a dynamic global marketplace in which educators can discover, share and sell original teaching materials; a lesson-building product where those resources can be freely integrated and implemented; and Wikispaces, open classroom management platforms that facilitate student-teacher communication and collaboration. Originally born in the United Kingdom TES has kept its focus on professional development opportunities for teachers and includes a job market platform and prebuilt teaching solution to schools as part of its services.

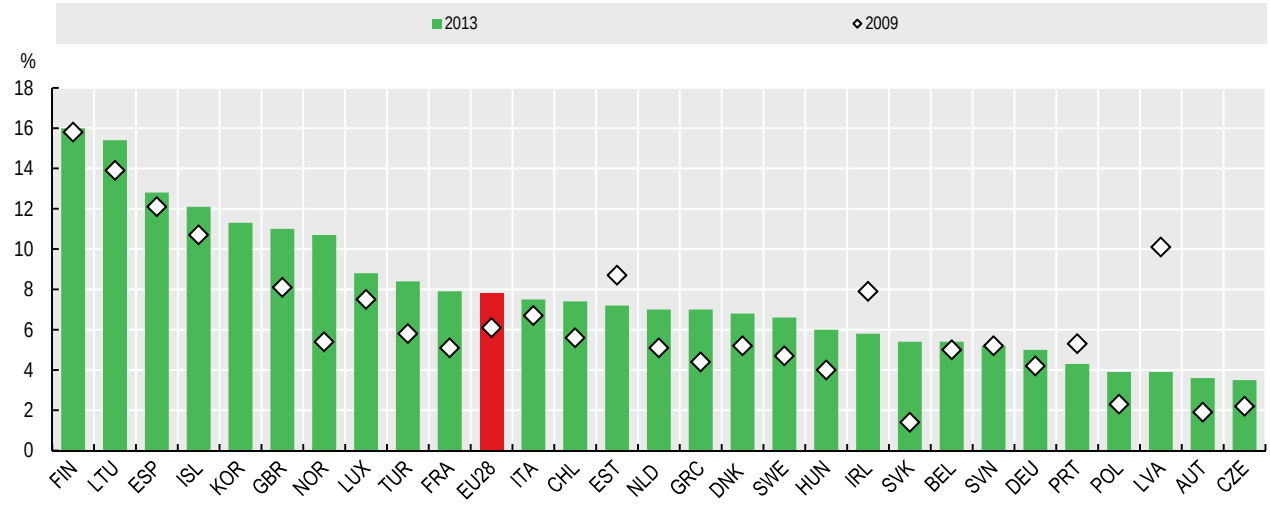
Massive Open Online Courses (MOOCs) for lifelong learning

In addition to revisiting the teaching profession, digital technologies open up opportunities for self-directed learning and continuous professional development. In particular, Massive Open Online Courses (MOOCs) appear to be well-suited to respond to the need of updating competencies in a lifelong learning perspective by overcoming time and resources constraints. As a result, online resources can offer a partial solution to the challenges of skills development, activation and effective utilisation.

Increasing connectivity and broadband capacity have reshaped the image and appeal of distance education. While its origins dates back to more than a century, distance education has evolved together with technology, from radio through television up to the Internet. Online education has slowly but steadily increased in popularity by mainly targeting continuing education and professional development and as a second best solution to provide access to an increasing demand for higher education. In the last five years, online education found its peak moment with the emergence of Massive Open Online Courses (MOOCs). MOOCs are fully fledged courses of lectures available online to serve a wide variety of purposes.

With MOOCs, the term 'massive' clearly implies a significant scale. Coursera, one of the leading educational platforms, has now reached approximately 17 million people while enrolments in EdX peaked to 5.3 million in June 2014. In 2013, 7.8% of Internet users in the European Union followed an online course against 6.9% in 2009. Across the 26 OECD countries on which data is available, 7.6% of people followed an online course, with peaks of 16% in Finland and the lowest levels in Austria, Czech Republic and Poland (Figure 9).

Figure 9. Individuals who participated in an online course



Source: OECD (2015o)

However, these numbers do not say the extent to which MOOCs contribute to student learning or skills development for it is known that on average only 5% of no-fee participants in EdX in complete these courses (Ho *et al.*, 2015). These high dropout rates can be explained by several factors; learner's motivation to start a course, incentives driving completion as well as the inherent difficulties that completing a MOOC may entail. As an illustration, educational research has shown that self-regulation skills which are particularly important for online courses, do not simply emerge from studying on line but are a precondition for effective self-directed learning (Orr, Rimini and Van Damme, 2015).

With less than five years of history, it is too early to determine the success or failure of MOOCs. Even the most consolidated providers continue changing their services in order to reach broader audiences and ensure long-term financial sustainability. Udacity, the first MOOCs provider, was also the first to shift from a student to a corporate -oriented model, whereas edX has kept its focus on their original mission of expanding access to knowledge. To better understand how they can address education and labour market challenges, it may be useful to classify MOOCs according to the main market they serve (Table 1).

Table 1. Classification of MOOCs by market served

Category	Major players	Primary "Customer "
Academic platform providers	Coursera, EdX, FutureLearn	Independent learners and Academic Institutions
New corporate courseware providers	Lynda.com, Skillsoft, Udemy	Corporate training departments
Continuous professional development providers	Udacity, FutureLearn	Lifelong learners/corporate training departments
Public Employment Services	Pôle Emploi France	Temporary unemployed and job seekers

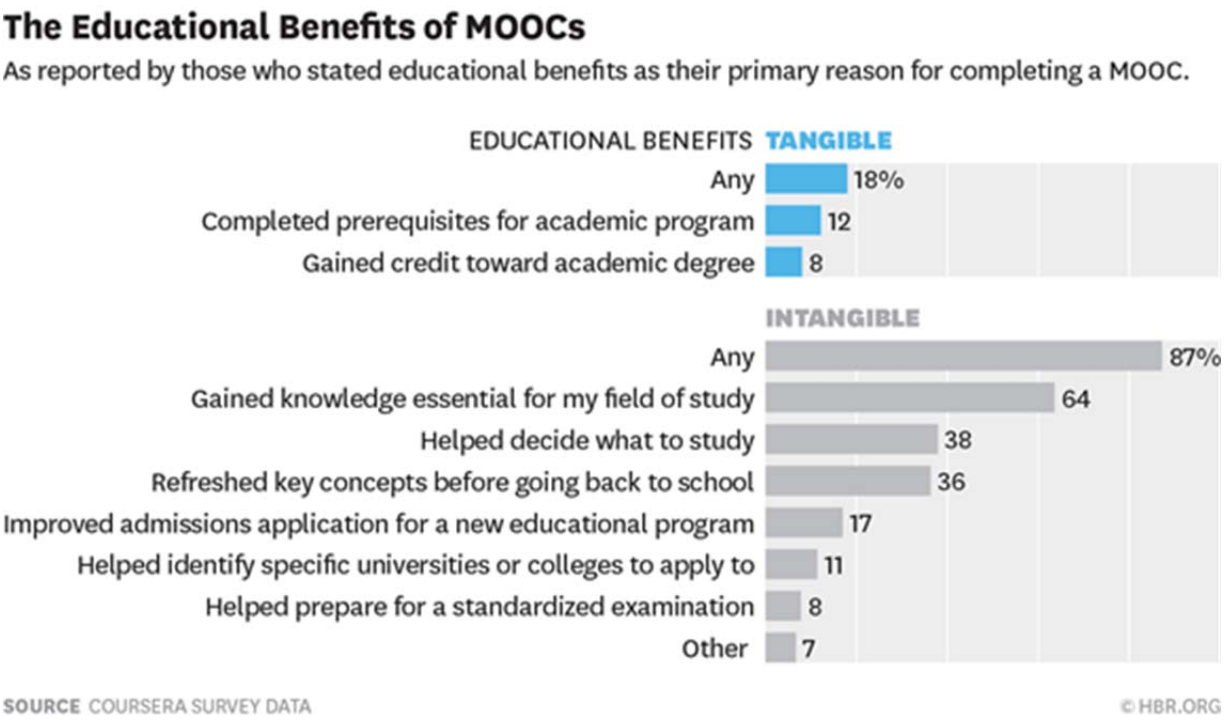
Learners taking part in MOOCs provided by academic platforms such as Coursera and EdX are driven by diverse motivations and incentives. Some may enrol a course out of personal curiosity for a specific subject, some may want to deepen their knowledge or strengthen their skills in a specific domain and others may enrol to prove their interest and knowledge to the eye of a current or potential employer (Zhenghao *et al.*, 2015) .

The latest demographic trends collected from EdX paint a picture of an average learner[3] who is highly educated (69% with a Bachelor degree) predominantly male (78%) and in 29% of the cases American (Ho et al., 2015). On average among the participants 17% explore more than half of the course content and 8% earn a certification (ibid.). The majority of learners took part in Computer Science courses (36%) followed by STEM (26%) and Humanities (21%). Across disciplines it is interesting to notice that computer science and STEM courses were mostly serving younger, male, international and less educated population whereas Humanities had a more gender balanced, older and educated population.

The main motivations for Coursera's learners to complete their course appear to be to improve their current job or finding a new one (52%) and to seek to achieve an academic objective (28%) (Figure 10). Looking at outcomes, 26% of those with professional ambitions found a new job while only 3% obtained a salary increase or a promotion after the successful completion of the MOOC. Among the educational benefits, only 12% of academic seekers actually completed prerequisites for academic programmes while 64% gained essential knowledge for their study field (ibid.).

Figure 10. Reported educational benefit from completing a MOOC

Survey of Coursera's learners



Source: Zhengao et al. (2015)

The demographic characteristics of the first cohorts enrolled in MOOCs have prompted providers to rethink their models. Among the big platforms, Udacity took the strategic decision to re orient its business model towards professional development.

MOOCs have the potential to address many shortcomings of workforce training. Firstly, they avoid the cost of setting up expensive training boot camps whose effects are limited in time. Secondly, semi-synchronicity allows learners to go through the materials at their own pace while motivating them to collaborate into reaching a common learning objective. Lastly, certificates allow employees to demonstrate the acquisition of specific skills (Meister, 2013).

Keeping the workforce up-to-date with technological change and new skills demands is a key priority for both policy makers and the private sector. Companies have started using MOOCs for training their workers and provide them with incentives for self-directed skills development. Google, for example, has enrolled its employees in Udacity's HTML5 course while Tenaris, a large player in the steel industry, teamed up with edX to expand its existing training programmes delivered through Tenaris University to nearly 27,000 employees worldwide (EdX, 2013). In contrast, McAfee adopted a flipped classroom approach to overhaul the new hires' initial boot camp programme.

Several companies are also using MOOCs to incentivise their employees to keep their skills and knowledge up to date. As an example, Deloitte encourages consultants to sign up for Coursera courses on corporate finance, financial markets and the energy industry (Deloitte 2015) while Yahoo reimburses software developers and engineers for participating in verified Coursera's MOOCs. MOOCs are used in this equal spirit also by International Organisations such as the World Bank and the IMF. The World Bank partnered with Coursera to build courses on education, health and climate change for its partners and technical experts in developing countries (ibid.). The IMF is working with edX to educate government officials around issues of public debt and financial policy making (Coughlan, 2013).

Employers' engagement with MOOCs goes beyond workforce training purposes. Employers have acknowledged that MOOCs could serve as a powerful instrument to secure the next generation of talents, in particular with respect to the needs of the ICT industry. The example of the Open Education Alliance (OEA) clearly illustrates the point. The OEA is a joint venture between Udacity and major software companies such as Google, Facebook, ATandT and Nvidia, and set to teach students and workers relevant skills to find a job in the industry in order to make high quality education available, and to connect learners with opportunities in industry.[4]

With the courses provided in the OEA, learners can take part in Nanodegree programmes whereby courses are aligned to meet the curricular requirements and skills that are highly in demand across the ICT sector. To incentivise students' buy-in a recent campaign is offering a 100% tuition fee refund, should the student not be hired within 6 months following the end of the programme[5]. In addition, many ICT companies have paid major MOOCs providers to match them up with high performing students who may be a good fit for their company (Deloitte, 2015). Consequently, MOOCs degrees designed in collaboration with employers have a high potential to facilitate students' school-to-work transition into the ICT industry.

With the ambition to facilitate the reinsertion into the labour market of the long term unemployed the French Public Employment Service, Pôle Emploi, has recently launched a MOOCs platform that provides professional orientation courses to help job seekers build their value proposition to potential employers. (Dauvergne, 2015) The platform offers 4 courses aiming at empowering job seekers with tools to prepare their professional project, organise the job search and select job offers matching their profile and aspirations, prepare a CV and cover letter as well as mock interview. As of May 2015, more than 14,000 job seekers subscribed to the platform (ibid.).

Data driven innovation in teaching and learning

Online resources such as MOOCs, together with digital administrative records, enable the collection of data about virtually every aspect of the educational enterprise, from the incidence of a certain type of error in a mathematics assignment to the expenditures of national administrations on schools subsidies. As in other industries, stakeholders in education and training have started to elaborate strategies to leverage big data.

In the case of MOOCs, most of the foreseeable benefits concern the improvement of personalised learning experiences via gradual and iterative product and process enhancement. At the same time,

effectively using the data collected via learning management or longitudinal information systems may address some educational systemic challenges such as monitoring and evaluation as well as school and system management.

The popularity of MOOCs has made a high volume of learner data available for analytical purposes. While some MOOC data is comparable to data coming from the classroom, the platform records capture every mouse click, video player control use, and every submission to the platform (O'Reilly and Veeramachaneni, 2014). As a result, the recorded detail of behaviours in a MOOC vastly exceeds what is recorded in conventional settings and enables a more granular understanding of learners' behaviours. In turn, large sample sizes allow confirming hypotheses about how learning takes place and existing learning styles In addition, they can expose effective ways to teach and learn and shed light on how to help students who make mistakes.

More specifically, predictive data analytics can predict students' performance by looking at student's interaction with peers and the teacher. Prediction models can also tell which students will be likely to exit the course before completion. Real time monitoring of collected data can provide intelligent and immediate feedback to students in response to their inputs to improve their performance and may also recommend new courses based on their interests to avoid misguidance in field choice ((Sin and Muthu, 2015).

Other predictive analytical models could estimate the skills acquired by the learner during the course. MOOCs can thus be used as a tool to improve student guidance and performance. An experiment used log students' log files to measure error and progress rates. In another experiment, a software was designed to recognise learners' facial expressions to predict their engagement, frustration and learning outcomes while taking the different modules of the course (Grafsgaard et al., 2015)

Predictive analytics can offer a partial solution to one of the central concerns for MOOCs, the very low levels of completion rates. In particular, learning analytics techniques and educational data mining allow for an analysis of the low level trace data regarding students' interactions with a course and with other students. From this kind of low-level structured data, it is possible to automatically infer higher level student behaviour (e.g. dropout) in order to inform educational decision-making (e.g. intervention). Leveraging big data in MOOCs ultimately translates into adding instruments to improve course content, student retention and the level of personalisation of the learning experience.

Other untapped resources of data in education are those contained in learning management and longitudinal information systems. The data contained in these resources span from student assessment and achievement data to system level data on national expenditures in education. With such breadth and depth these systems have the potential to inform systemic improvements and policy decision in a number of educational situations including resource management, evaluation and funding priorities. In addition, from an e-government perspective, the availability of these data greatly improves transparency and accountability in education thereby enabling parents to make more informed choices for the future of their kids.

Longitudinal information systems, whereby students are tracked individually and over time, may provide policy-makers and educational researchers with broad avenues for research to analyse the determinants of student success as well as the effectiveness of educational interventions and reforms (Vincent-Lancrin and Gonzalez-Sancho 2015) . Additionally, data collected from longitudinal information systems can support schools self-assessment initiatives and strengthen public accountability by informing a better contextualisation of school performance. As in the case of MOOCs, longitudinal information system can drive personalised learning by identifying individual learning patterns to tailor instruction and reconcile it with the overall classroom learning objectives.

As an example, since 2012 the Teacher to One: Math (TtO) model was implemented in eight schools of Chicago, Washington DC and New York to tailor instruction to individual needs. The programme assesses students' skill levels on a daily basis and uses algorithms to target content delivery and assign students to varying instructional modes. The model relies on data from continuous formative assessment to identify individual learning gaps in maps describing progression in skills.. The generated data can be pulled together and analysed to understand personal learning patterns (ibid).

The integration of such system with other data sources on teaching practices and other educational variables can open up numerous avenues of research and exchange of good practices. In a more widely adopted system of this nature teacher could collaborate and identify more appropriate teaching practices, share experiences through social networks and inform decision on curriculum design at school, local and national level.

Fulfilling this potential hinges on the capacity of teachers and school leaders to make sense of the vast amount of data provided by the system. Although it may be unrealistic and unnecessary to expect all teachers to become well-versed in data analytics, there is still a need to provide adequate training to a few teachers or school leaders in each educational establishment. Indeed, teachers require training in digital technology as much data analysts need to stay up-to-date stay with the fast developments in big data (OECD, 2015m)

A good practice example comes from the Netherlands where a *Datateams* procedure has been developed to use data for school improvements (Vincent-Lancrin and Gonzalez-Sancho, 2015). According to this approach, teachers, data experts and school leaders attempt to address specific school problems and use data to solve them. The collaborative procedure has proved effective in increasing teachers' data literacies and skills for data use (ibid).

Longitudinal information systems raise many privacy issues as educational data are particularly sensitive in that they provide information about children, without them having awareness or control in the process. The exposure of personal data at an early age may be conducive to situations of cyber-bullying, fraud and other related internet risks affecting young people (Rimini and Howard, 2015). Policies allowing for restricted access to specific categories within school administration offer a partial solution but, at the same, limit data use. Moreover, concerns are sometimes raised with regard to bad use of data, whereby failures in earlier years of schooling could prejudice further educational and professional opportunities (Vincent-Lancrin and Gonzalez-Sancho, 2015).

While a wealth of data is produced daily in education, information may not be always available due, for instance, to incomplete digitisation or limited interoperability among different applications. Building partnerships and trust for data sharing and data use is therefore crucial (ibid). Such partnerships should be established across the different agencies and institutions at local, regional and national level and may lead to establishing formal procedures. Last but not least, the spill-over effects of releasing educational data to wider audiences, including the business sector, should be taken into account when considering licensing regimes for non-sensitive information. Openness in data generated in the public sector can fuel greater levels of innovation activities by the business sector (Box 14).

Box 14. Open data strategies: The United Kingdom case

In June 2012, the UK Cabinet published its open data white paper, which set out how the government intends to put data and transparency at the heart of public services. The white paper is integral to the full commitment to make open data an effective engine of economic growth, social well-being, political accountability and public service improvement in the United Kingdom. In order to frame a feasible public sector implementation plan for open government data, the paper highlights that following two years of the centre of government leading the initiative, government departments are expected to take a greater role in driving efforts forward. Therefore, alongside the white paper, each government department published their first open data strategy.

The Department of Education published its Open Data Strategy in 2012 where alongside the objectives of increasing transparency and accountability an explicit point is made about the necessity to opening up the market for innovative products. *Shared data standards are an important underpinning to a more transparent system, and help save money because they allow for greater competition in the supply of services and systems to schools* (DoE 2012)

Adapted from: OECD (2015), Data-Driven Innovation: Big Data for Growth and Well-Being, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264229358-en

The ability to track individuals from early childhood to the labour market opens up a range of possibilities for gaining better insights on school to work transitions. While to date longitudinal information systems are seldom capable to deliver such services, they will be fully able to do so when appropriate data sharing agreements will connect schooling with labour market data. As noted during a recent OECD –CERI workshop on longitudinal information systems, integrating data on personal learning trajectories and labour market needs could improve study design programmes and talent management by government and business officials (Vincent-Lancrin and González-Sancho 2015).

Digital technologies and the labour market

In addition to their benefits for education and training, digital technologies ICTs can also help to identify emerging skills needs, evolving demands and potential skills gaps by providing real time intelligence on the labour market. Workers, firms and policy-makers can monitor changes in occupational demands and adjust their strategies accordingly with potential benefits with reference to school to work transitions and labour market reinsertions. Moreover, digital technologies can help Public Employment Services facilitating the exchange of information about employment opportunities and produce efficiency gains by serving larger audiences at similar or lower cost.

With an increasing number of vacancies going online, the amount of data concerning labour markets is on the rise paving the way to important avenues of research on labour market trends. Innovative businesses are ready to jump on such data goldmine to create services for intelligence and analytics and better match demand and supply to the benefit of jobseekers and employers. In this relatively new field a number of private firms like Burning Glass and Jobfeed and a few National Statistical Offices have started to collect and to analyse online job postings to compile statistics on online job vacancies.

Online job vacancies have the potential to improve the analysis on labour markets in a number of fields. These may range from a detailed description of the skills required to fulfil specific roles, to the analysis of shifts in skills demands for those very roles as well as shifts in job profiles based on a large range of job requirements related to skills, education and experience. In addition, real-time data can provide evidence of skills gaps across economic sectors at local, regional, national or supranational level. By analysing job seekers profiles and job postings it becomes possible to identify career paths across professions. Moreover, by looking at career paths, employers can better understand skills supply chains so that their job openings can be better planned.

The analysis of online vacancies can empower policymakers and other stakeholders with a better understanding of newly emerging profiles which may not necessarily be reflected into occupational standards, despite increasing in demand. These new professions are essentially driven by technology and call for a set of skills that are not typically included in traditional academic courses. To illustrate, analyses performed by Burning Glass on the US labour market have revealed the emergence of a new kind of hybrid jobs blending technology with marketing which are typically advertised as User Experience Designer or Product Manager roles (Burning Glass, 2015).

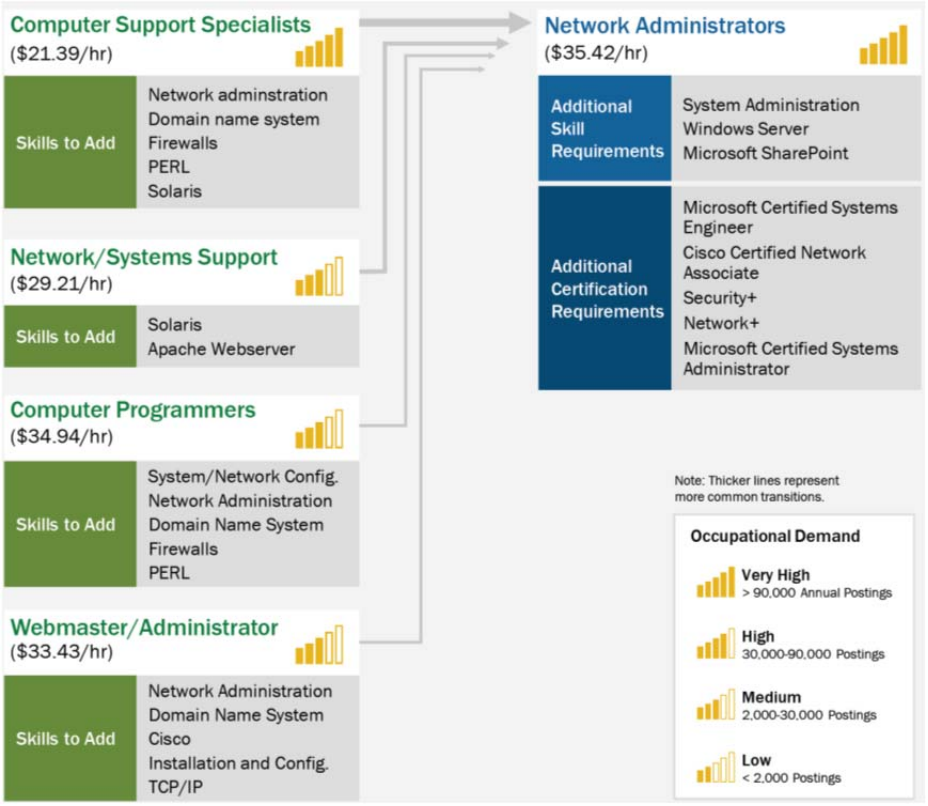
These roles require a combination of programming skills and skills commonly found in design, data analysis, and marketing. In a 12-month period (April 2014 – March 2015), more than a quarter million advertised job postings in the United States sought this kind of hybrid talent (ibid.). These roles in many cases do not typically align well with established higher education programmes and, as a result, concerns regarding the existence of skills gaps are legitimately raised. Arguably, the kind information emerging from the analysis of job vacancies can contribute to multi-stakeholder discussions on skills and inform policy decisions.

The intelligence gathered through online vacancies can provide a better understanding of career paths within and across industries, as illustrated in Figure 11. This type of information can be beneficial to jobseekers, professionals, employers and policy makers alike. It allows job seekers to plan their career projects by giving them an overview of what their career may look like once a certain step is undertaken. It may help professionals to better plan their career evolution by showing them what skills are required to progress to a more senior position. Moreover, it can help employers in their talent acquisition decisions such as whether to open a more junior post and provide the candidate with additional training or directly look for someone with a senior profile.

The example in Figure 9 illustrates common pathways to becoming a network administrator. As displayed, people with different job profiles can aim at the role, providing that they acquire the described missing skills. The process can be also reverse engineered by looking at the different professional development options that a worker may pursue. The worker may benefit from a clearer picture of the potential earnings, the training needed and may better assess his or her bargaining power at the negotiation table, depending on the specific overall occupational demands.

Figure 11. Network administrator career pathways (2015)

Common pathways into network administrator roles



Source: Accenture et al. (2015), based on Burning Glass data

From a more systemic perspective, the analysis of online vacancies can offer an instantaneous picture of existing skills gaps. A recent analysis of the United States Labour market conducted by Burning Glass looked into the existing gaps in STEM professions (Figure 12).

Figure 12. Skills gaps in STEM professions (2014)



Source: Burning Glass. 2014.

The analysis revealed that, in 2013, there were 5.7 million total postings in STEM fields in the United States. Of those, 76%, or 4.4 million, require at least a bachelor's degree (BA) and 41%, or 2.3 million, are entry-level jobs requiring less than 2 years of experience.

Calculations comparing graduation rates and online vacancies also illustrate the presence of severe skills gaps. According to the study, in 2013 there were 2.5 entry-level job postings for each new 4-year graduate in STEM fields compared to 1.1 postings for each new Bachelor graduate in non-STEM fields. In addition, STEM jobs were offering substantial salary premium. The average advertised salary for entry-level STEM jobs requiring a Bachelor's degree was 26% higher than for non-STEM jobs. However, the salary premium for jobs not requiring a Bachelor degree was even higher for STEM jobs with a difference of over USD 10 000 equal to a 28% premium (Burning Glass, 2014).

While significantly revealing in terms of skills gaps, the use of data from online vacancies presents some limitations for policy-making. The rapid pace at which technology advances combined with business cycle fluctuations may change the economic scenario affecting the labour market. This has important consequences on how real time data can be used to define education and training policies whose effects will be visible after a significant time lag. As a result, real-time data from online vacancies should be handled in a similar spirit as the one driving the discussion on Skills Assessment and Anticipation exercises. Namely, to develop re-skilling training programmes and inform education, migration and labour policies (OECD, 2015e).

Public Employment Services are increasingly making use of digital technologies to facilitate the exchange of information on employment opportunities and act as job-brokers for the unemployed (OECD, 2015g). Compared to private employment agencies, PES are requested to gain an additional level of trust from employers who sometimes believe that jobseekers referred by the PES are less motivated and trustworthy as they appear unable to find a job through regular market channels. In addition, employers suspect that the PES hide important information in attempting to reintegrate an individual (ibid.).

An alternative approach to circumvent this information asymmetry problem has been championed by several OECD countries who decided to run completely open vacancy database to complement private sector offering. In some countries, the PES online vacancy databases have established strong positions and now are the single most used vacancy platforms. For example, in Sweden the ratio of vacancies notified to the PES database to total new hires in the labour market was 44% in 2013, and in Germany around 50% of all vacancies are reported to the PES (ibid.).

Box 15. Example of labour market information tools in OECD countries

Canada Job Bank

The Canadian job bank website (www.jobbank.gc.ca) is administered by the Government of Canada and provides information in French and English on jobs, career paths, employer resources and job market trend nationally as well as provincially. By the virtue of including postings from some private sector job boards, the job bank could be considered as an open vacancy database. The homepage interface provides a search function to look for jobs in specific locations, functions to set up job alerts, analysis of top advertised jobs and job search safety tips. Employers as well as jobseekers can create a personal account that keeps track of their postings or searches. Career paths can be explored according to occupation, education attainments, wages, outlook and skills. The job market trends are updated constantly with news feeds (OECD, 2015h).

Swedish Platsbanken

In Sweden the Platsbanken job bank is run by the national Public Employment Service (arbetsformedlingen) and has more than 1,7 million visitors every month. The platform contains around 1.045 000 job announcements and covers the majority of job vacancies in the country. Platsbanken is available as an app for smartphones. Under the tab Yrke och framtid (Occupation and Future) a section contains information about most occupations, what are the educational criteria to qualify for them and what prospects they offer. A career guidance section explains to the job seeker how to write a cv and cover letter. (http://www.arbetsformedlingen.se/)

Publicly funded online job portals have thus proved their effectiveness in a number of OECD countries (Box 15). The impact of digital technology in helping PES deliver their services is not limited to online vacancy databases as IT systems continuously improve and increasingly allow routine tasks to be automated. In this context, PES are concentrating more on front-line services and may free up additional resources to address the needs of those most in need.

In an attempt to reduce costs the Dutch Public Employment Service developed a wide range of digital services to cater to a larger number of jobseekers in a more efficient way. These include a new profiling tool called “work explorer” which determines the probability that a jobseeker will resume work within a year, an e-coaching plan which automatically delivers action plans and matched vacancies to the jobseeker and monitor his or her response, as well as a range of technologies supporting counselling to monitor job search and CV effectiveness. These technologies can be used to effectively address job seekers’ needs during personal counselling interviews (OECD, 2015f, p. 149).

CONCLUSION

The pervasiveness of digital technologies in daily life is fundamentally changing the way individuals access and elaborate knowledge. Individuals have to process complex information, think systematically and take decisions weighting different forms of evidence. They also have to continuously update their skills to match rapid technical change at the workplace. More fundamentally, in order to seize the new opportunities that digital technologies are opening in many areas, individuals have to develop the right set of skills to make a meaningful use of these technologies.

The OECD Skills Strategy provides a useful approach to inform the policy discussion on the opportunities and challenges created by the digital economy for skills development. The OECD Skills Strategy help countries assessing strengths and weaknesses of their systems in developing relevant skills, activating skills and putting skills to effective use.

In addition to digital literacies and ICT-specific skills, the identification of the skills relevant for the digital economy and of the strategies to develop them is entrenched with the notions of higher order thinking, communication and social skills. While OECD countries have not yet developed systemic policies in this sense, a great deal of experimentation is taking place in of them.

Massive Online Open Courses (MOOCs) and Open Educational Resources (OER) modify learning methods and give access to quality resources to a larger population over more flexible hours. The use of digital technologies in formal education and vocational training has the potential to improve learning, although the outcomes depend on the capacity to link these tools to effective pedagogy. Big data analytics can also complement labour market information systems with a more timely and precise monitoring of changing skills demand to adapt skills development and activation policies.

Seizing the educational opportunities from digital technologies requires a process of institutional learning, where actors are given sufficient scope to experiment with new tools and approaches and systematic assessment of outcomes leads to select the most effective practices. Barriers to access have to be addressed, as well as existing concerns about quality and status. To meet the challenges for education and training specific to the digital economy, the OECD approach could be further developed with a focus on “Skills for a Digital World”.

This approach consists of three main steps:

- First, identify more precisely the kind of skills required in the digital economy, through the definition of an agreed framework for digital literacy, further cross-country analysis of existing datasets and the development of new surveys.

- Second, examine how these changes may translate into curriculum reform, teacher training and professional development.

- Third, leverage ICTs to improve the access to and the quality of education and training, e.g.: through online courses, new learning tools at school and adequate recognition of skills acquired through informal learning.

NOTES

[1] See here for http://www.edutopia.org/

[2] See here for https://www.tes.com/

[3] The statistics refer to the subset of population who have registered and have been exposed to the content of the course.

[4] See here for https://www.udacity.com/open-ed

[5] See here for https://www.udacity.com/open-ed

REFERENCES

Agenzia per l'Italia Digitale (2015), *Italian Digital Agenda*, http://www.agid.gov.it/. (accessed 23 May 2016).

Ananiadou, K., and Claro, M. (2009). 21st Century Skills and Competencies for New Millenium Learners in OECD, (41).

Autor, D.H., et al, (2003), "The Skill Content of Recent Technological Change: An Empirical Exploration", Quarterly Journal of Economics, Vol. 113, No. 4, pp. 1279-1333.

Atkins, H., et al, (2013), "On Becoming Digital Educators: Supporting Faculty and Student Growth in Technological Pedagogical Content Knowledge" in R. McBride and M. Searson (Eds.), *Proceedings of Society for Information Technology and Teacher Education International Conference 2013* (pp. 1229–1233). New Orleans, Louisiana, United States: Association for the Advancement of Computing in Education (AACE), http://www.editlib.org/p/48292 (accessed 23 May 2016).

Behaghel, L., et al, (2014). Age-biased Technical and Organizational Change, Training and Employment Prospects of Older Workers. *Economica*, *81*(322), 368–389. doi:10.1111/ecca.12078.

Behaghel, L., and Greenan, N, (2012), "Training and Age-Biased Technical Change" in *Annals of Economics and Statistics / Annales d'Economie et de Statistique*, (99/100), 317–342, http://www.jstor.org/stable/41219169 (accessed 23 May 2016).

Burning Glass (2014), *Real-Time Insights into the Market for Entry-Level STEM Jobs*, http://burning-glass.com/wp-content/uploads/Real-Time-Insight-Into-The-Market-For-Entry-Level-STEM-Jobs.pdf (accessed 23 May 2016).

Burning Glass (2015), *Blurring Lines: How Business and Technology Are Merging to Create High Opportunity Hybrid Jobs*, http://burning-glass.com/wp-content/uploads/Blurring_Lines_Hybrid_Jobs_Report.pdf (accessed 23 May 2016).

Coughlan (2013), IMF launching courses on online university, *BBC News*, http://www.bbc.com/news/business-22938868 (accesed 23 May 2016).

de Corte, Erik (2010), "Historical developments in the understanding of learning", in Hanna Dumont, David Istance and Francisco Benavides (eds.), The Nature of Learning: Using Research to Inspire Practice, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264086487-4-en.

Dauvergne (2015), J'ai testé pour vous les Mooc de Pôle emploi, *L'Express*, http://www.lexpress.fr/emploi/formation/j-ai-teste-pour-vous-les-mooc-de-pole-emploi_1683490.html (accessed 23 May 2016).

Deloitte, B. (2015), Putting MOOCs to work-how online education impacts corporate training, http://www.slideshare.net/jbersin/bersin-moo-cs-forslideshare12-29054376/14-The_MOOC_Market_PlayersCopyright_2013 (accessed 23 May 2016).

Dumont and Istance (2010), Analysing and designing learning environments for the 21st century. In *The Nature of Learning: Using Research to Inspire Practice* (pp. 19–34), OECD Publishing, Paris.

Empirica (2014a), e-skills for jobs in Europe: Measuring Progress and Moving Ahead, http://eskills-monitor2013.eu/fileadmin/monitor2013/documents/monitor_final_report.pdf (accessed 23 May 2016).

Economist, T (2011), Flipping the Classroom, p. 3. London, http://www.economist.com/node/21529062 (accessed 23 May 2016).

EdX (2013), Global Steel Manufacturer Tenaris Adopts edX Platform for Employee Training, http://blog.edx.org/global-steel-manufacturer-tenaris-adopts (accessed 23 May 2016).

Empirica (2014b), *e-Skills in Europe - Sweden Country Report*, http://ec.europa.eu/growth/sectors/digital-economy/e-skills/index_en.htm (accessed 23 May 2016).

Empirica (2015), e-Leadership. Retrieved January 13, 2016, http://eskills-lead.eu/about/

Espana, G. de (2013), Plan de Implantación de la Garantía Juvenil en España, http://www.empleo.gob.es/ficheros/garantiajuvenil/documentos/plannacionalgarantiajuvenil_es.pdf (accessed 23 May 2016).

European Commission (2016), e-Skills for growth and jobs, http://ec.europa.eu/growth/sectors/digital-economy/e-skills/index_en.htm (accessed 23 May 2016).

European Commission (2007), E-Skills for the 21st Century: Fostering Competitiveness, Growth and Jobs. *October*, http://ec.europa.eu/enterprise/sectors/ict/files/comm_pdf_com_2007_0496_f_en_acte_en.pdf (accessed 23 May 2016).

European Commission (2013a), Active Labour Market Policies, (Figure 1), 1–14.

European Commission (2013b), Reducing early school leaving : Key messages and policy support, (November), 46.

European Commission (2015a), EU Youth Guarantee : Questions and Answers, (April 2013).

European Commission (2015b), The Youth Guarantee - First Successes - The Youth Guarantee on the Ground, 4, http://ec.europa.eu/social/main.jsp?catId=738andlangId=enandpubId=7763andtype=2andfurtherPubs=yes (accessed 23 May 2016).

Federation for Industry Sectors, Skills and Standards (2015), *Our Membership: Employer-led partnerships*, http://fisss.org/sector-skills-council-body/ (accessed 23 May 2016).

Grafsgaard, J. F., Lee, S. Y., Mott, B. W., Boyer, K. E., and Lester, J. C. (2015). Modeling Self-Efficacy Across Age Groups with Automatically Tracked Facial Expression. In *Proceedings of the International Conference on Artificial Intelligence in Education* (pp. 582–585), http://research.csc.ncsu.edu/learndialogue/pdf/LearnDialogue-Grafsgaard-AIED-2015.pdf (accessed 23 May 2016).

Go ON UK (2015), *Go ON UK Basic Digital Skills Framework*, http://www.go-on.co.uk/get-involved/basic-digital-skills/ (accessed 23 May 2016).

Halbert, K. (2013). *OECD Innovative Learning Environments Canada (British Columbia) system note*, http://www.oecd.org/edu/ceri/50301622.pdf (accessed 23 May 2016).

Ho, A. D., Chuang, I., Reich, J., Coleman, C. A., Whitehill, J., Northcutt, C. G., … Petersen, R. (2015). HarvardX and MITx : Two Years of Open Online Courses Fall 2012-Summer 2014. *SSRN Electronic Journal*, (10), 1–37. DOI:10.2139/ssrn.2586847.

Kärkkäinen, K., and Vincent-Lancrin, S. (2013). Sparking Innovation in STEM Education with Technology and Collaboration. A Case Study of the HP Catalyst Initiative. *OECD Education Working Papers*, *91*, 128, http://dx.doi.org/10.1787/5k480sj9k442-en (accessed 23 May 2016).

Ikanos (2015), *Ikanos project Basque Country, Spain*, http://ikanos.blog.euskadi.net/wp-content/uploads/2014/04/ikanos_project_en.pdf. (accessed 23 May 2016).

Interface3 (2014), Rapport d'activité 2013, 88–94.

IVI, and Empirica. (2014), *e-Skills: The International dimension and the Impact of Globalisation (Final Report)*, http://eprints.maynoothuniversity.ie/5559/1/CT_e_Skills_report.pdf (accessed 23 May 2016).

Levy, F., and Murnane, R. (2007), How computerized work and globalization shape human skill demands. *Learning in the Global Era: International Perspectives on Globalization and Education*, 158–174.

Livingstone, S., and Helsper, E. (2007), Gradations in digital inclusion: children, young people and the digital divide. *New Media and Society*, *9* (4), 671–696. DOI:10.1177/1461444807080335.

Lowell Bishop, J., and Verleger, M. (2013), The Flipped Classroom : A Survey of the Research. *Proccedings of the Annual Conference of the American Society for Engineering Education*, 6219. DOI:10.1109/FIE.2013.6684807.

McGowan, M., and Andrews, D. (2015), *Labour Market Mismatch and Labour Productivity : Evidence From Piaac Data*, Available at https://www.oecd.org/eco/growth/Labour-Market-Mismatch-and-Labour-Productivity-Evidence-from-PIAAC-Data.pdf.

Meister. (2013). How MOOCs Will Revolutionize Corporate Learning And Development, http://www.forbes.com/sites/jeannemeister/2013/08/13/how-moocs-will-revolutionize-corporate-learning-development/#7f9747a83e85 (accessed 23 May 2016).

Mevarech,Z. and B. Kramarski (2014), *Critical Maths for Innovative Societies: The Role of Metacognitive Pedagogies*, Educational Research and Innovation, OECD Publishing, Paris. DOI:http://dx.doi.org/10.1787/9789264223561-en.

Murphy, R., Gallagher, L., Krumm, A., Mislevy, J., and Hafter, A. (2014), Research on the Use of Khan Academy in Schools. *SRI Education*, (March), 17, http://www.sri.com/work/publications/research-use-khan-academy-schools (accessed 23 May 2016).

National Research Council. (2012), *Education for life and work: developing transferable knowledge and skills in the 21st century*. (D. of B. and S. S. and E. Board on Testing and Assessment and Board on

Science Education, Ed.)*National Academies Press*. Washington, DC: The National Academies Press. DOI:0-309-25649-6.

OECD (forthcoming), *New Skills for the Digital Economy: Measuring the demand and suppy of ICT Skills at Work* (DSTI/ICCP/IIS(2015)4/FINAL)

OECD (2015a), *Adults, Computers and Problem Solving: What's the Problem?*, OECD Skills Studies, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264236844-en

OECD (2015b), *Age, Ageing and Skills: Results from the Survey of Adult Skills*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/5jm0q1n38lvc-en.

OECD (2015c), *Education Policy Outlook 2015*. DOI:http://dx.doi.org/10.1787/9789264225442-en.

OECD (2015d), *Education Policy Outlook: Poland*, OECD Publishing, Paris, 1–26. Available at: http://www.oecd.org/edu/POL-country-profile.pdf

OECD (2015e), *Getting Skills Right: Assessing and Responding to Changing Skill Needs,* OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264252073-en.

OECD (2015f), *OECD employment Outlook 2015*, DOI: http://dx.doi.org/10.1787/empl_outlook-2015-fr ISBN.

OECD (2015g), *OECD Skills Strategy Diagnostic Report Korea*. Available at: http://www.oecd.org/skills/nationalskillsstrategies/Diagnostic-report-Korea.pdf.

OECD (2015h), *OECD Skills Strategy Diagnostic Report: Spain*. Available at: http://skills.oecd.org/developskills/documents/Spain_Diagnostic_Report.pdf.

OECD (2015i), *Skills for social progress: the power of social and emotional skills*. *OECD skills studies*, OECd Publishing, Paris, http://www.gbv.de/dms/zbw/824458117.pdf.

OECD (2015j), *Starting Strong IV: Monitoring Quality in Early Childhood Education and Care,* OECD Publishing, Paris. DOI:http://dx.doi.org/10.1787/9789264233515-en.

OECD (2015k), *Students, Computers and Learning: Making the Connection*, PISA, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264239555-en

OECD (2015l), *The Innovation Imperative*. DOI:http://dx.doi.org/10.1787/9789264239814-en.

OECD (2015m), *Data-Driven Innovation: Big Data for Growth and Well-Being*. Paris: OECD Publishing, Paris. DOI:http://dx.doi.org/10.1787/9789264229358-en.

OECD (2015n), *Schooling Redesigned: Towards Innovative Learning Systems*. OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264245914-en

OECD (2015o), *Science, technology and industry scoreboard 2015*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/sti_scoreboard-2015-en

OECD (2015p), *The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence, PISA*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264229945-en

OECD (2014a), *OECD Skills Strategy Action Report: Norway*. Available at: http://www.oecd.org/skills/nationalskillsstrategies/OECD_Skills_Strategy_Action_Report_Norway.pdf.

OECD (2014b), *OECD Skills Strategy Diagnostic Report: Norway*. Available at; http://www.oecd.org/skills/nationalskillsstrategies/Diagnostic-report-Norway.pdf

OECD (2014c), *PISA 2012 Results: Creative Problem Solving (Volume V) : Students' Skills in Tackling Real-Life Problems*, PISA, OECD Publishing, Paris. DOI : http://dx.doi.org/10.1787/9789264208070-en

OECD (2014d), Skills Beyond Schools - Synthesis report. Available at http://www.oecd.org/edu/skills-beyond-school/Skills-Beyond-School-Synthesis-Report.pdf.

OECD (2014e), *Measuring the Digital Economy: A New Perspective*. DOI:http://dx.doi.org/10.1787/9789264221796-en.

OECD (2014f), *Talis 2013 Results: An international perspective on teaching and learning*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264196261-en.

OECD (2013a), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264204256-en

OECD (2013b), *PISA 2012 Results: Excellence through Equity (Volume II): Giving Every Student the Chance to Succeed*, PISA, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264201132-en

OECD (2012a), *Connected Minds: Technology and Today's Learners*, Educational Research and Innovation, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264111011-en.

OECD (2012b), *Innovative Learning Environments, Chile System note.* Available at http://www.oecd.org/edu/ceri/CHL.SystemNote.pdf.

OECD (2010a), *Inspired by Technology, Driven by Pedagogy*. *Educational Research*. DOI: http://dx.doi.org/10.1787/9789264095687-2-enhttp://dx.doi.org/10.1787/9789264094437-en

OECD (2010b), *The nature of learning: using research to inspire practice*,OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264086487-en.

OECD (2010c), Innovative Workplaces: Making Better Use of Skills within Organisations, OECD Publishing, Paris. DOI: http://dx.doi.org/9789264095687-en.

O'Reilly, U.--M., and Veeramachaneni, K. (2014). Technology for mining the big data of MOOCs. *Research and Practice in Assessment*, *9*(2), 29–37.

Quintini, G. (2014), Skills at Work: How Skills and their Use Matter in the Labour Market. *OECD Social, Employment and Migration Working Papers*, (158), DOI: http://dx.doi.org/10.1787/5jz44fdfjm7j-en\nOECD.

Orr, D., M. Rimini and D. van Damme (2015), Open Educational Resources: A Catalyst for Innovation, Educational Research and Innovation, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/9789264247543-en

Rodrigo, D., L. Allio, P. Andres-Amo (2009), "Multi-Level Regulatory Governance: Policies, Institutions and Tools for Regulatory Quality and Policy Coherence", *OECD Working Papers on Public Governance*, No.13, OECD Publishing, Paris.

Rimini, M., Howard, C. (2015), *Digital Resilience: Empowering Youth Online: working paper*.

Rockoff, J. (2004), The Impact of Individual Teachers on Student Achievement : Evidence from Panel Data. *American Economic Review*, *94*(2).

Schneider, H. (2005), Rapid ICT Change and Workplace Knowledge Obsolescence. *SSRN Electronic Journal*. DOI:10.2139/ssrn.870084.

Sin, K., and Muthu, L. (2015), Application of big data in education data mining and learning analytics—A lterature review. *ICTACT Journal on Soft Computing*, *5*(4), 1–35.

Statista (2015), *Online gaming in the U.S. - Statista Dossier*.

Vieluf, S., Kaplan, D., Klieme, E., and Bayer, S. (2012), *Teaching practives and pedagogical innovation - evidence from TALIS*.

Vincent-Lancrin, Gonzalez-Sancho, C (2015), Longitudinal data systems in Education -Workshop summary report, http://www.oecd.org/edu/ceri/EDU-CERI-CD(2015)10.pdf (accessed 23 May 2016).

Van den Brande, Lieve (2015), *EU Common Digital Competence Framework,* powerpoint presentation

Van Reenen, J. (2011), "Wage inequality, technology and trade: 21st century evidence", Labour Economics, Vol. 18, No. 6, pp. 730–741

Zazryn, T., et al (2012), Innovative Learning Environments (ILE) Inventory Case Study The Royal Children's Hospital, Melbourne.

Zhenghao, C, et al, (2015), Who's Benefiting from MOOCs, and Why. *Harvard Business Review*, https://hbr.org/2015/09/whos-benefiting-from-moocs-and-why#