THE e-SKILLS MANIFESTO

With contributions from leading figures in government, education, policy, research and industry

This Manifesto is produced by European Schoolnet and DIGITALEUROPE as part of the eSkills for Jobs 2016 campaign.

The eSkills for Jobs 2016 campaign is an initiative of the European Commission financed under the EU programme for the Executive agency for Small and Medium-sized Enterprises (EASME).

Publisher: European Schoolnet
(EUN Partnership AISBL)
Rue de Trèves 61, Brussels
1040 Belgium

Editors: Emma Bluck and Amy Carter, Gold Spark Consulting

DTP, design and printing: Hofi Studio, Czech Republic

Published: December 2016

ISBN:

TABLE OF CONTENTS

FOREWORD

Europe's actual position in the global economic world is the result of choices made when the industrial revolution rose more than a century ago. In each European country, national policies, including education, were turned toward the goal of industrial success. This affected the way of working, the way of living. Today, we face a new revolution. At first, ICT has come as an accelerator for our industrial processes. But now technologies offer new ways of trading in a globalised world, new disruptive business models, and new services to sell. It changed the access to knowledge, introducing new ways of learning and thinking. Also, relationships and hierarchies between people are evolving. There is no doubt that this new revolution is already having a deeper impact than the previous one.

Europe cannot afford a lower rank in this world economy. It must embrace this revolution and become a leader, not a follower. eSkills are the primary keys for everyone. Many people can be afraid of all this surrounding technology, concerned by their own privacy, not confident with online activity etc. The solution lies in the understanding and mastery of the devices and apps they use everyday, free from any kind of enslavement. But skills are only a first piece of a necessary larger solution. Why do so many young Europeans with a bachelor's or master's degree immigrate to the Silicon Valley? They want to be the pioneers of new hardware, connected devices, software applications… They want to create their own company to explore this new wide and wild territory. And they usually think the US offers a better context to do all of this, while Europe is missing a true and efficient ICT ecosystem. True or not, the cliché remains. A new state of mind is needed. Entrepreneurs can succeed in Europe. The resources and funding exist, innovation is present, and the European market is the first world economic zone in terms of GDP.

A wide delivery of theses messages is important. Schools, and education in general must reflect this revolution. From kindergarten to universities, a strong focus on coding, on collaboration and teamwork, on diversity, creativity and mind agility should take place. Among other private and innovative institutions, school 42 decided to train both the ICT skillset and the mind-set. It directly answers the need of qualified ICT professionals in the French market and also leads students to entrepreneurship.

Europe is an asset for our countries and our common economy. It already discovered and tested new methods, new paths, and success stories. Now it shows directions for global policies. It is time to move forward. All together.

Xavier Niel
Entrepreneur & Co-Founder of 42 School

EXECUTIVE SUMMARY

Since the "eSkills for Jobs" campaign began in 2010, the e-Skills Manifesto has been an important tool for briefing and advising policymakers on the state of digital skills demand, supply, development and best practice across EU member states. Each year, leading experts in eSkills research and policy, from industry and the education sector have been consulted on both the topics to be addressed within the Manifesto as well as on chapter preparation and review. The result is a series of five Manifestos, each exploring broad and specific themes from different perspectives. As a collection, the Manifestos cover a very broad range of eSkills topics.

The 2016 Manifesto is the latest and the last edition for eSkills for Jobs. While new, it complements the Manifestos that precede it.

As Chapter 1 of the 2016 Manifesto outlines, today, there are more than half a million unfilled digital jobs in Europe. The demand for digital jobs is outstripping supply. What is more, the number of new digital jobs is increasing at around 4% a year. This is a paradox. Unemployment rates are at an all-time high, yet industries are unable to find the appropriately skilled people to fill their digital needs.

Europe needs people with the right skills, not just technical or digital, but also soft skills, management skills and leadership skills to manage the companies supplying the products. Chapter 2 and 7 of the Manifesto explore the increasing need for people with eLeadership and T-shaped skills. These are people who have both a technical skills base and the ability to think laterally and who understand the wide impact of technology on organisations and society, now and in the future.

In addition, Europe's citizens need to be ICT savvy. Chapter 9 makes it clear that the excuse, "I am not technical", no longer stands. With both public and consumer services now online, and with the far reaching impact of the Internet of things (IoT) on all aspects of our daily life, citizens need, as a minimum, a basic understanding of technology and how it works. Europeans are diverse; they are male and female, young and old, European-born and migrant. No one should be left behind in the drive to improve eSkills in Europe. Chapters 9 and 10 build upon previous Manifesto editions by providing new references to the broad range of successful, inclusive policies and educational programmes that exist across the EU.

The competences acquired by pupils and the example modelled by teachers to pupils in European educational institutions is a core eSkills topic that is addressed in all e-Skills Manifestos. This topic encompasses teacher training, the focus on STEM education, technology in the classroom, pupil competency

levels across member states, industry collaboration and well as ICT related pedagogies. This year, in Chapter 11, teacher competence levels and coding as a pedagogy are examined. The continued demand for STEM skills and best practices for fostering them are also a key theme in Chapter 12.

Adaptability is crucial when it comes to technology creation, sales, support and use. Change and rapid evolution is inherent to the ICT sector and the products and software it produces. This places a strong emphasis on the need for both ICT sector employees and citizens to be habitual life-long learners. The life-long learning theme is addressed across all five Manifestos and is evoked in different chapters be they about professional ICT workers or about users.

The digital transformation of the economy is also a common theme across the e-Skills Manifesto collection. The explosion of mobile technologies, social media, cloud and big data and their impact have been assessed as well as the potential impact of the IoT on skills demand. This year, the high demand for expertise in the field of cyber security (Chapter 13), as well as the impact of the flourishing area of robotics on jobs and skills demand (Chapter 6), have been explored. Concerns about the changing nature and elimination of jobs have also been addressed from a trade union perspective this year with a specific chapter on fairness in the European labour market (Chapter 8).

e-Skills Manifestos have endeavoured to encompass a broad geographic assessment of eSkills policies, best practices and evolutions across Europe and, over the years, parallels have also been drawn with countries outside of the EU. This year in Chapter 5 the challenge of growing talent and maturing the ICT profession in Canada and Japan as well as the nature of digital skills supply and education in the United States (Chapter 3) have been looked at. The impact generally of globalisation on eSkills demand was already addressed in previous Manifestos and this year in Chapter 4, it was explored again with a focus on the global geography of talent and the nature of talent competitiveness: a set of policies and practices that enable a country – or a city – to attract, develop and retain the human capital that contributes to its productivity.

The e-Skills Manifesto is distributed to thousands of political and business decision-makers across the EU member states. It has become a core reference on eSkills shortages, demand and best practice.

CHAPTER 1

Reflections and lessons from the eSkills campaigns

Introduction

For many years, business leaders and managers from every sector of the economy and from all over the world have been voicing similar messages around the following themes:

- the future for those seeking careers in digital jobs and functions is bright and there are major new opportunities available not only in the information technology (IT) industry but across all sectors of the economy;

- the types, diversity and number of digital jobs is growing at rates hitherto unseen.

The European Commission has been at the forefront of public policy initiatives in addressing these issues. In 2007, the Communication "e-Skills for the 21st Century: Fostering Competitiveness, Growth and Jobs" included a long-term EU eSkills strategy. Two evaluations of its implementation, in 2010 and 2013, concluded that good progress had been made and that efforts should be intensified with the launch of a "Grand Coalition for Digital Jobs" and the "eSkills for jobs" campaign.

Business leaders are also keen to point out that the digital skills needed to fill such functions are evolving in parallel. The dichotomy though is the gap between current demand and supply for such jobs. This can partly be attributed to a lack of interest and awareness by the young of digital education and these new opportunities, and to the skills in the market place that are not up to par with the needs of industry.

Luckily though European and national policy initiatives and actions have been rolled out to attract the young to IT education and careers and to train them and others looking at career moves in the new digital technologies and functions.

Why are digital skills important for Europe?

Europe needs a strong business environment which brings users digital services that are modern, efficient and easy to use. For this to happen, industries and the public sector should adopt digital technologies to the fullest. Companies

that use digital technologies are more innovative, competitive and will grow faster and create more jobs. Europe's challenge is how to get more people using technologies and how to get more companies - SMEs and start-ups - to reap the benefits of digital transformation.

There are a number of things that need to happen to make this a reality - a sound infrastructure for communication and a "fit for purpose" legal framework together with a strong digital supply sector. With better suppliers, users will get better products and services. In line with this, if people are to adopt digital technologies, they must be able to trust them and they must be easy to use. Finally, Europe needs people with the right skills, not only technical or digital but also soft skills, management skills and leadership skills to manage the companies supplying the products. These skills are not just critical for the specialists but increasingly for all jobs in the economy. On top of this we need a digitally qualified user base – all citizens of Europe.

Opportunities in the digital sector

Today, there are more than half a million unfilled digital jobs in Europe. The demand for digital jobs is outstripping supply. What is more, the number of new digital jobs is increasing at around 4% a year. This is a paradox. Unemployment rates are at an all-time high, yet industries are unable to find the appropriately skilled people to fill their digital needs.

What is this gap due to? There are several reasons

As mentioned previously, there is a lack of awareness of the types of digital jobs available today and an uncertainty about the digital jobs that will be available in the future. Also there is limited interest amongst young people to pursue a career in digital professions. Taken together with an education and training system that fights to keep pace with ever evolving skills demand, we face digital skills gaps and mismatches.

The new digital careers and functions

The pace of technology change is also leading to new digital job profiles. Four emerging technology trends have now become a reality - big data, cloud computing, social and collaborative networking, and mobile technology.

All these will bring new types of digital jobs in security, data analytics, digital marketing to name a few. These jobs will be created in all industry sectors and not just the IT sector. Paradoxically, 50% of the job types that will be available in five years are not known due to the rapidly evolving technology space.

Relatively new digital jobs are available today. Web-based search engines reveal a raft of different digital functions across many sectors. Here are some examples:

- a car manufacturer looking for an e-commerce specialist;
- a fashion house seeking a digital marketing manager;
- an IT company needing systems engineers;
- an online game company searching for developers;
- a law firm recruiting a chief digital officer;
- a marketing research company looking for data analytics managers;
- a national security agency recruiting cyber security specialists.

The "uberisation" of industry also brings new business models to market requiring new digital skills for both entrepreneurs and intrapreneurs.

There are the many varied and exciting jobs that exist in IT, and indeed IT jobs across ALL industries, whether this is in retail, fashion design, automotive or manufacturing to mention just a few. There has never been a better time for European students and professionals to embrace digital technologies.

European awareness raising campaigns have made a difference

Many European policy initiatives, as well national actions at member state level, have focused both on how to attract people into the digital workforce and also on providing access to training so that people have the appropriate skills to meet the job requirements.

The European Commission has orchestrated several campaigns aimed at increasing the awareness of digital careers and digital education and training at secondary, tertiary, VET and industry in-house levels. Two "e-Skills Weeks" were organised in 2010 and 2012. The "eSkills for jobs" 2014-2016 campaign is now coming to a close. This campaign aimed to raise awareness of the need for citizens to improve their command of digital skills for work.

The campaign is a response to the growing demand for IT-skilled professionals which is currently not met, despite high levels of unemployment in Europe. It has informed students, unemployed people, IT professionals and SMEs in across all 28 member states about the vast range of opportunities that IT-related jobs present. Together, industry, education bodies and public authorities have delivered events and communications activities throughout 2015 and 2016.

Awareness raising – a strong impact in member states

The "eSkills for jobs" campaign has directly involved a large number of top-level national government representatives including heads of state, ministers, secretaries of state, members of national parliaments and digital champions who have proactively supported its objectives. The involvement of such representatives is indicative in itself of the strong commitment demonstrated by member states.

In many cases, national digital skills policies have embedded the results and recommendations stemming from the campaign and several initiatives have been launched. Examples include:

- education curricula reforms (integration of coding in school curricula in 15 countries, update of computer science programmes, development of strategies to digitalise schools, introduction of IT security and copyright issues into college curricula, closer collaboration with industry);

- partnerships between eSkills national contact points and national employment agencies to raise awareness among unemployed people of digital skills trainings;

- appointment in all member states of "digital champions" who actively promote the development of digital skills.

The impact and success of the national eSkills campaign can also be measured against the proactive engagement of a large number of stakeholders from industry and education (more than 400 in 2015-16) and the remarkable number of people touched by the campaign, through traditional and social media and via events and other initiatives.

Strong tie-ins have also been made with the successive EU presidencies since 2010 with the organisation of high-level conferences and multi-stakeholder political dialogue.

Conclusion

The future for those seeking careers in digital functions is flourishing. Huge opportunities are there for the taking. There are so many types of digital jobs and the skills needed to fill these are evolving.

European policy initiatives and national actions have made a major impact in reducing the digital skills gap. More people are now attracted to these jobs and opportunities to train and upskill in digital skills, whether formal or informal, have increased.

Building on the positive results of the EU eSkills strategy, the "Grand Coalition for Digital Jobs" and in coordination with the work under "Education and Training 2020", the European Commission is launching the "Digital Skills and Jobs Coalition" on 1 December 2016. The purpose is to develop a digital talent pool further and ensure that individuals and the labour force in Europe are equipped with adequate digital skills.

The European Commission will bring together member states and stakeholders, including social partners, to pledge actions and to identify and share best practices, so that they can be more easily replicated and scaled-up. It will improve the dissemination of information about available EU funds and explore possible new funding opportunities. EU member states are invited to develop comprehensive national digital skills strategies by mid-2017 on the basis of targets set by the end of 2016 and establish national digital skills coalitions.

The first chapter is over – let us now start the next one.

CHAPTER 2
T-shaped skill set and mindset

Introduction

This chapter explores the need for T-shaped skill sets and mindsets in the context of eSkills for jobs. Currently, eSkills, ranging from data science to cyber security, are in high demand in Fortune 500 companies, government and non-profit organisations. Getting hired for one of these jobs requires depth in at least one eSkill area. However, long-term career success is associated more often with being T-shaped. T-shaped professionals possess depth and breadth, resulting in better teamwork and collaboration as well as faster learning and adaptation to change.

The demand for eSkills is well documented (Orihuela R, 2015). Less well documented is the benefits for long-term career success of a T-shaped skill set and mindset. Skill set means the proficiency to use technical tools, while mindset means the lens to use in navigating life (Huhman H, 2011). For example, data scientists are expected to know how to use technical tools like Python and R. However, to achieve long-term career success, mindset is used to navigate through challenges and towards opportunity, and collaborate with others.

What are T-shaped professionals?

It is not uncommon to hear about I-shaped, T-shaped, M-shaped, H-shaped, Pi-shaped, and Dash-shaped professionals (Donofrio N et al, 2010a). The shape of a professional is a description used to understand whether a professional is a deep specialist in one area ("I-shaped"), deep specialist in two areas ("Pi-shaped" or "H-shaped"), deep in just one area, but with good knowledge and communication skills across many other areas ("T-shaped"), or not deep, but with good breadth, a generalist ("Dash-shaped") (Demirkan H & Spohrer J C, 2015).

Today's T-shaped professionals are in contrast to I-shaped professionals of the past. During the 20th century, universities produced I-shaped graduates, deep in one area (silo), and jobs changed relatively slowly. For I-shapes, just one area of depth could easily last a decade, if not an entire career. Liberal arts graduates were the generalists, who could communicate with I-shaped professionals and help integrate their ideas to solve the problems of business and society. In this earlier time, most people specialised in either depth or breadth, and there were good jobs for both types of people that could span decades or more.

In contrast to I-shaped professionals, T-shaped professionals are characterised by breadth as well as depth in one person. T-shaped breadth requires a type of

boundary spanning ability, boundary spanning being the ability to communicate across disciplines, systems, and cultures, as well as self-knowledge, or the "me" in the T (T Summit, 2016). The boundary spanning ability is often associated with empathy. Design firms seek out T-shaped professionals with empathy not only for customers and their problems, but also empathy for other teammates pooling their knowledge to solve the customers' problems (Hansen M, 2010).

Why are they so sought after?

In the 21st century, T-shaped professionals are sought after because of problem complexity and the pace of change. Complexity means the number of areas of knowledge that must be combined to solve problems is growing. Almost every unsolved problem today requires engineers, managers, behavioural and social scientists, communications, and policymakers working together. For example, consider driverless cars and what just one incident of a malfunction can create in terms of a problem to be solved.

The pace of change is driven largely by rapid technological changes, but demographic, social, economic, environmental, and regulatory changes also contribute. For example, storm surges along the coastline and flows of migrants that result from environmental change can dramatically impact regions and the work that people do from one year to the next. Artificial Intelligence (AI) will have a dramatic impact on the types of jobs and skill requirements as well (Chui M et al, 2015).

Problem complexity places a premium on teamwork, and pace of change places a premium on adaptability. T-shaped professionals excel at teamwork and adaptability, over their I-shaped co-workers. T-shaped people's breadth of knowledge and experience enables faster adaptation and role changes, in addition to better communication skills for teamwork in multi-disciplinary, multi-functional, or multi-cultural contexts (Demirkan H & Spohrer J C, 2015). Similar to T-shaped people, Gartner also uses the term "versatilist" noting: "versatilists are people whose numerous roles, assignments and experiences are enabling them to synthesise knowledge and context to fuel business value. Versatilists are applying their depth of skills and experiences to a rich scope of situations and challenges and implementing their cross-organisational insight to flesh out teams and fill competency gaps." (Morello D, 2005).

How to become a T-shaped professional?

The only known way to become T-shaped is to participate in multidisciplinary project teams working on problems that have no known solutions, with academic and professional mentors who encourage empathy and a growth mindset. For example, being part of a start-up, even if the start-up fails, as most will, is a great way to develop as a T-shaped professional.

The "me" in the T is self-knowledge. A T-shaped mindset requires self-knowledge, and a growth mindset (Dweck C, 2006). A growth mindset is based on the belief that intelligence can be developed, leading to a desire to learn and a tendency to:

- embrace challenge;
- persist despite obstacles;
- see effort as a path to mastery;
- learn from criticism;
- be inspired by the success of others;
- be a continuous learner.

Working on multidisciplinary teams to solve problems with no known solutions is common in business and academic research, but rare in university education settings where a known correct solution often exists. To produce more T-shaped graduates, education must evolve to be more project-based and focus on work to solve problems with no known solutions versus a focus on individual projects with known solutions.

How to interview for T-shaped professionals?

When interviewing candidates for an eSkill job opening, applicants can be given a problem to solve with a technical tool as a good way to measure the applicants' depth. However, determining if applicants are T-shaped requires reviewing the portfolio of projects they have worked on, their role in those projects, what other types of disciplines, systems, and cultures were represented on those projects. Asking applicants about their most successful such project, as well as how they dealt with setbacks on an unsuccessful project are good ways to assess T-shaped skill sets and mindset. T-shaped professionals will be more open and mature about failure and learnings, whereas I-shapes may seek to blame others for less than satisfactory outcomes, or avoid the topic all together.

How to market oneself as a T-shaped professional?

It is important to market one's depth first and foremost, when dealing with first line managers who are seeking to fill an eSkill job opening. Technical depth and proficiency in technical tools can be established relatively quickly in an interview based on certifications and detailed discussions of how problems can be approached and solved technically.

Once one's area of depth has been established, it is important to ask the interviewer if there are any other aspects of the job role that require technical proficiency before moving on to other topics. Only after the interviewer acknowledges the applicants' depth and technical match for the job opening, is it appropriate to guide the discussion towards breadth and mindset discussions.

By focusing early on multidisciplinary project teamwork and the ability to overcome challenges, an applicant can leave the interviewer with doubts about one's depth. Depth must be firmly established before breadth and mindset can be used to differentiate T-shaped professionals from I-shaped applicants with equivalent depth.

Because many interviewers have never heard of the concept of the T-shaped professional, it is best to refrain from mentioning that you are a T-shaped professional, unless the interviewer uses the terminology first. Also, many organisations do not know how to develop and retain these people effectively and efficiently. As the value of T-shaped professionals becomes better known in workplaces, this will likely change.

Conclusion

eSkill depth is enough to get hired. However, developing one's T-shaped skill set and mindset is the best way to have a long and successful career. The demand for T-shaped innovators is growing across all knowledge-intensive areas and there is a great need for more research to understand T-shaped professionals (Donofrio N et al, 2010a; Donofrio N et al, 2010b). Many organisations do not assess and build the kind of values, beliefs, skills and behaviours their people need to build new things that make a big impact.

The trend towards T-shaped professionals, citizens, and even organisations is becoming increasingly clear, but so too are the costs. T-shaped people may take twice as long to gain the required experiences and documented outcomes, in part because of the costs of interacting across boundaries and organisational siloes. Educating and developing T-shaped people may be twice as complex as training I-shaped people, since it requires developing an I-shape and then more. In addition, recall that the rise of T-shaped people does not mean the extinction of I-shaped people, only a change in the ratio for maximum performance in a changing world. Some I-shapes can go on to become T-shaped. For example, if more I-shapes go into a startup as a first career step that will increase the number of T-shapes in the population.

CHAPTER 3
Digital skills in the United States

Introduction

As an advanced economy and leader in many technology fields, the United States' (US) future hinges on having a workforce with broad overall digital competencies and science, technology, engineering, and mathematics (STEM) skills, as well as highly trained individuals with advanced degrees in fields such as computer science and engineering. However, the US faces a shortage of workers with digital skills, caused by a failure to provide computer science and other digital training to many students in primary and secondary schools, low rates of women and minority inclusion in technology and engineering, and slow adjustment by the university system to accommodate and train a larger number of computer science students.

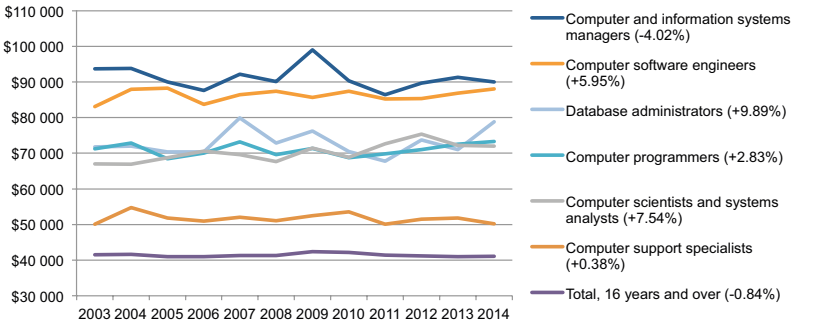
Digital skills in the marketplace

Digital skills are becoming increasingly important in all sectors of the economy, and have revolutionised industries from marketing to manufacturing. Every sector of the economy demands workers with STEM skills, not just traditional technology based industries (Nager A, 2014). In fact, half of jobs requiring information communications technology (ICT) skills are not classified as tech jobs by official US statistics (Change the Equation, 2016a). As many as half a million US jobs are unfilled for want of adequately skilled workers (Lapowsky I, 2015a). Moreover, as digital skills become useful in myriad occupations, workers are increasingly served by having "double-deep" skills, or complementary expertise in both digital skills and in another field (Moschella D, 2015).

Over the last decade, the US economy has added over 1.1 million new ICT jobs, a 36% increase compared to just a 3% increase in the overall US job market (Bureau of Labor Statistics, 2015). The majority of CEOs report that they have trouble finding workers with advanced IT training (Business Roundtable & Change the Equation, 2014). Even during the "Great Recession", while unemployment rates reached 9.4% in the US economy in 2010, unemployment for STEM graduates hovered around 4%, and there were two job openings listed for every unemployed worker with a STEM degree (Change the Equation, 2015).

Because of short supply, pay for workers with digital skills is high. Median starting salaries for computer science and engineering graduates are estimated at around $67,300 and $64,400 respectively, 80% higher than starting salaries for humanities and liberal arts majors (National Association of Colleges and Employers, 2014).

Figure 1: Wage increases, total and in computer occupations, in 2014 dollars, 2003-2014



Source: Bureau of Labor Statistics (2015), Current Population Survey

However, despite elevated wages in part created by high demand, US students and the US education system have largely failed to adjust and respond to wage incentives. Given projected job growth and current graduation levels, the US's STEM shortage is likely to deepen, forcing many industries to forego the benefits conferred through ICT adoption.

Digital skills in US primary and secondary schools

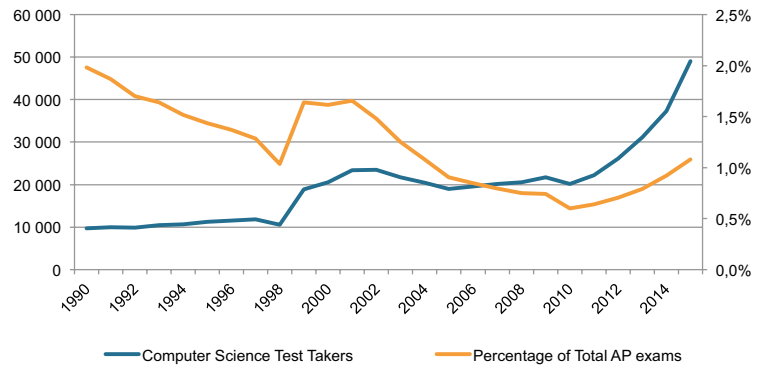
Support for expanding access to quality digital skills education is growing in the US. In 10 years, all public schools in New York City will offer computer science classes (Turkel D, 2015). Early in 2015, the state of Arkansas passed legislation mandating that computer science be taught at all public and charter high schools (Lapowsky I, 2015b). In addition, Idaho, Alabama, Utah, and Washington have prioritised computer science education, and are actively working to improve the curriculum and expand access. Virginia is in the process of passing legislation that will make it the first state to make computer science a core academic requirement for all K-12 (kindergarten to year 12) students (Heitin L, 2016).

Despite the significant demand for computer science and digital skills in the workforce, US primary and secondary schools have for the most part failed to adapt and teach in-demand computer concepts. Only 37% of US states have standards that include computing concepts, rather than just skills and capabilities (Computer Science Teachers Association, 2015). Even when rigorous courses are offered, digital skills still take a back seat to traditional STEM courses, and students are encouraged to take biology, chemistry, and physics before taking computer science or engineering courses. Only 29 states have passed reforms allowing computer science to count as a maths or science

course, whereas prior to that all states counted computer science as an elective (Stephenson C, 2015).

The number of students taking the Advanced Placement (AP) computer science exam, a national benchmark that can measure the progress of computer science education, has more than doubled since 2010 after being stagnant for much of the 1990s and 2000s. However, computer science is still below 1990 levels as a percentage of AP exams taken (College Board, 2015a). Only 18% of schools offering AP calculus exams offer the AP computer science exam (College Board, 2015b). This is especially problematic, because students who took the AP computer science exam are eight times more likely than other incoming freshmen to major in computer science (Mattern K et al, 2015).

Figure 2: AP computer science test takers, total and as a percentage of all AP Tests, 1990-2015



Source: College Board

No federal policy has yet unified disparate attempts to promote computer science. President Obama's $4.1 billion "Computer Science for All" proposal, if implemented and funded by Congress, would support and guide plans to increase computer science course offering at the high school level, recruit and train computer science teachers, and improve the quality of the curriculum by awarding matching grants to states which make proposals to improve computer science education (The White House, 2016).

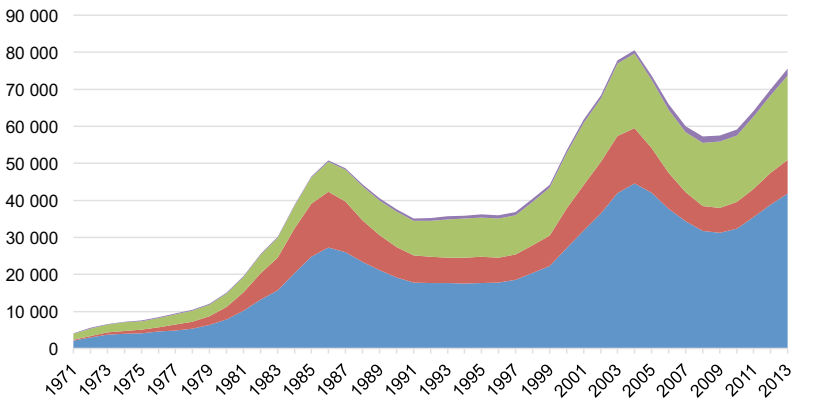
Barriers to computer science and digital skills in US universities

While America's primary and secondary schools have lagged behind in recognising the importance of digital skills, the US boasts world-class computer

science departments at the tertiary level. Led by the world-leading Massachusetts Institute of Technology (MIT), Harvard, and Stanford, the US has 19 of the top 50 international computer science departments (US News Education, 2015).

In 2013, US universities graduated 50,962 computer scientists with bachelor's degrees -a high-water mark for recent years that reflects a spike in interest in computer science - as well as 24,603 computer scientists with advanced degrees (National Center for Educational Statistics, 2015). However, fewer than 2,000 doctorates are awarded per year and for bachelor's degrees, only 18% are awarded to women, compared to 27% a decade earlier.

Figure 3: Bachelor degrees in computer science, 1971-2013



Source: National Center for Educational Statistics

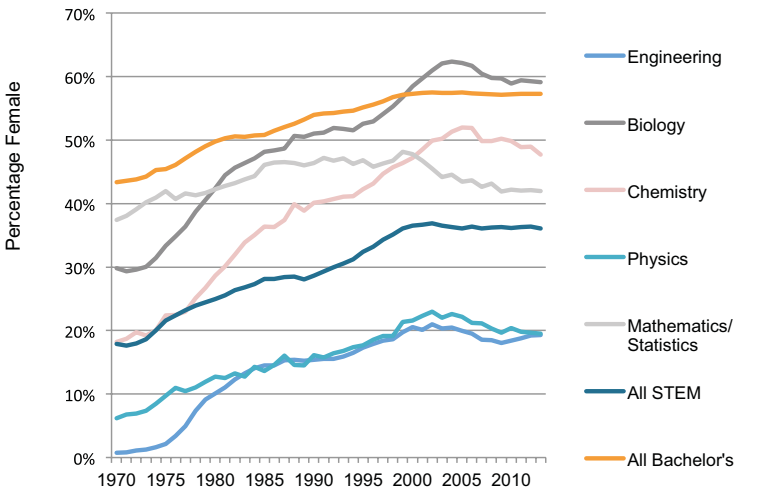
Despite the recent increase in computer science degrees, there is some evidence that universities are not expanding enrollment enough to respond to increased demand (Nager A & Atkinson R, 2016). Offering more courses is costly for universities as computer science is more expensive to teach than most non-STEM fields and adding tenured faculty is challenging. Instead of addressing these challenges head on, many universities have instead taken steps to limit the number of students in computer science courses by increasing tuition for computer science majors or restricting the size of the major by implementing "weed-out" classes. Others lessen the quality of the courses they offer by resorting to large lectures or online courses (Lazowska E et al, 2014). Expanding existing computer science programmes at universities is essential to training the quantity of workers with digital skills demanded by the economy. To address this problem, in 2015, Google awarded six computer science capacity grants to eight universities with three-year proposals to implement "innovative, inclusive, and sustainable approaches to address current scaling issues in university computer science educational programmes."

Opportunity for diversity in US digital education

The US falls severely behind in ensuring equal access to and inclusion in digital skills education along ethnic, gender, and socioeconomic lines. Women and underprivileged minorities are underrepresented in digital skills education and the digital workforce. Currently, 76% percent of US workers in computer occupations are male (Bureau of Labor Statistics). Only 20% of students taking the AP computer science test are female, the heaviest gender bias of any AP exam. Hispanic and black students are also underrepresented, and on average they score significantly lower on the exam (College Board, 2015a).

Women now represent 57% of all college graduates, yet only 36% major in STEM. For physics and engineering majors, where the US is in most direct need of fostering talent, women make up only 20% of majors. Even more worrying, the percentage of women in STEM has not increased at all since 1999 (American Physics Society, 2015).

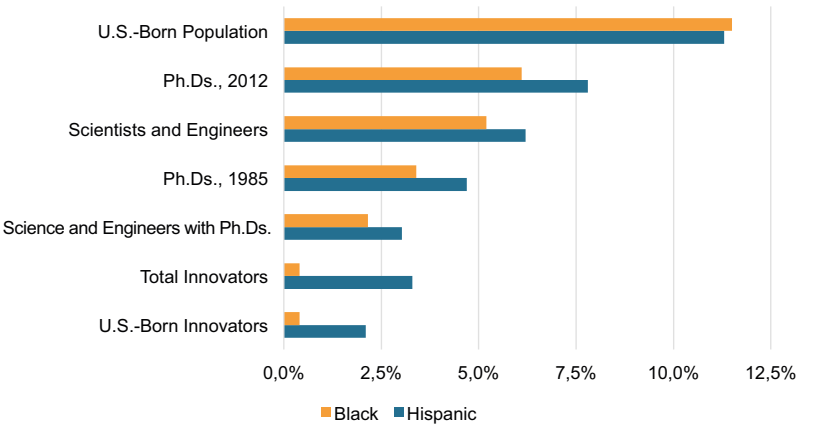
Figure 4: Percentage of women receiving bachelor's degrees, by major, 1970 to 2013



Source: American Physics Society, 2015

However, the lack of women and minorities is most apparent among the US's top innovators, as explored in a recent survey "The Demographics of Innovation in the United States", where it was observed that just 10% of innovators born in the US were female, 3% were Hispanic, and fewer than half a percent were black.

Figure 5: Percentage of blacks and hispanics in the US population and among innovators



Source: United States Census Bureau, 2016

Unfortunately, these rates contribute directly to wide gender and racial gaps in the labour market. Some of the leaders in combatting this trend are non-profit organisations attempting to bolster interest in digital skills among girls and minorities at an early age. Code.org coursework has a focus on promoting inclusion of female and minority students. Similarly, "Black Girls Code" and "Girls Who Code" seek to democratise access to computer science education across gender lines and socioeconomic divides.

Immigration bolsters the US's high-skilled workforce

High-skilled immigration is the US's saving grace in mitigating its STEM-skills shortage. Indeed, a recent survey of America's top innovators found that 35.5% of the US's elite innovators were born abroad, with most of these innovators coming from Europe and Asia. Of this population, over two-thirds hold a PhD in a STEM subject, showing that especially at the top of the US's technology workforce, immigrants are as important as ever.

The US has long been an attractive destination for skilled workers. With the US debate on immigration still focused on low-skilled immigration from Latin America, US policymakers have been unable to increase the availability of green cards and H-1B guest worker visas that allow globalised talent in engineering and IT to relocate to the US. Even foreign students who graduate from US universities with STEM degrees find that opportunities for staying and working in the US are limited (Nager A & Atkinson R, 2015).

Conclusion

The US is at a crossroads in its attempts to endow its workforce with digital skills. While world-class universities produce top graduates in computer fields, the US educational system has largely failed to produce the quantity of skilled workers to satisfy domestic demand. Additionally, low rates of inclusion among women and minorities, as well as the failure of the US immigration system to accept enough foreign workers, exacerbates the digital skills gap found in the workforce. However, both public and private initiatives outside of the education system have recently begun to act to give eSkills to both students and professionals.

CHAPTER 4
A new geography of talents

Introduction

Issues related to eSkills are not just a priority area for Europe. All over the world, governments and businesses are concerned about growing, attracting and retaining the skills and knowledge that will enable them to face the challenges of the changes in the global economy. It is difficult to track the multiplicity of trends and policies adopted on different continents. Since 2013, however, IUNSEAD, Adecco and HCLI have published an annual report, the Global Talent Competitiveness Report, based on the Global Talent Competitiveness Index (GTCI). After a brief description of the index's methodology and main results, this chapter focuses on the talent performance of European countries, and identifies how current global trends such as a redefined mobility and a new geography of talents may affect eSkills strategies in the future.

The GTCI conceptual framework

Information technologies are critically important in redefining the global geography of talents in at least three respects:

- information networks (in particular broadband internet) are affecting the mobility of talents as they allow more collaboration between various contributors to a common project (e.g. high-performance collaborative networks have allowed the Airbus project to benefit from continuous intense cross-border cooperation);

- new digital platforms allow both job seekers and employers to address labour markets in unprecedented ways, offering new business models and posing new legal and regulatory challenges (e.g. Uber);

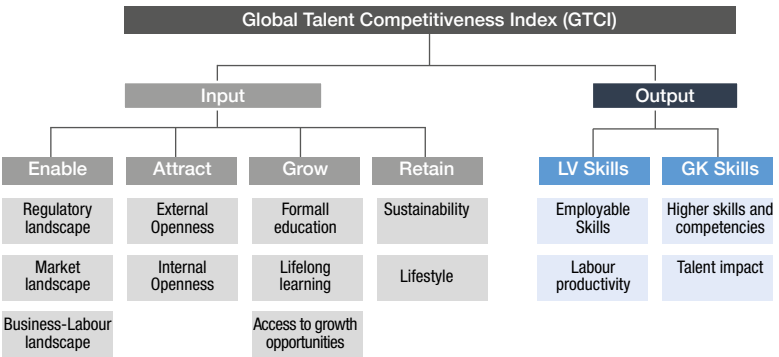
- as information flows become critically important to competitiveness and innovation, eSkills are becoming equally crucial to build and manage the infrastructure required, as well as to derive economic value from "big data", for example.

Published annually since 2013, the GTCI has attempted to assess and measure this type of phenomena, help decision makers anticipate new challenges and opportunities in global labour markets, and offer new ways to create jobs and manage talents. Each year, the GTCI organises its research and chapters around a specific theme: after looking at education and talent growth, international talent mobility, it will devote its next edition to "technology and jobs". Under

each and every one of these themes, eSkills has emerged repeatedly as a key element by which the strategies followed by firms and national economies are making a difference, and getting ahead in global talent competitiveness.

Countries are competing globally to grow better talents, attract the talents they need, and retain those that contribute to competitiveness, innovation and growth. They seek to put economic and social policies in place that will facilitate this. In such a context, governments, businesses and various other stakeholders need quantitative instruments that can inform their decisions (as investors, employers, employees or jobseekers) and help design and implement better policies in areas such as education, human resource management and immigration, to name a few. This is the purpose of the GTCI.

Figure 1: GTCI core model (2015–16)



Notes: based on 61 variables, comparing 109 economies

In the context of the GTCI, talent competitiveness refers to the set of policies and practices that enable a country to attract, develop and retain the human capital that contributes to its productivity. The model is sometimes described as an "input-output model", as it combines an assessment of what countries do to produce and acquire talents (input) and the kind of skills that are available to them as a result (output).

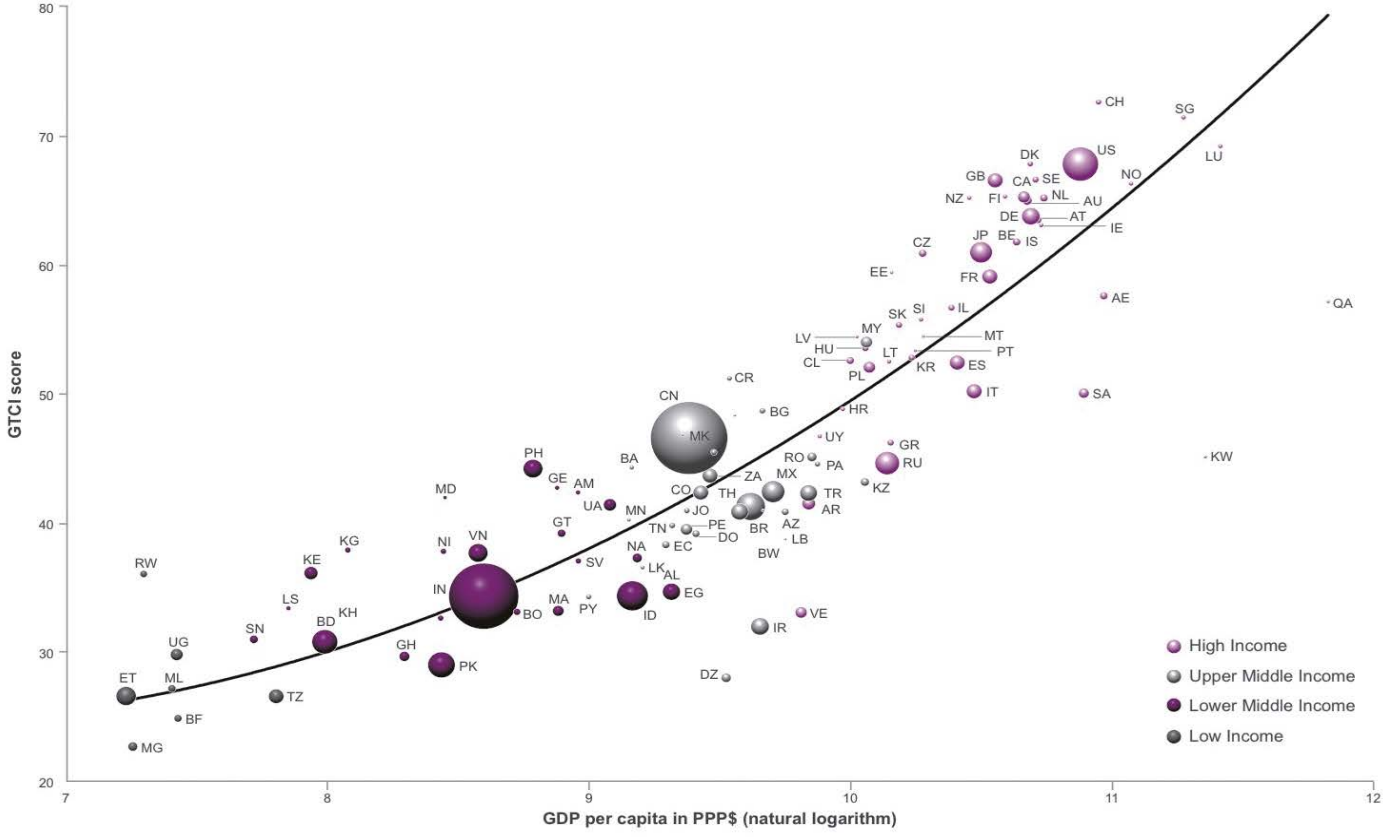
The GTCI is therefore a composite index, which attempts to offer an approach to talent competitiveness issues that is comprehensive, action-oriented, analytical and practical. It allows an annual ranking of national economies, which can be read in a variety of ways.

For example, if one compares GTCI performance to GDP/capita (see Figure 2), one correlation is particularly clear: rich countries tend to be more talent competitive than poor countries. Yet, beyond such "prima facie" conclusions, more detailed analyses of the underlying data lead to more policy-oriented

considerations, including about the importance of eSkills, and how they can best be produced and managed.

Not surprisingly, rich countries tend to have better universities, and a greater ability to attract foreign talents through better quality of life and higher remuneration. Indeed, the top-scoring countries in the GTCI 2015–16 are all high-income countries. However, GTCI data allows us to look beyond this "top-level correlation" and consider the ways in which countries of different types and development levels are affected (negatively or positively) by the global competition for talent, and how they fare in terms of their abilities to grow, attract and retain the talents that their characteristics and development strategies require.

It is also interesting to compare how individual countries fare, within a particular income group or geographical region. The next section shows that European countries, in that respect, have a rather diverse record.


GTCI score
GDP per capita in PPP$ (natural logarithm)
80
70
60
50
40
30
20
7
8
9
10
11
12
CH
SG
LU
US
DK
GB
CA
SE
NO
NZ
FI
NL
AU
DE
AT
IE
JP
BE
IS
CZ
EE
FR
AE
QA
SK
SI
IL
LV
MY
MT
HU
LT
PT
CL
PL
KR
ES
CR
IT
SA
CN
MK
BG
HR
UY
GR
RO
PA
RU
KW
PH
BA
ZA
MX
GE
AM
CO
TH
TR
KZ
MD
UA
MN
JO
AR
GT
TN
PE
BR
AZ
DO
LB
BW
NI
VN
EC
NA
KG
KE
RW
SV
LK
AL
LS
IN
MA
PY
EG
BO
ID
VE
SN
BD
KH
IR
UG
GH
PK
ET
ML
DZ
TZ
BF
MG
High Income
Upper Middle Income
Lower Middle Income
Low Income

How is Europe doing in terms of global talent competitiveness?

If one considers, for example, the top 20 of GTCI 2015-16, it is quite striking that 14 of these 20 countries should be European, the only exceptions being Singapore, United States (US), Canada, New Zealand, Australia and Japan. Several of the key GTCI variables mentioned earlier explain many of the differences between European economies. For example, the United Kingdom and Germany have centuries-old universities, Switzerland and Scandinavian economies have a long tradition of integration between universities and businesses. Similarly, countries with high-performance information networks tend to be ahead of less technologically advanced ones.

Yet, another important explanation for this rather dispersed performance among European countries can be found in the uneven degree of priority that they have been giving to the changes brought about by technological change, and their impact on the geography of talent.

◀ *Figure 2: GTCI scores versus GDP per capita*

Notes: GDP per capita in PPP$ and population data (represented by the size of the bubbles) are drawn from World Development Indicators, World Bank. The trend line is a polynomial of degree two (R2 = 0.77).

Figure 3: Global talent competitiveness index 2015–16 rankings (top 20)

Country	Score	Overall Rank	Income Group	Regional Group	Regional Group Rank
Switzerland	72.648	1	High Income	Europe	1
Singapore	71.456	2	High Income	East, South Asia and Oceania	1
Luxembourg	68.978	3	High Income	Europe	2
United States	67.902	4	High Income	Northern America	1
Denmark	67.865	5	High Income	Europe	3
Sweden	66.621	6	High Income	Europe	4
United Kingdom	66.597	7	High Income	Europe	5
Norway	66.339	8	High Income	Europe	6
Canada	65.346	9	High Income	Northern America	2
Finland	65.333	10	High Income	Europe	7
New Zealand	65.264	11	High Income	East, South Asia and Oceania	2
Netherlands	65.219	12	High Income	Europe	8
Australia	65.080	13	High Income	East, South Asia and Oceania	3
Germany	63.850	14	High Income	Europe	9
Austria	63.552	15	High Income	Europe	10
Ireland	63.137	16	High Income	Europe	11
Iceland	62.001	17	High Income	Europe	12
Belgium	61.849	18	High Income	Europe	13
Japan	60.978	19	High Income	East, South Asia and Oceania	4
Czech Republic	60.949	20	High Income	Europe	14

Figure 4: GTCI 2015–16 rankings (European countries after 20)

Country	Score	Overall Rank	Income Group
Estonia	59.471	21	High Income
France	59.165	22	High Income
Slovenia	55.863	26	High Income
Slovakia	55.429	27	High Income
Malta	54.530	28	High Income
Latvia	54.456	29	High Income
Hungary	53.630	31	High Income
Portugal	52.868	33	High Income
Lithuania	52.585	35	High Income
Spain	52.511	36	High Income
Poland	52.085	38	High Income
Italy	50.209	41	High Income
Croatia	48.929	43	High Income
Bulgaria	48.731	44	Upper Middle
Montenegro	48.480	45	Upper Middle
Macedonia	46.847	46	Upper Middle
Greece	46.234	49	High Income
Serbia	45.501	50	Upper Middle
Romania	45.180	52	Upper Middle
Bosnia & Herzegovina	44.339	55	Upper Middle
Moldova	42.022	64	Lower Middle
Ukraine	41.430	66	Lower Middle
Albania	36.611	85	Upper Middle

ICTs and eSkills redefine mobility and jobs

Mobility is being redefined on a global scale due to a combination of economic and technological factors. This redefinition applies to all dimensions of the talent equation: skills, people and jobs. Skills have become more mobile across space and time, as learning opportunities have spread between geographies (e.g. through online education and training) and between generations (through lifelong learning and mentoring, for example). People have become more mobile across borders because of improvements in transport, but also in telecommunications (allowing in particular a global sharing of knowledge about opportunities and living conditions abroad). Finally, jobs have become more mobile thanks to the advent of global virtual teams and teleworking.

Such a massive redefinition of mobility (and of the relationship between different types of mobility, notably between goods, services, capital and labour) is making talent attraction a key objective for all kinds of economies, whatever their development levels. The international mobility of talent is a core dimension of any national (or regional) strategy, as it will largely determine the ability of countries (but also regions and cities) to connect to globalised value chains and develop successful strategies for sustainable growth.

In the emerging "new geography of talents", new competitors are also becoming more visible, such as cities and regions, while some fundamental notions regarding eSkills, their current value, and their growing strategic importance, are receiving renewed attention. With the exception of city-states such as Singapore, talent attraction has increasingly become a "local issue". Often for different reasons, all countries, large and relatively small, have seen, encouraged or suffered from new dynamics of talent attraction involving regions, provinces, or cities. Contrary to predictions made a few decades ago, and in spite of exponential developments in the area of international telecommunications, the "death of distance" has been largely overstated. The growth of global logistic chains, for example, has reaffirmed rather than eroded the role of geography: ports, communication hubs, cities and regions have recaptured roles they once had, including as attractors of talents.

eSkilled individuals are at the forefront of this redefined mobility. Some cities have successfully exploited that particular niche. Dublin, for example, has built a reputation as a technology hub and today Ireland is the world's largest software exporter behind the US. In the US, New York City and its "Silicon Alley" is challenging San Francisco's Silicon Valley.

New mobilities, new geography of talents: eSkills implications

Mobility has become a key ingredient of talent development. The migration debate has moved from the 20th century focus on "brain gain vs brain drain" to "brain circulation". The new context of talent mobility leads to a different paradigm, by which all parties (country of origin, country of destination and the individuals themselves) stand to gain in a process best described as "brain circulation".

To the extent that internationally mobile people maintain ties to their country of origin, both countries benefit because of remittances (currently bigger than global aid flows), diaspora investments, the acquisition of know-how and experience via networks, and the innovativeness and entrepreneurship qualities acquired through mobility by successful returnees. In today's world of innovation, mobility develops talent: the global mindset, the networks, the innovative capabilities that characterise creative talent cannot be fully developed if such international mobility and brain circulation is not encouraged.

In this new world, people continue to move to jobs and opportunities, but, more and more, jobs are now increasingly moving towards the talent. Information technology plays a central role is skewing patterns toward the latter, and eSkilled workers are well placed to benefit from this trend as their skills require less and less physical presence.

Although the GTCI methodology does not identify "eSkills" as such, it is safe to consider that they are part of the "GK Skills" (Global Knowledge Skills) contained in one of the two output pillars of the GTCI model. This is a category in which some emerging countries have reached impressive levels: China (ranked 41st overall) is 26th for innovative creative GK skills; other Asian countries show the same pattern (ranking higher on creative GK skills relative to their overall GTCI ranking. Corporations are beginning to move strategically important product development and research and development activities to these countries, attracted by quality talent at low cost, facilitated by efficient international communications and technology diffusion. This is also the case, to a significant extent, in other regions, where some countries have started to attract the attention of international investors and individual talents, as shown by relatively high GTCI scores for creative talent. In Europe, this is the case for Malta, Slovenia, Cyprus and Moldova.

New "talent magnets" are emerging, which will attract eSkilled workers. While the US, Switzerland, Singapore and other developed counties have long been attractive destinations, other countries are showing strong potential as "talent magnets". For example, Indonesia has a low stock of migrants (compared to the total population), although business leaders perceive the country as being attractive to high-skilled people (scoring high on potential "brain gain"). China

will soon be part of this group, particularly if it manages to lure back former emigrants with STEM skills. Rwanda stands out in Africa, and Azerbaijan is worth mentioning in Central Asia. Competition will become fierce among such emerging talent hubs and those who aspire to join the group of attractive talent destinations. In Europe, countries with high external openness but lower attractiveness to talent include Czech Republic, Estonia, Cyprus and Montenegro. Elsewhere in the world, New Zealand, Uruguay and Uganda face similar issues.

In this world of talent circulation, cities and regions are becoming critical players in the competition for global talent. An increasing number of large cities are becoming "global talent hubs", attracting skilled and creative workers from all parts of the world with their high-quality infrastructure and competitive market conditions.

Cities today are increasingly adopting proactive strategies, including imaginative policies, to attract global talent. The role of cities is increasing for two main reasons. First, large countries are heterogeneous, with diverse internal socioeconomic contexts across regions. Therefore, cities and regions are often better positioned than countries to develop and brand features (e.g. "quality of life") that are attractive to both internal and international migrants. Second, cities can differentiate themselves through local capabilities – e.g. agile responses to market opportunities for innovation.

High performance information infrastructure can also be developed more easily on a municipal/regional scale than nationally, especially in large countries such as China, India or Brazil.

This "differentiated globalisation" will continue to have profound consequences on how eSkills are valued and combined to generate competitiveness, innovation and productivity. Lessons learned globally could be of interest to European firms and governments.

CHAPTER 5

Joining forces to strengthen the ICT workforce and ICT professionalism

Introduction

There is a worrying shortage of ICT professionals around the globe. In 2016, Europe has 272,000 unfilled vacancies, which could rise to over half a million in 2020 (European Commission, 2016). Large economies such as the USA, Canada and Japan are experiencing similar labour market trends. The high unemployment figures in Europe need urgent policy actions to turn this trend around. Besides the economic factors of ensuring sufficient numbers of ICT professionals and tackle unemployment, there is also a need to mature the ICT profession itself. The fact that the physical and digital worlds are blurring imposes more risks for society. Privacy and security are added variables due to the Internet of things (IoT). There are also risks from unethical behaviour as recently demonstrated by Volkswagen for example.

It is important to continue to nurture trust in ICT professionals. Continuous development of knowledge, skills and competences is vitally important to reach that goal. Professionalism is absolutely fundamental to the effective practice of ICT. The ICT profession is relatively young and maturing the profession will undoubtedly take time, but the time for engagement and action is now (CEPIS, 2012).

Stronger investment in digital skills is vital for strengthening competitiveness and boosting growth. It is crucial "to help people realise their professional dreams and goals to reach their potential" as European Commissioner Marianne Thyssen said earlier this year (European Commission, 2016b). The Comprehensive Skills Agenda for Europe released in 2016 aims to help people develop a broad set of digital skills from early on in life which will help boost employability, competitiveness and growth in Europe.

But it is easier said than done. The challenge of growing talent and maturing the ICT profession is not an easy task for Europe or other global economies. This chapter reflects on parallel efforts in other parts of the world. The next two paragraphs provide a glimpse of the experiences and current challenges faced by the Information and Communications Technology Council (ICTC) in Canada and the Information-technology Promotion Agency (IPA) in Japan. The common purpose of these leading examples is to show how these efforts can be put into practice.

Lessons from Canada: revolutionising the education sector

Even though Canada is experiencing rising talent shortages, the concept of ICT professionalism in Canada has not gained momentum. ICT occupations are non-regulated and a large number of the ICT workforce has varied skills and qualifications. Most of the new and emerging technologies require talent from varied educational backgrounds, including social sciences, mathematics, statistics, computer science and engineering. This highlights the hybrid, interdisciplinary nature of ICT professions that require high-level cognitive skills.

Canadian employers have noted persistent challenges in finding ICT professionals who can also understand new technologies and platforms like cloud computing at a macro level. As businesses increasingly rely on cloud infrastructure to host their big data solutions, or other technologies such as high-performance computing or mobile solutions, there is a need to close the gap between the demand for and the supply of ICT talent from the post-secondary institutions.

Youth across all nations are tomorrow's innovators, entrepreneurs and solution providers. In the rapidly shaping knowledge and intelligent economy, the ICT sector can be an excellent entry point for today's graduates. However, young Canadians are not selecting STEM (science, technology, engineering and mathematics) disciplines in schools or ICT as a career choice that can actually help mitigate Canada's current and future ICT talent needs. Integrating and teaching STEM based subjects, such as computer science, maths, and physics, in elementary and secondary schools can be an important gateway to future education and careers in ICT.

Research and discussions with key players of Canada's labour market - the government, ICT industry, the education sector and ICT professionals - confirms that more active engagement from and collaboration between these four players is needed. The proposed engagement and collaboration can help boost investment in the post-secondary STEM programmes that are powering the technologies to drive innovation across the global economy. Lessons learned from Canada's approach are:

- partnerships for informed strategic action are a key requirement for an innovative economy;
- Canada's industry eco-system comprises small and medium enterprises (SMEs) which are often cash-strapped. The partnership between large industry and SMEs alongside the government can be very beneficial to provide training to the staff for new technologies;
- youth is tomorrow's workforce and investing in their professional development from their foundational years will be very helpful.

Lessons from Japan: IoT Acceleration Consortium

The IoT Acceleration Consortium was established in Japan in autumn 2015 with the aim of creating an environment for attracting investment for the IoT through public-private collaboration. The development of IoT, big data, and Artificial Intelligence (AI) is the greatest change to conventional industry and the structure of society in recent years. While the development of IoT creates new services using data, it also generates concerns about existing businesses rapidly growing obsolete.

The IoT Acceleration Consortium aims to combine the strengths of government, industry and academia and build a structure for developing and demonstrating technologies related to the promotion of IoT, as well as creating and facilitating new business models. More than 700 companies have already joined this consortium.

The consortium consists of:

- a Technology Development Working Group (Smart IoT Acceleration Forum) to develop, demonstrate and showcase other activities related to the Consortium;

- an Advanced Business Model Promotion Working Group (IoT Acceleration Lab) to create an advanced business model and make recommendations such as regulatory reforms necessary to run those projects. The IPA has the key responsibility for the IoT Acceleration Lab and is taking actions to promote the project;

- a Special Working Group in accordance with the Consortium's issues.

In addition, as one of the activities related to IoT, the IPA has promoted the exploratory ICT human resources project (the MITOH Programme) to identify and develop outstanding candidates to play key roles in creating next-generation ICT markets. It also supports entrepreneurs in acquiring skills and knowledge necessary to start-up businesses. For example, it provides mentoring from an entrepreneur and an ICT corporate executive, as well as funding. It is similar to the seed accelerator programmes and venture capital funding in Silicon Valley. The creation of new businesses in the Japanese ecosystem is also supported by senior entrepreneurs.

The IPA is also considering developing an advanced business model and workforce requirements in order to promote the IoT further and create standards that can be used by all types of businesses.

Europe: an ICT professional framework that supports continuous development

The European Commission has started an initiative to develop and implement the first comprehensive "European IT Professional Framework". The framework is based on four building blocks essential to mature the ICT profession:

- bodies of knowledge;
- competences (e-CF);
- education, training and certification;
- professional ethics.

The main strength of the proposed framework is the combination of stable components with a high degree of flexibility allowing it to adapt to rapid ICT changes and emerging market requirements. This project showcases examples of how these building blocks establish synergies for both the ICT practitioners as well as for the many users that exist in education, government, professional associations, certification providers and employers.

Any organisation would want its ICT staff to be professional in their practice, and to be recognised and accepted as being professionals. A framework for the ICT profession helps employers to have a common language for the professional development of ICT professionals across Europe (and potentially beyond), while stimulating the mobility of employees and offering them tools to develop their careers. The benefits to organisations and society include practitioners having an adequate level of knowledge, providing a higher level of products and services, and abiding by professional standards and codes of ethics (Ridge J, 2013).

The European IT Professional Framework is user-centric and offers value in each stage of the ICT professional's career path – for example "preparing to enter the ICT profession", 'starting a career in ICT", "changing a career", and "developing a career". Each describes the challenges encountered in these stages of a career and how the framework instruments could help.

It sounds good, but how do we deliver on those benefits? The key is through raising awareness, increasing the adoption of the framework and adopting the standards and tools it promotes. The key factors driving success are:

- demonstrating value: what's in it for me? It is essential to make clear how the framework serves ICT practitioners while orienting and planning their career. Also how it supports education providers, professional associations, industry and public sector in creating the right conditions to mature and promote ICT professionalism, and ultimately increase Europe's competitiveness;

- sending a clear message to raise awareness: clear value propositions to ensure continuous engagement of stakeholders in the further development and - most importantly - the uptake of the framework;

- creating sustainable stakeholder networks: to ensure that the implementation triggered in countries will continue when the project ends and take up widened to other countries. It is essential for these coalitions to move forward.

- scalability of implementation activities: front-runners that "lead by example" help to trigger other countries to set up something similar. These actions will also contribute to maturing the pillars of the framework. A learning environment that facilitates knowledge exchange is pivotal.

Successful implementation is designed for impact. Spain, Ireland and Italy provide excellent examples of how this can be done in practice. Spain was among the first countries to announce its support. It drew up a roadmap consisting of a variety of actions that will be prioritised quickly and supported by a network of Spanish experts. The announcement triggered other organisations to step in. Other countries are following this approach and through mobilising stakeholders are working towards further adoption of the framework and its instruments.

Conclusion: successful implementation is "joined-up" and designed for impact

A multi-stakeholder partnership to help develop ICT skilled talent has proven to be effective for Canada, Japan and also Europe. Undeniably, collaboration is at the heart of growing the talent pool of skilled ICT professionals globally and to advance the profession which has become the backbone of all economic sectors for innovation.

However, the key challenge is in defining the strategic action itself. It is of utmost importance that any national economy en route to technological advancement, entrepreneurship and innovation develop a skilled ICT workforce that understands the global economic shifts and is prepared to adjust accordingly. This can only be achieved if all strategic stakeholders of the economy – industry, policymakers and educators – participate in the design and development of the strategic action to help strengthen ICT professionalism and mitigate the looming global skilled ICT talent shortage. As an old proverb says: "you can go fast alone, but you go far together".

CHAPTER 6

Digitalisation, jobs and convergence in Europe: strategies for closing the skills gap

Introduction

Since the digital revolution, the potential scope of job automation has expanded dramatically. At the same time as digital technologies are destroying some jobs and transforming others, entirely new types of jobs and industries - such as app development, big data and software design - are being created. While these constitute only a fraction of the workforce, the arrival of digital technologies is changing demand and the type of skills required by employers - not only in ICT but also in other sectors. These developments are most certainly going to boost productivity in the coming decades, but the associated benefits are unlikely to be widely shared across Europe unless substantial investments are made to up-skill the European workforce. Thus, the EU has to help workers acquire the necessary skills and put in place plans to achieve this.

The changing composition of European labour markets

Two trends in particular have significantly shaped European labour markets since the computer revolution of the 1980s:

- computer technology has increased demand for college educated workers, which in turn explains a growing wage gap between skilled and unskilled workers.

Technological change does not benefit all workers equally and nearly all European labour markets have experienced some level of polarisation. There has been rapid employment growth at the upper end of the skills market due to computer technology uptake across the workplace. At the bottom end, growth has been confined to low-skilled manual occupations requiring physical or social interaction such as sales and service jobs since robots have been unable to emulate human perception and manipulation.

- computers have replaced labour in a wide range of routine job tasks, which has contributed to the disappearance of middle-skill routine work.

In the past, computerisation was largely confined to routine tasks, resulting in a secular decline in employment over recent decades (Autor et al, 2003; Autor & Dorn, 2013 & Goos et al, 2009).

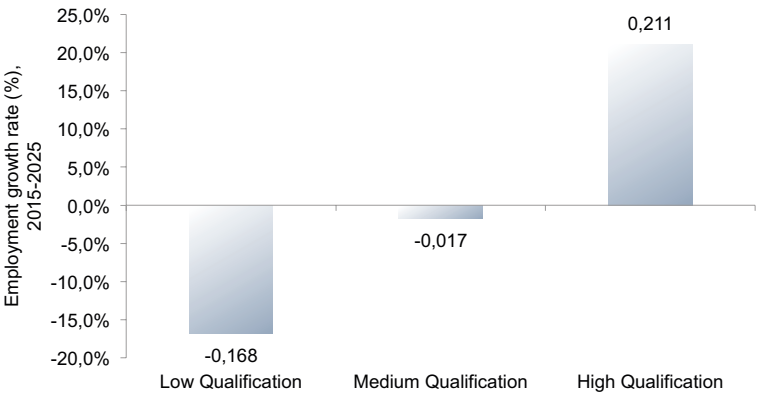
But more recently, automation has widened in scope and promises to reshape a wide range of jobs. For example, advances in robotics are making non-routine manual tasks in manufacturing, construction and services susceptible to automation. In particular, developments in natural language processing and machine vision suggest that robots may soon expand into an even wider range of service jobs that revolve around very basic social interactions.

This potential scope of computer-for-labour substitution could constitute a watershed for European labour markets over the forthcoming decades.

So how susceptible are current jobs to computerisation? According to some estimates, as many as 54% of the current jobs in the EU27 could be computerised (Bowles, 2014). Across all countries, most workers in administration, office jobs as well as transportation, logistics and production are at high risk while workers in occupations requiring creativity and social intelligence remain in the low-risk category.

A key finding of a 2013 study (Frey C B & Osborne M A, 2013) shows that for the first time, low-skilled workers are most susceptible to automation, not middle-skilled workers. Another recent study (Graetz & Michaels, 2013) supports this prediction, showing that the use of robots has contributed to declining working hours for low-skilled workers. This trend is mirrored by employment projections for the EU28 which forecast that employment growth will increase proportionally with skill levels over the next decade.

Figure 1: Projected employment growth by level of qualification in Europe



Notes: this figure shows projected employment growth in low-, medium-, and highly qualified jobs in the EU-28 between 2015 and 2025, based on CEDEFOP's 2015 skills forecast. http://www.cedefop.europa.eu/en/publications-and-resources/data-visualisations/employment-trends.

Competing for talent: skill requirements in the digital economy

While digital technology is displacing workers in some tasks, it is also creating entirely new jobs and transforming existing occupations and industries. This is in turn significantly changing the demand for skills beyond the technology sector as new jobs and tasks emerge.

New technologies are increasing job opportunities for workers with problem-solving and technical skills. But narrow technical skill sets are unlikely to be sufficient. Cross-functional skill sets - such as a mix of creative, social and technical skills – are increasingly required.

Particular importance needs to be paid to the increase in demand for eLeaders who play a crucial role in adapting to technology advances such as big data, the Internet of things (IoT) and integrating digital technology to build new businesses and strengthen existing ones (Hüsing et al, 2013). One survey suggests that this demand will increase by 4.6% annually until 2020 (Hüsing et al, 2015).

Although the demand for high-level ICT skills and eLeaders is expected to continue, at the same time basic user skills are becoming a necessity for most workers. Already today, workers without basic ICT user skills are hard pressed to find a job in many European labour markets. For example, only 7% of UK workers are employed in jobs that require no digital skills (UK Parliament, 2014-2015).

Against this backdrop, Europe faces critical skills shortages in the supply of both basic user skills and digital specialists. These shortfalls are creating a bottleneck to the digital transformation of European firms.

As a result, finding ways of putting workers' skills to better use by reducing skills mismatches and promoting the creation of quality jobs that allow workers to develop their skills throughout their working life is the crucial challenge for policymakers.

Bridging the skills gap

As European economies transition into the digital age, workers will have to move to new types of industries, occupations and tasks that require different skills. They will therefore need to update their skill sets.

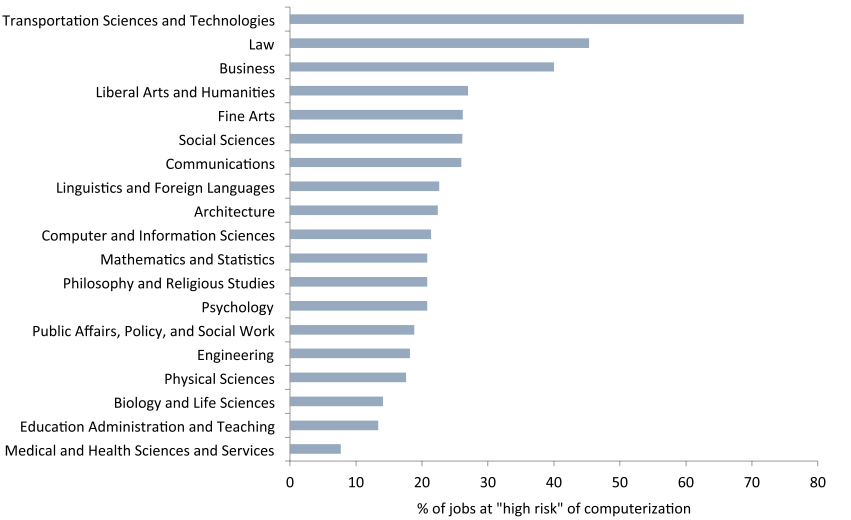
In order to meet these challenges, educational institutions, industry and governments will need to adapt the provision of education and training.

Putting digital learning, exposure to the internet and digital technologies on curricula from the earliest stage of schooling and continuing throughout higher education is key to addressing the digital divide.

Educational providers should also work closely with other stakeholders who may contribute to exposing children to the opportunities of digital technology and encouraging young people to pursue careers in ICT.

In the near future, disruptive technology advances in machine learning and mobile robotics will also shape skill demands significantly and have an impact on educational demands. For example, workers in fields such as education and medical services have a low risk of seeing displacement due to automation, while 40 – 70% are at "high" risk of computerisation in fields such as business, law and transportation.

Figure 2: Jobs at "high risk" of computerisation by field of degree



Notes: this figure shows the percentage of jobs that are at "high risk" of computerisation based on the definitions derived in Frey & Osborne (2013) by field of college degrees. Data is based on Frey & Osborne (2013) and the 2010 American Community Survey that provides a 1% random sample of the US population, restricted to employed workers aged 18-65. Data matched from Frey and Osborne (2013) of each job's probability of computerisation to the worker-level data in the ACS sample to calculate the share of jobs at "high risk" of automation by field of degree.

Another knock-on effect of accelerating technical change is a continued decline in employment duration. As a result, employers want workers with broad skill sets who can adapt to changing circumstances. Workers with narrow skill sets

will need education and training programmes to help them refine and update their skill sets throughout their careers. Indeed, skill obsolescence is already becoming increasingly common amongst European workers – a recent study found that nearly one in five German, Hungarian, Dutch and Finnish workers had seen their skills become obsolete in the past two years (Cedefop, 2012).

Shorter employment durations are also reducing firms' willingness to invest in training for their workers, who are now increasingly bearing the responsibility for re-skilling.

Self-directed learning and MOOCs offer flexible and low-cost ways to learn, re-skill and enhance digital skills. However, as creative, interactive and social skills are likely to increase in importance, online learning needs to be complemented with face-to-face interaction – such as tutorial style teaching and problem-based learning - to deliver the skills needed in the 21st century.

It is also important to anticipate skill shortages and maintain an up-to-date view of skill gaps and mismatches. The creation of a unified European digital job portal is an attractive option to reduce skills mismatches and offer a standardised way of certifying and validating digital skills and competencies across EU member states.

Conclusions

Digital literacy will be required in the vast majority of jobs and a large proportion of European workers currently lack basic digital skills. In addition, skills are unequally distributed and are closely linked to the economic circumstances of these countries and regions.

To achieve economic convergence, improving digital skills needs to be a key priority. One way of addressing this would be to establish digital competence centres in NUTS2 (Nomenclature of Territorial Units for Statistics) regions to support and incentivise the adoption of digital technology in local companies and to engage with local stakeholders to promote basic digital skills.

The second critical area to address is the shortage of digital specialists and eLearning needs to play a larger role in advancing digital skills. There is evidence to suggest that digital specialists already use self-directed learning to obtain new skills and this should be built on. Online learning can provide an effective and financially attractive way to teach high-level technical skills, while tutorial style teaching is best suited to deliver creative, social and leadership skills.

Finally, developing a skill anticipation system that can provide up-to-date labour market intelligence, alongside a unified online job portal will be crucial to monitor evolving industry skills demands and provide an accurate picture of existing and future job prospects.

Taken together, these initiatives would serve to narrow the digital divide across countries and regions, while at the same time boosting job creation and productivity in the EU as a whole.

CHAPTER 7
eLeadership skills for Europe

Introduction

Disruptive business models and technology trends will undoubtedly generate new international market opportunities. At the same time these opportunities require the necessary skills at all levels – especially at the leadership level – in order to exploit them fully. This will reap benefits for Europe by increasing competitiveness and making it a better place for business and investment.

The innovation push from the current and emerging Information and Communications Technology (ICT) and Key Enabling Technologies (KETs) trends will have a strong transformational impact on the EU economy and society until 2020 and beyond. It will drive an increase in demand for ICT, Research and Development (R&D) and especially eLeadership skills. The demand for eLeadership skills varies depending on the type of technology. However, big data, the Internet of things (IoT) and the combination of cognitive systems and robotics are likely to have the most disruptive impact and be the main drivers of demand for eLeadership skills. Approximately 70% of the experts surveyed in a recent study agreed that the increase in demand for skills will create a skills gaps in Europe (Dashja E & Hüsing T, 2016).

Although there are no current statistics regarding the demand or supply of eLeadership skills, an estimate in 2013 put the number of innovative eLeadership positions in Europe at around 568,000. By extrapolating growth trends to 2015, there are around 620,000 innovation eLeaders in Europe with 60% coming from business units within companies and not from ICT departments (empirica, 2015).

To forecast future eLeadership demand we have extrapolated using estimated growth rates for highly skilled ICT positions. Using this estimate, we forecast demand at 776,000 in 2020 (Hüsing T et al, 2015a).

Europe will therefore need 200,000 additional innovation eLeaders by 2020, or 40,000 per year. Without further action by all stakeholders concerned, Europe will not be in a position to create the required number of 40,000 innovation eLeaders per year. There is a job to do!

European Commission actions

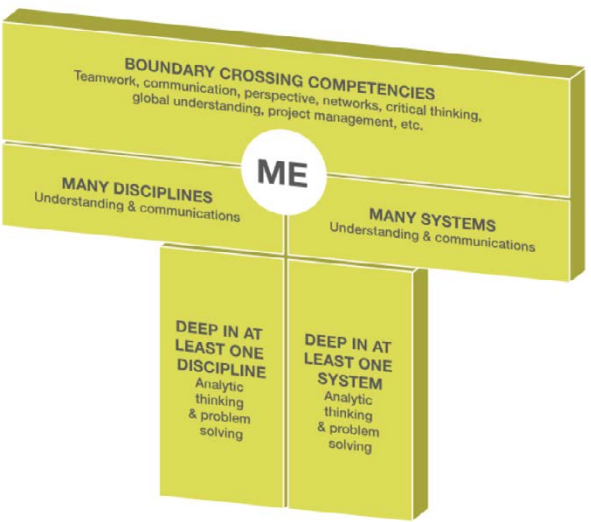
In order to ensure that Europe is a global leader for skills and talent for digital and KETs, the European Commission started the eLeadership Skills Initiative in 2013 and expanded it in 2014 to include small and medium enterprises (SMEs).

The European Commission has recently commissioned a consortium of partners to develop an agenda on "Leadership Skills for the High-Tech Economy". This is taking place on a step-by-step basis and is supported by experts providing feedback during a series of workshops in 2016.

The importance of talent creation is shared by many leading organisations in the world. For example, the International Society of Service Innovation Professionals (ISSIP) is promoting "T-shaped" professionals who are "future ready" adaptive innovators. In 2016, the T-Summit brought together government, industry and academia to discuss the latest research about T-shaped professionals, and how policies, curriculum and student and employee behaviour can prepare the future workforce.

T-shape is a way to navigate and present individual career experience with breadth of experience (top of the T) with depth in a recognised discipline (the "I" of the "T"). The core idea is to enable professionals to work with others in complementary disciplines and to be able to pivot with uncertainty and changing workplace requirements (T-Summit, 2016).

Figure 1: T-shape metaphor



The T-shape metaphor is used within eLeadership initiatives when describing digital leadership (eLeadership) skills. It is used in addition to the presentation format of the eLeadership skills triangle – these are the skills required by an individual to initiate and achieve digital and other types of innovation.

Figure 2: The eLeadership triangle

- *Strategic leadership: lead inter-disciplinary staff, and influence stakeholders across boundaries (functional, geographic);*
- *Business savvy: innovate business and operating models, delivering value to organisations;*
- *Digital savvy: envision and drive change for business performance, exploiting digital technology trends as innovation opportunities.*

In 2007, the European Commission adopted a Communication on "eSkills for the 21st Century" which included a long-term eSkills agenda aimed at creating a large digital talent pool for Europe.

Communication activities have also been launched to create the necessary awareness of the need for European and national policy development in these fields.

Expert opinions on eLeadership skills

Experts believe that the wider availability of digital talent, workers and executives with eLeadership skills is an absolute must if Europe is to compete, grow and generate jobs. Europe has to address its current acute shortage of people capable of leading the innovation needed to capitalise on advances in ICT. Economic growth to create jobs requires that innovation opportunities are identified and effectively exploited. In a recent survey (Dashja E & Hüsing T, 2016) around 90% of European experts agreed that digital savviness was crucial for leadership positions both now and in the future. No expert disagreed with this view. Almost all experts believed that for companies to stay competitive in the future, leadership needed to become more digital-savvy. More than 80%

also argued that people in leadership positions required more knowledge on the possibilities that new digital technologies have to offer and even more saw the need for these leaders to be better at integrating digital technology in their business approach.

Finally, and to prepare the future generation of professionals, more than 90% would like to see digital savviness integrated in formal education programmes (higher and executive).

EU member state policies and initiatives on eLeadership skills

The European Commission's eLeadership initiative has triggered relevant policy and stakeholder activities in different EU member states. These were monitored for the first time in 2009 and the results were published by the European Commission in 2010 (European Commission, 2010).

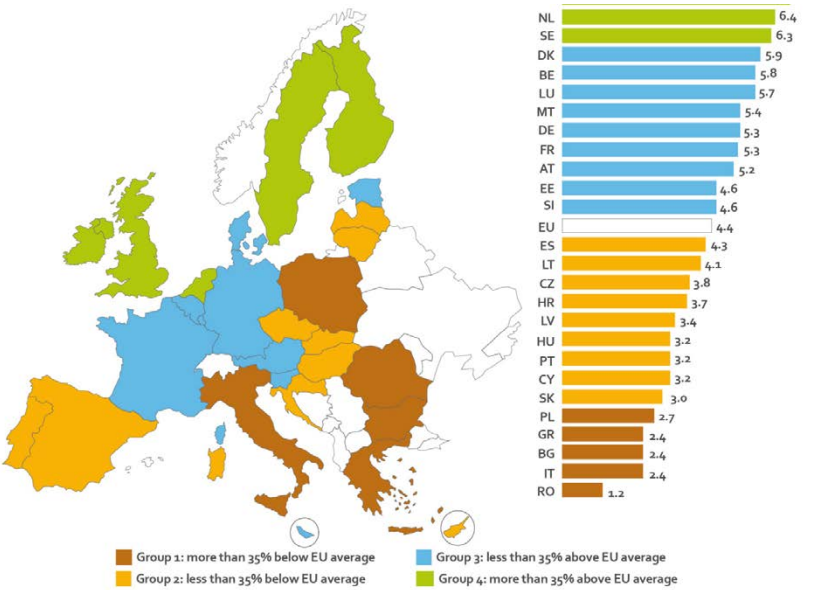
The monitoring and benchmarking of eSkills and eLeadership policies and multi-stakeholder partnerships in the EU member states, with a special focus on education and training initiatives and policies, have continued regularly since and the latest results were published in 2015 (European Commission, 2015).

"eLeadership Index" – benchmarking EU28 member states

In 2015, empirica developed an eLeadership scoreboard which monitors progress in eLeadership skills development, covering areas of the eLeadership eco-system. The 28 indicators have been developed in an "eLeadership Index" which combines each of the different dimensions of the eLeadership scoreboard in order to monitor and benchmark EU member states. Individual countries can use the eLeadership Index to monitor performance over time or benchmark domestic developments against other countries, identify role models and start learning about how different policies may affect eLeadership practice.

The eLeadership Index tries to amalgamate into one figure the different indicators relating to the business and policy climate, infrastructure and related outcomes on eLeadership. It is intended to contribute to the much-needed development of metrics, identification of policies and good practices for the better measurement and understanding of eLeadership (Hüsing et al, 2015b).

Figure 3: European map of eLeadership index quartiles



Source: empirica: e-Leadership – digital skills for SMEs, 2015

Designing a "leadership skills for the high-tech economy" agenda for Europe

The European Commission is now preparing for a new policy to build on the results of the European Commission eLeadership Initiative. In particular, it will focus on defining the vision for eLeadership, developing new curricula for skills supply, fostering eLeadership skills and investigating skills for KETs.

The agenda will significantly extend the current scope of the European Commission eLeadership initiative to include:

- synergies with skills requirements for leadership in businesses exploiting advanced manufacturing technologies;
- synergies with skills requirements for leadership in businesses exploiting KETs; skills for eLeadership in liberal professions;

- opportunities for applying eLeadership skills to address present and expected disruption in the labour market triggered by (information) technology development;

- the international dimension of eLeadership skills, including impacts of the global talent competition and requirements from cross-border processes and services.

It will be developed in close collaboration with leading stakeholders and will include concrete recommendations for action at the EU and national level to build up the supply of a comprehensive range of eLeadership skills and ensure their future optimal availability throughout European enterprise.

CHAPTER 8

eSkills: an opportunity for more inclusion and fairness in the European labour market - a trade union perspective

European trade unions have played a very active part in the recent public policy debate on the digital transformation of work. In particular, trade unions have focused on examining industrial policy, in order to secure jobs in a European digitally transformed economy, and social policy to make sure that these jobs are of high quality. European trade unions are specifically worried by the potential obsolescence of workers' competencies, and the ensuing threat on their long-term employability, caused by digital technologies. The concentration of wealth and power elicited by the digital economy, the dissolution of the employment relationship and the precarious working conditions epitomised by crowd-working platforms, are additional sources of concern.

European trade unions also consider eSkills as a major field of discussion for social dialogue, and for action by public authorities. From an industrial point of view, a workforce with the adequate skills to use and programme the digital tools currently being used for the design or production of (material or immaterial) goods is an essential asset for the development of European industry. From a social point of view, the provision of eSkills must foster the internal and external employability of all European workers, and contribute to a more inclusive and fair labour market.

European trade unions recommend actions regarding:

- the institutional and economic arrangements for the provision of eSkills to the existing work force;
- the content of the eSkills being provided;
- the teaching methods for eSkills.

The institutional and economic arrangements for the provision of eSkills to the existing work force: fairness and social dialogue

European trade unions support the following institutional and economic arrangements for the provision of eSkills for the existing work force:

- the acquisition of eSkills can require a long up-skilling or re-skilling process, for whole populations of workers. Like any demographic phenomenon, the need for the acquisition of eSkills must be anticipated early enough, in a strategic skills planning exercise, at company or sector level, in a national framework. An example of this is the agreement signed in 2016 in Germany by IG Metall and Gesamtmetall adapting VET curricula to the needs of "Industry 4.0";

- all workers should have equal access to eSkills at all levels, regardless of their age, gender, employment status, or nationality, and particularly groups with low participation, such as the low-skilled, older workers and workers on temporary or part-time contracts. Those that need training the most should not be the least likely to obtain it (ETUC, 2010). It should be an obligation (and not an option) for the employer to offer training courses to acquire eSkills, underpinned by an individual right to training, preferably guaranteed by collective agreements, if not by law (ETUC, 2016). This "lifelong learning" concept is particularly relevant for eSkills, which tend to become obsolete quickly;

- social dialogue and collective agreements should define essential aspects of training and lifelong learning measures at company, sector or national level, such as the access to training, its financing and the use of working time for training (ETUC, 2009). Social dialogue should also define the way its outcomes are validated and recognised in the salary and the career evolution of the worker, both within the company and on the general labour market. For example, using the European Qualifications Framework for Lifelong Learning (EQF);

- the digital competence centres that the European Commission plans to implement in each EU Region in the framework of its 2016 strategy to "Digitise European Industry" could be used as training centres to dispense eSkills.

Trade unions also welcome the efforts by the European Commission to support the mobility of workers in Europe. However, mobility must be a voluntary process, and making workplaces and investment mobile, instead of workers, would be a good way of achieving a geographic match between supply and demand of eSkills in Europe.

The content of digital skills: long-term, vendor-neutral and focused on programming

European trade unions appreciate the initiatives by the European Commission regarding eSkills, such as the Digital Skills and Jobs Coalition or the e-Leadership initiative, but believe that training should not be a tool for dominant vendors of ICT technologies to pursue their lock-in strategy - training and lifelong learning must be a means for users, both employers and workers, to achieve their goals. This is why trade unions believe that social partners of user sectors, in the framework of social dialogue at all levels (industrial site, company, sector, EU member states and the EU) should take the lead in defining the precise content of eSkills courses, curricula and certificates.

The eSkills transmitted to the workforce should ensure their long-term, internal and external employability, for workers to be able to re-use them throughout their whole career, in the whole labour market. This means that these eSkills being taught must be vendor-neutral, based on general scientific and technical principles and on open standards, which are permanent and transposable in all working environments.

Skills for the digital workplace should not be confused with the ability to surf the internet, to send tweets or to post on a social network. The fundamental change brought by digital technologies is programming. This requires an extremely rigorous and structured mindset, with a good capacity for abstraction, and significant learning which cannot be gained overnight, as well as needs some science, engineering, technology or mathematics (STEM) background. Teaching methods for eSkills should acknowledge, and be adapted to, the fact that not all workers in manufacturing have this background of abstract thinking.

Teaching methods for eSkills: technology is no magic wand

Workplaces need to be transformed in order to maintain and improve the capacities of workers to learn in the demanding environment of digitalised industry. They must be designed to be stimulating, while providing opportunities to exercise and improve all forms of intelligence and professional competence.

Digital technologies also provide new methods for distance learning, such as Massive Open Online Courses (MOOCs). These courses are quick, easy and cheap to produce and disseminate but need to be effective and efficient, with measurable outcomes.

Specifically, distance learning suffers from massive drop-out rates and its digital version is no exception (Gült C et al, 2014). Simply watching a video, with no interaction with the teacher, and a teacher who has no feedback on the level

of understanding by his/her audience, is a very inefficient means of learning. In addition, issues regarding security and the verification of the identity of participants affect the credibility of eLearning. These digital learning tools should be complemented with a lively interaction with a teacher or tutor, with active exercises, and with a final certification of the acquired competence.

Conclusion: European trade unions are willing to shape the eSkills landscape

European trade unions believe that providing quantitatively and qualitatively appropriate eSkills to the workforce is an important way of enhancing the competitiveness of European industry. It is also an opportunity to improve the inclusiveness of the labour market. However, this positive potential will not happen spontaneously. It will take a structured and serious social dialogue, at all levels, to achieve it. Trade unions are willing to contribute, along the directions outlined in this chapter and hope employers will respond positively.

CHAPTER 9

Lack of digital skills is a universal disadvantage

Introduction

There is a two-way correlation between digital skills and social and economic inclusion. Many consider the digital skills gap a consequence of economic and social exclusion. This is, of course, true, but it is only one side of the coin. The flip side is that digital exclusion can lead to social and economic exclusion, unemployment and poverty.

In the coming years 90% of jobs will require digital skills and competences at a higher than basic level. These are jobs not only in, but also outside of the office. Farmers, electricians, car mechanics, police detectives, teachers and doctors, among others use digital tools in their everyday tasks. Most job offers are advertised and applied for online. If we lack adequate digital skills, we can lose our jobs or be unable to find one. It is as if we are unable to read and write! And it's not only about jobs. People who are disconnected from the digital world today experience a multitude of disadvantages: they have few options to access formal education, find alternative courses or undertake continuous educational opportunities such as eLearning; are unable to use online services (housing, health and well-being, funding, banking, administrative, leisure, etc.); stay in touch with friends and relatives, launch their own initiatives, etc.

Yet, 18% of Europeans do not use the internet and 40% do not have adequate skills

This is why in this chapter we look at digital exclusion not as a mere consequence of social exclusion but as an exclusion phenomenon in its own right. We consider all those who lack digital skills to be disadvantaged groups.

Today, the digital gap is more a competence gap than an access gap. Policies on digital inclusion in past decades have focused on providing ICT access and infrastructure. Today ICT is spread throughout Europe thanks to affordable digital devices (PCs, smartphones and tablets) and sinking connectivity costs.

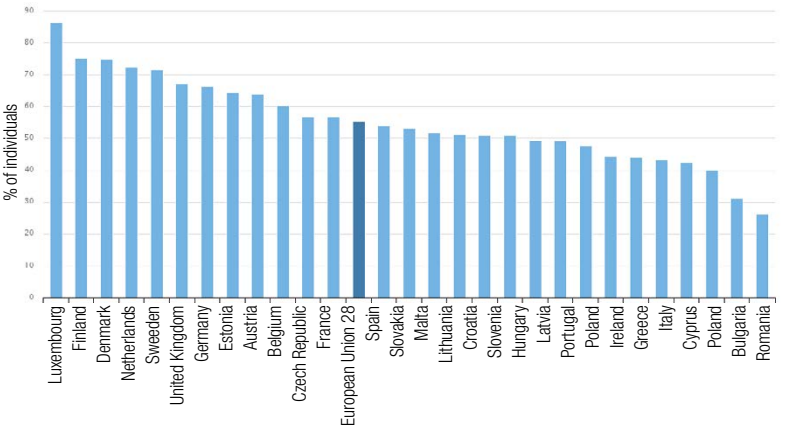
However, meeting targets related to the competence of use (using eGovernment, returning forms, buying online) is not a given. This raises the question of how to provide digital skills for all.

Which digital skills do all Europeans need?

The digital skill gap is recognised by the new EU skills agenda. Two actions tackle it directly – the Skills Guarantee, which will help low-skilled adults acquire a minimum level of literacy, numeracy and digital skills, and the Digital Skills and Jobs Coalition, which will continue the work of the Grand Coalition for Digital Jobs.

As noted above, 40% of Europeans are considered insufficiently skilled digitally. We need to raise awareness and help these citizens acquire the skills they need. In 17 member states the situation is looking even gloomier. In Romania for example 74% of citizens do not have the skills to function effectively in the digital world.

Figure 1: DESI indicator showing Europeans with basic or above basic digital skills



A significant challenge in ensuring digital literacy for all is the lack of a precise understanding of what digital skills are. What are these much-needed digital competences that everyone should have? The answer is quite complex due to the fast evolving nature of digital technologies and the diversity of those lacking digital skills. Does a driver need to know how to write an application that would help him or her find the nearest parking space? Should a doctor be able to develop an online system for patient registration? No. But basic knowledge of patient online registration forms will certainly increase a doctor's efficiency.

The EU tried to answer this question by creating the European Framework for developing and understanding digital competence back in 2013. Based on solid research, it defined 21 competences in five competence areas: information, communication, content creation, safety and problem solving. In 2016 the framework is being revised to include online collaboration and data literacy and is renamed European Digital Competence Framework for Citizens.

Is this enough to answer the question? New devices are being developed, software is upgraded on a daily basis, and interfaces are constantly changing. Some would argue that over and above the need for concrete skills to use a specific programme or device, we need adaptation skills. If we understand the logic behind digital tools and the principles of working with them, we will be able to find our way around different interfaces and programmes. This way, when an interface changes, we will not get lost because the button is not where it used to be.

This is what we should be aiming for. Whoever we are, wherever we live across Europe, we learn every day of our life. And we should learn to learn digital skills on the go. I am not good with technology is no longer an excuse. So, here we come to our next argument about flexible learning-by-doing approaches to teaching digital skills and where to find them.

Non-formal training community addressing the digital skills gap

A key aspect in teaching skills, including digital skills, which was long underestimated, is finally being recognised by the new EU skills agenda. It is **the importance of lifelong and non-formal learning opportunities**.

Because the digital world is evolving so fast (a fact we cannot underline enough), the best way to keep up is "by doing". By experiencing digital technologies on the job, in the local training centre or library, citizens acquire the skills they need. Formal education is not the only player in teaching digital skills. The non-formal education community offers efficient and fast ways to upgrade skills through mentoring and project-based learning.

Telecentres make up a big part of this community. As locally entrenched providers of ICT access and digital competences, they are low threshold physical spaces where one does not need previous digital experience. Telecentres cover the intersection of digital competences (learning how to use a computer, applications, how to surf the web or handle a tablet, but also more advanced skills such as coding, web development and online marketing), ICT based learning (for any purpose, be it employability or leisure, lifelong learning or personal development), and community building (local groups of interest like senior internet cafes, youth clubs or telecentres for migrants).

The European Commission's science and knowledge service acknowledges them as "...digital inclusion and social inclusion actors such as Public Internet Access Points, public libraries, Third Sector organisations including NGOs as well as social workers, in a word, eInclusion intermediaries."

So how do non-formal training centres do it? As low threshold spaces, telecentres offer basic skills to those making their first steps in the digital world – seniors,

household women, long-term unemployed. But as demand from telecentre users changes, trainings on the higher end of the digital skills spectrum are now increasingly part of their offer. These include courses on programming, web development, robotics and specific software. For example, in 2016 more than 2000 young people are learning about the Internet of things, cyber security and entrepreneurship through self-paced online Networking Academy courses delivered in telecentres in partnership with Cisco. In Code your future almost 1000 children and young people from disadvantaged groups learned to code at telecentres using Microsoft coding resources such as Kodu or TouchDevelop.

Photo 1: coding at a young age in Italy (courtesy of Fondazione Mondo Digitale)

A proven approach in non-formal education is intergenerational learning and it works quite well with digital skills. With this approach, young people teach digital skills to the older generation and in return, the adults pass on their life experience and foster critical thinking, confidence and skills such as public speaking, presenting oneself during a job interview, etc. Why does this work so well? Neither is only the learner or the mentor. By switching roles participants overcome some barriers to learning (I am too old to learn or I am too young to teach) and get more from the learning experience.

Another important issue is information. Many people do not upgrade their skills because they do not know about the opportunities around them. Since 2010 Telecentre Europe, a Pan-European network of ICT training centres, organises an awareness-raising campaign called European Get Online Week (GOW)

to help everyone know how to get online. Over one week, telecentres across Europe organise workshops, training sessions and roundtables to empower different vulnerable groups such as Roma, household women, unemployed youth, etc., giving them a taste of ICT and motivating them to learn new skills through further training. Since 2010 when GOW campaign began 170,000 Europeans have used the internet for the first time, 900,000 have gained relevant digital skills for employment and 15,000,000 have heard about eSkills and the opportunities offered in telecentres. Campaigns such as GOW demonstrate high success rates and attractiveness.

Figure 2: Infographic showing participation in GOW 2016, an initiative contributing to the eSkills for Jobs campaign

But let us come back to the digital skills that everyone needs in today's digital society, and in particular to adaptation skills. Because adaptation is more of an attitude than a skill, it is all the more difficult to get there. Flexible teaching methods, learning-by-doing and community-based training seem to be the right mix. The latter is also considered key in other parts of the world. When in 2010 the Canadian government asked the public how it could build digital skills, the most popular answer was to support community technology centres that help more people per day to incorporate new technologies into their lives.

Coding is another way to teach adaptation skills and to understand the digital world. Furthermore, learning how to code means you learn computational thinking; logical thinking, step-by-step analysis, breaking up a problem in bits and pieces, abstraction, generalisation, adapting an idea and using it for something else, as Vice-President of the European Commission Andrus Ansip rightly notes.

New challenges and opportunities for Europeans

a. Digital Single Market: cyber security

Digital inclusion and ensuring basic digital literacy for all is one of the priorities in the European Union's Digital Single Market (DSM) Strategy. And rightly so, because the success of all pillars of the strategy depends on people having the appropriate skills. This is not new for telecentres as they have been working to ensure that every European benefits from the digital world for almost two decades now.

But new challenges arise and providers of digital literacy, such as the non-formal training centres we talked about, need to take them into account. They need to consider hyper connectivity, the abundance of information online, how to critically select it (media literacy) and stay safe, among others. And it all comes down to education and digital literacy again!

b. Migrants and refugees

Migrants and refugees have been the main target group of telecentres since they first emerged in the 90s. In Spain, Italy, Hungary, Germany, Belgium and many other countries, telecentres have acknowledged migrants as one of the vulnerable groups when it comes to digital exclusion. In Barcelona, El Teb telecentre works in the Raval district where migrants from 70 different nationalities are almost 50% of the population. In Croatia, Telecentar Zagreb was one of the initiators of the creation of the regional network of Telecentres in the Balkans, within the South East European Refugee Assistance Network that operated between 2002 and 2008 and focused on providing ICT skills to refugees and displaced persons.

A good practice from Sweden, IT guide, trains young digitally skilled migrants to be ICT guides for elderly Swedes, who in turn teach them local language, history and habits. The potential of telecentres to help in the integration of migrants and refugees from the recent waves in Europe will be further explored in the imminent and near future.

Photo 2: working session @ IT Guide, Sweden

Recommendations

- Digital skills for jobs and inclusion for all should be brought to the forefront of the DSM Strategy, and should be a priority at EU member state level. Targeted financial support should be designated for national and local coalitions for digital jobs.

- There should be political recognition of digital and media literacy as a "creation" skill and not only as a "consumer" skill, as promoted by industry.

- Political recognition of non-formal training providers. Let's not reinvent the wheel every time but support those who are already working for many years in this area and help them to expand their offer, and use their know-how to improve people's lives.

- Encourage collaboration between formal and non-formal educational institutions by providing incentives for schools and universities to collaborate with telecentres, NGOs and libraries in teaching digital skills.

- Encourage collaboration between businesses, employers and telecentres, NGOs and libraries in teaching digital skills by providing incentives for the employers.

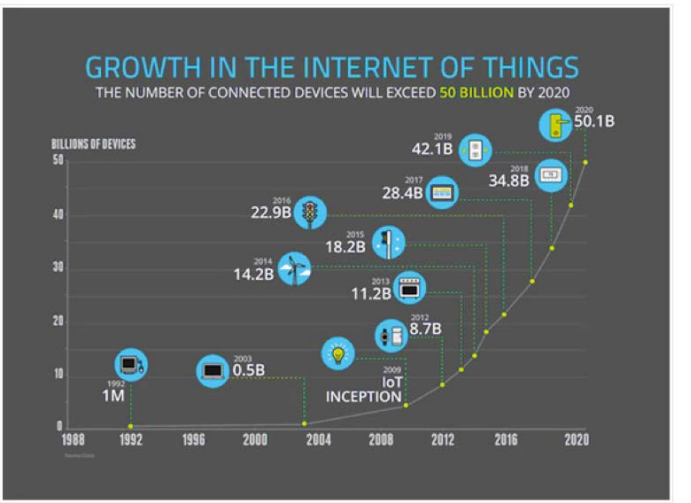
CHAPTER 10

Towards inclusive digital transformation in Europe

Introduction

The world is becoming digitalised at an unprecedented rate. The advent of the internet, mobile devices and cloud working has put vast connectivity and computing power in the hands of individuals at the most personal level, the world over. Since 2000, subscriptions for mobile services in the world have grown tenfold to seven billion, and today, 3.5 billion people are online, most of whom live in developed countries (ITU, 2016). By 2020, it is estimated that people will be joined on the internet by more than 50 billion objects (Open Mind, 2015), only one percent of which are connected today (Cisco, 2011). The future scope of digitisation is staggering, and the speed of its onset, and apparent inevitability, has given rise to what is called "digital disruption". The consequences of this digital disruption - for our lives, the planet and our fellow creatures - are still largely unknown.

Figure 1: Growth in the Internet of things (IoT)



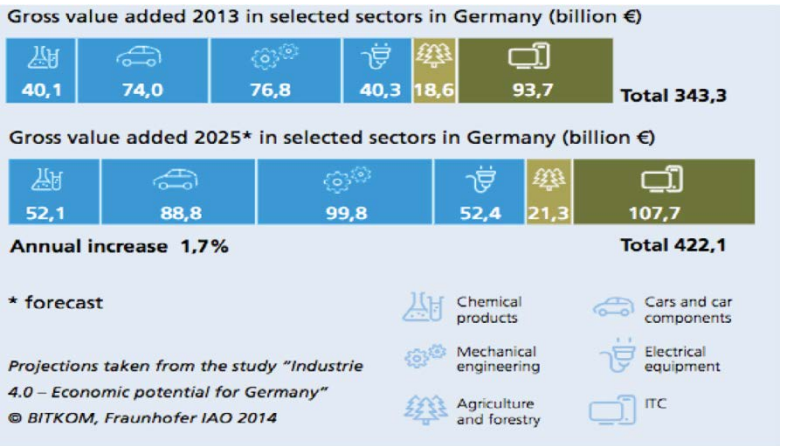
Source: Open Mind, 2015

Digital disruption is impacting the technology sector itself, where demand for skills and the computing power to fuel the transformation is far outstripping our collective ability to keep up. Digitalisation is affecting non-tech industries

too (Fraunhofer, 2016), where market leaders in sectors like financial services, energy and even government are reinventing themselves as "digital" organisations.

The rate of digital transformation represented by consumer-focused cloud computing, whose generated revenue is predicted to quadruple over the next ten years to $173 billion (Forbes, 2016), will be further dwarfed by the coming of age of the "industrial internet". The digital transformation of the world's power and production facilities, connected across a digital landscape populated by massive amounts of data (GE & Accenture, 2015) is heralding the fourth industrial revolution, and is predicted to add €422 billion in value to Germany industry along by 2025 (Fraunhofer, 2016).

Figure 2: growth potential offered by industrie 4.0, Germany



Source: Fraunhofer, Trends in industrie 4.0

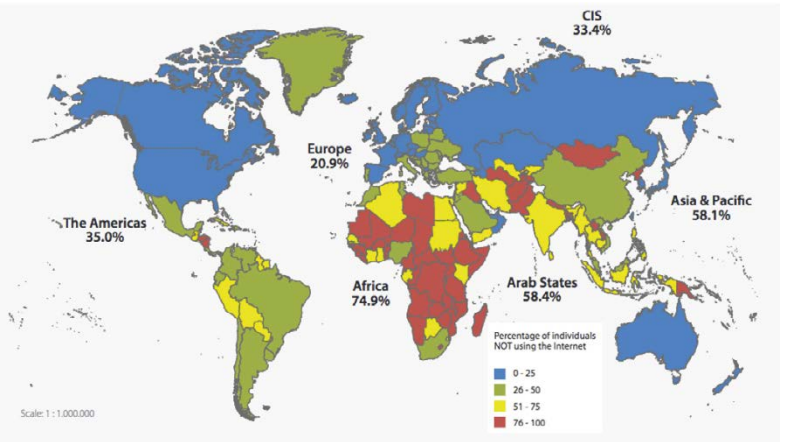
While we are starting to get our heads around what digital disruption is and what it means, it is also important to understand what it is not. Not all continents - let alone countries - enjoy large bandwidth and high availability online access today (ITU, 2015), and 53% of the people in the world are not online. This situation belies a harsh reality underpinning the digital disruption: not everyone is on board.

The digital divide

As digital transformation goes, Europe enjoys an unrivalled position in the world (European Commission, 2016). Twenty-five EU countries score higher than the OECD average for ICT indicators, and nine out of the ten nations with the fastest broadband in the world are located in Europe (OECD, 2015c). As ITU figures suggest, however, differences in broadband speed persist (ITU,

2016) and a "digital divide" among regions of the world which parallels socio-economic realities, is clearly observable. In 2016, more than half the world's population – 3.6 billion people – remain offline, and of the nearly one billion people living in the Least Developing Countries (LDCs), 851 million do not use the internet (ITU, 2016).

Figure 3: World's offline population, 2016



Source: ITU, ICT facts and figures, 2016

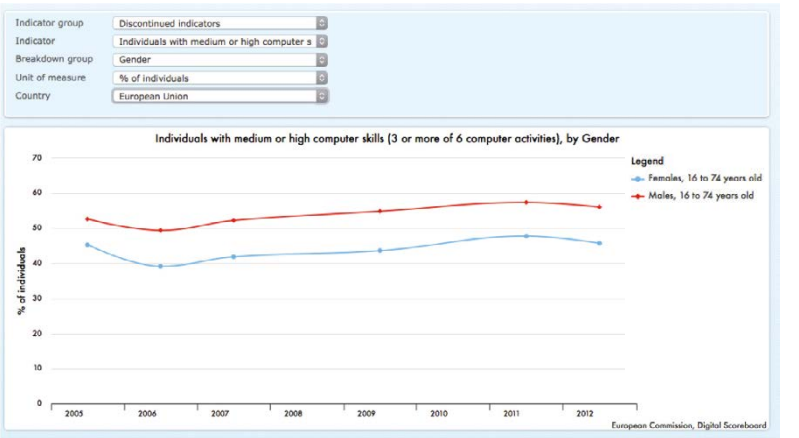
Among regions of the world, a second, persistent phenomenon may also be observed that cuts across geographic locations and even socio-economic conditions. Around the globe, no matter where they are, women as a demographic are less likely to be online than men, and despite its apparent leadership, Europe's women are also being left behind (ITU, 2015b). Of the three and a half billion people online in the world, 18% are men and 16% are women, reflecting 200 million fewer women online overall (Broadband Commission, 2013). In Europe, of the 21 countries for which the ITU collected sex-disaggregated data in 2015, men enjoy greater online access than women in 18 countries (ITU, 2016b). In addition, women are coming online at a slower rate than men, meaning that the gender gap is likely to widen (Broadband Commission, 2013).

Towards inclusive digital leadership

In addition to enjoying less online access, European women have fewer digital skills than men, are less likely to engage in formal computer science studies and hold 20% or less of the technical and leadership roles in ICT organisations (Broadband Commission, 2013). Tech entrepreneurs are five times more likely to be men than women, and in some places this ratio is closer to 100:1. In leadership positions across all sectors, including in the technology sector,

women make up only 4% of corporate CEOs and they hold less than 15% of board positions in the private sector. Since the tech sector is both a key driver of digitalisation as well as a reflection of the general digitalisation of a society, diversity in this sector is particularly indicative of digital inclusiveness.

Figure 4: Individuals with medium or high computer skills by gender



Source: European Commission Digital Scoreboard, 2012

Where digital skills are concerned research over a seven-year period (from 2005 to 2012) showed a consistent and persistent lag in the digital skill levels of European women (European Commission, 2016).

When overall skill levels increased or decreased across EU member states, a corresponding shift in women's skill sets was also reported. In every case a lag remained, roughly representing a 10% difference between the genders. These percentages represent the following absolute numbers:

2012 - EU population: 502 million people (Eurostat, 2016)

Men: 49% or 246 million people in Europe
- Men with medium-high computer skills: 57% or 140 million people
- Men with low or no computer skills: 43% or **106 million people**

Women: 51% or 256M people in Europe
- Women with medium-high computer skills: 46% or 118 million people
- Women with low or no computer skills: 54% or **138 million people**

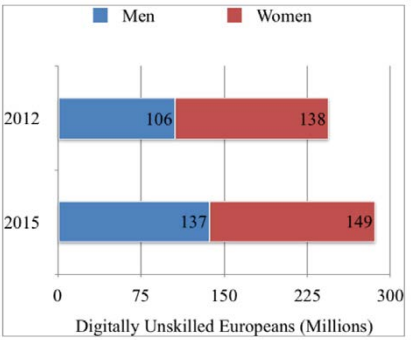
For a European population of 560 million people in 2015 (Eurostat, 2016), the data for individuals with basic, no or low digital skills, shows the following evolution:

2015 - EU population: 560 million people (Eurostat, 2016)

Men: 49% or 274 million people in Europe
- Men with basic, low or no digital skills: 50% or **137 million people**

Women: 51% or 286 million people in Europe
- Women with basic, low or no digital skills: 52% or **149 million people**

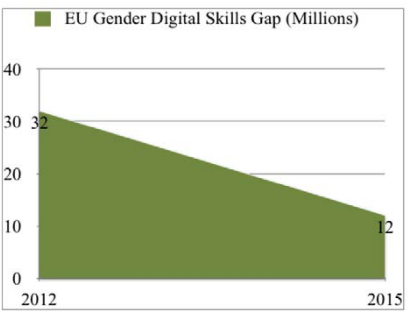
Figure 5: Digitally unskilled Europeans (millions)



Source: Eurostat, 2016

From this data, the following may be concluded:
- 286 million people, or over half of Europe's population, have basic, low or no digital skills;
- 149 million people of Europe's digitally under-skilled, or 27% of the total EU population, are women;
- 12 million more women than men in Europe, or 2% of the total EU population, are digitally under-skilled;
- these numbers reflect a significant and persistent trend.

Figure 6: EU gender digital skills gap (millions)



Source: Eurostat, 2016

Although a decline in European digital skills over the 2005-2015 period may be explained by EU enlargement and changes to data collection approaches, the following facts are clear.

A woman in Europe is:
- less likely to be online;
- more likely to be digitally under-skilled;
- at a greater risk of being excluded from the digital disruption underway.

Towards inclusive digital transformation

Like online access, digital skill levels are an excellent indicator of the general education and economic integration of a given demographic, and they are an even stronger litmus test of how well that demographic is engaged in the digital transformation afoot. As such, the situation described above represents a vast lost potential to Europe and to the young and adult women of Europe who are unable to realise their place as productive members of our increasingly digital society. There is a risk that the needs of these women go unheeded and the benefits of engaging them in the further digitalisation of European society go unrealised.

A 2013 European Commission report demonstrated that equal participation of women in the ICT sector — as a quick-win to address the growing skills and job gap in Europe — would contribute as much as €9 billion to the European economy every year (European Commission, 2013). A United Nations (UN) study in the same period linked every 10% increase in access to broadband with a 1.38% growth in Gross Domestic Product (GDP) for developing countries, and noted that bringing 600 million additional women and girls online specifically could boost global GDP by up to $18 billion (Broadband Commission, 2013). The increasing rate of digital disruption could certainly serve to compound the upside potential as captured in these reports as much as it could multiply the downside risk from exclusion that is already happening.

For this reason, the following resources and actions need to be supported at the EU level:

- curtail the risk of further digital exclusion of Europe's 286 million women;
- close the digital skills gap impacting women in Europe;
- maximise the opportunities presented by engaging Europe's women to design, build and lead Europe's digital transformation.

To this end, initiatives that increase entrepreneurship, science, technology, engineering, arts and maths (ESTEAM) - including digital - skills for girls and women and prepare them to lead Europe's digital transformation need to be promoted, scaled-up and replicated. Such initiatives should embody best practices of the following kind:

- focus on girls and women specifically;
- promote female role models in tech, and more generally;
- stimulate learning through hands-on, result-driven and values-oriented activities;
- develop a rich, diverse and widespread community of European female digital leaders in the public and private sector, including entrepreneurship.

Many world-class initiatives of this kind have been developed and carried out in Europe by organisations and through campaigns such as the Digital Leadership Institute, the GEM-TECH Awards, Stemettes, Ada Lovelace Day and girlscodeEU to name just a few.

CHAPTER 11

Digital skills at the heart of education

Introduction - digital skills gaps are bigger than we expect

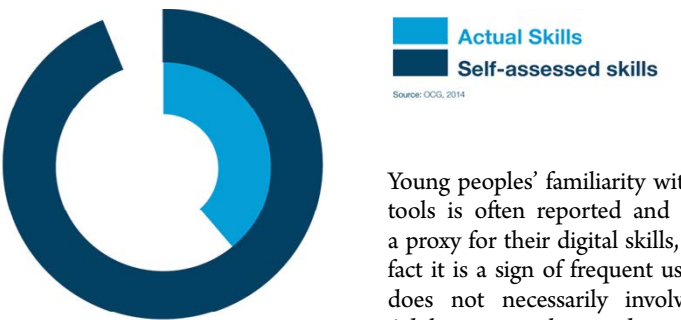
The Digital Economy and Society Index (DESI) indicates that almost half (45%) of Europeans (European Commission, 2016) still do not have basic digital skills. This is measured in the index as the ability to use a mailbox, edit tools or install new devices.

Most international indicators are based on activities that people say they do online. However, these indicators do not measure how good people are at these activities, nor if they have the right skills to carry them out effectively and safely. In fact, recent studies show the shortcomings of self-assessment as a measure of digital skills.

A representative study, carried out in Austria, found out that 94% of Austrians assess their general computer skills as "average" to "very good" (see Figure 1). However, when they were required to take a practical test to check their actual skills levels, only 39% of study respondents scored that high (ECDL Foundation, 2016).

Similar studies were also replicated in Denmark, Finland, Germany and Switzerland. All of these studies revealed the same results: people cannot adequately assess their digital skills levels. This trend could be explained in two ways: people either assume that they automatically develop the right skills simply by using digital applications, or they are trying to show themselves in a better light for potential employers. In order to avoid self-assessment bias, an objective measure of digital skills is essential.

Figure 1: Self-assessment vs. actual general computer skills. Results from the study carried-out in Austria. OCG, 2014.



Source: ECDL Foundation

Young peoples' familiarity with digital tools is often reported and taken as a proxy for their digital skills, while in fact it is a sign of frequent use, which does not necessarily involve skills. Adolescents might spend most of their time using technologies to play games,

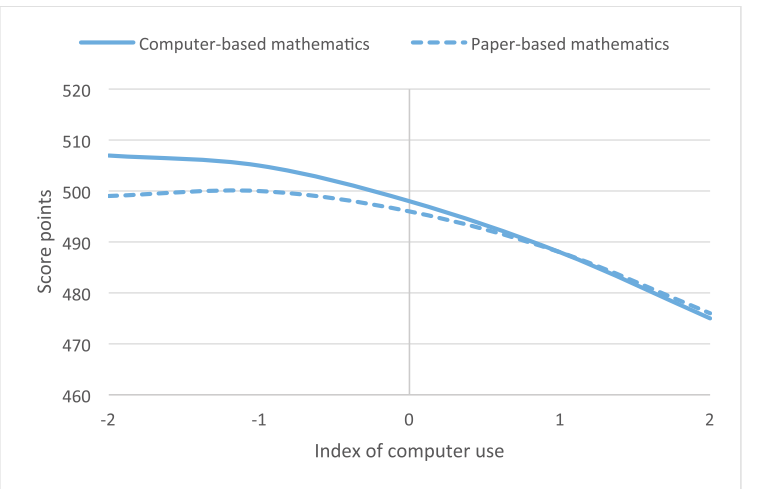
communicate on social networks and consume digital content. These activities do not develop the skills required to use the computer in an effective and safe manner, find a job or use online public services. The assumption that young people are "digital natives" is a dangerous fallacy. Only consistent education and training can equip young people with the skills required to become successful learners, employees, entrepreneurs and citizens.

In order to grasp and recognise the variety of digital skills for citizens, the European Commission developed a Digital Competence Framework, also known as DigComp. The framework provides a common language to describe digital competence and is used as a reference in several countries in Europe.

Simply equipping schools with digital technologies is not enough – skills are needed

When every sphere of life is becoming more dependent on digital technology, education systems are pressured to transform rapidly. Multiple solutions are available, but they do not always bring about the desired results. A recent OECD study states that using digital technology in the classroom does not always lead to a better quality of education and higher achievements by students (OECD, 2015). In fact, the study found that, in mathematical tests, almost any time spent on the computer led to poorer performance by students, even after accounting for differences in socio-economic status (see Figure 2).

Figure 2: students who do not use computers in maths lessons score highest in mathematics.



Source: based on OECD (2015a), "Students, Computers and Learning. Making a Connection".

These findings do not suggest that countries should stop investing in digital technologies for education. Andreas Schleicher, OECD Director for Education and Skills, said "technology is the only way to dramatically expand access to knowledge. To deliver on the promises technology holds, countries need to invest more effectively and ensure that teachers are at the forefront of designing and implementing this change" (OECD, 2015b). In other words, school staff, teachers and students should be provided not only with digital tools, but also with consistent training and guidance on how to use them.

The need to develop teachers' skills in using and applying digital technologies in teaching practices has been revealed by several research studies. According to the study commissioned by DG CONNECT at the European Commission, only 25% of students in Europe are taught by digitally confident and supportive teachers (European Schoolnet & University of Liege, 2013). Moreover, an OECD survey of the teaching profession (TALIS) found that 56% of teachers report moderate or high professional development needs regarding the use of digital technologies in the workplace (OECD, 2014). Teacher training is central in ensuring that teachers understand the key concepts and benefits of using ICT to support and enhance teaching: learning and assessment in the classroom; planning ICT-enhanced lessons; understanding safety, security and well-being considerations when using ICT in education; understanding how to source and evaluate ICT resources to support and enhance teaching and using key features of a learning platform, etc (ECDL Foundation, 2016).

Computer science and digital literacy are both important in digital education

Many countries in Europe and beyond are considering coding as a possible skill to be develop in formal education. Coding can enable people to become creators of digital applications rather than just passive consumers of digital content. Moreover, knowing how to code is considered to be useful in the labour market, as demand for ICT specialists is outstripping supply. According to forecasts, there might be 765,000 unfilled vacancies for ICT professionals in Europe by 2020 (empirica, 2015b).

The European Commission has promoted coding through numerous initiatives, such as the Opening Up Education Initiative, the European "eSkills for Jobs" campaign and the EU Code Week. The European Coding Initiative was created under the auspices of the European Commission, and is led by partners from the technology industry, including Facebook, Liberty Global, Microsoft, Samsung and SAP. Data collected by European Schoolnet shows that five countries in Europe have introduced coding at primary school level (Estonia, France, Spain, Slovakia and the UK (England)) and eight countries have introduced it at upper secondary school in general education (Austria, Denmark, Estonia, Lithuania, Malta, Poland, Spain and the UK (England)) (European Schoolnet, 2015).

Moreover, numerous voluntary-led afterschool activities, such as Coder Dojos, Code Clubs and Rails Girls, are happening across Europe.

While initiatives around coding are increasing worldwide, it is important to consider this skill from a broader perspective. As defined by European Schoolnet, coding "on a technical level is a type of computer programming that closely or exactly represents what happens at the machine level. However, when most people talk about coding, they usually mean something at a higher, more human-readable level" (European Schoolnet, 2014). It is important to have in mind that coding is just one element of a broader discipline of computer science. This discipline encompasses the theory of computation, as well as various concepts that range from programming to data structures and systems architecture. In order to equip children with a full set of transferable skills and knowledge, all of these areas should be covered in digital skills education. This does not mean that current educational provision should ignore general digital skills. The International Computer and Information Literacy Study (ICILS), which assesses computer and information literacy skills of 60,000 eighth graders (14 year olds) from 21 education systems all over the world, revealed that around 17% of students do not reach the lowest level of their scale and only 2% score at the highest level, which requires the application of critical thinking while searching for information online (ICILS, 2014). Digital skills are crucial for every area of life – studying, travelling, commerce, managing personal finances, accessing public services amongst others. They should be developed together with, and be complementary to, computer science.

CHAPTER 12

STEM education for STEM careers: tapping into technological potential to attract talent

The acronym STEM (Science, Technology, Engineering and Maths) refers to an array of subjects and disciplines that are today widely promoted in education throughout Europe and around the world. What stands behind this acronym is much more than a definite number of subjects, as the push for STEM education is a way to address a lack of skilled talent, rising youth unemployment rates and even as a call to update teaching and learning methods and educational content.

Demands and supply in STEM

Every year in Europe about 640,000 students graduate in STEM subjects (empirica, 2015b). The number of people working in STEM is increasing and demand is anticipated to grow even more (European Commission, 2015). In the short to medium term, the main reason for the increase in demand is the need to replace highly-skilled professionals who are retiring, which leads to concerns about the adequate supply of skilled talent in Europe (Ulicna D & Royale R, 2015). However, the demand-supply issue is not as clear-cut as it may seem at first sight. Demand will not grow across the board in a homogeneous way. First of all, there are pockets of need in certain parts of Europe, which implies that certain European regions will have higher demands than others (European Parliament, 2015). Secondly, demand varies according to sectors. In particular, shortages are expected in professional services and computing, for example, and some demand might be specific to highly specialised STEM sub-fields (European Parliament, 2015). Overall the science and technology sectors provide work for over half of the EU's workforce (European Commission, 2014).

STEM skills are also needed and applied beyond STEM careers. Individuals with STEM degrees or training are significantly less likely to be unemployed than the average, and this holds true despite the current economic crisis (Cedefop, 2014) and even in countries that currently have high unemployment levels such as Greece, Portugal, Spain (European Parliament, 2015).

STEM skills are regarded as a trigger for innovation. At the same time, the ongoing changes in economic and social life will affect the relevance of the skills and knowledge held by STEM professionals. In the coming years, the required skills and competences will change as a result of technological development and convergence (Ulicna D & Royale R, 2015).

An ongoing issue is the gender balance in STEM studies and careers. Across the EU-28, 14% of female students graduate in a STEM subject versus 40% of male students (European Commission, 2015). Despite various initiatives and policy efforts that have improved the situation, the STEM gender gap persists.

STEM in Europe: the European Commission's role

Ensuring the supply of STEM-skilled individuals has been tackled through several projects, initiatives and campaigns. This focus includes an effort to address lower numbers of women choosing these subjects. Several initiatives converge towards this aim and these include campaigns (e.g. Science, it's a girl thing) and work programmes (e.g. Sciences with and for Society).

A number of European projects aim to raise awareness among students about opportunities in STEM fields and support teachers and students who engage in science education. Examples include Scientix, a community for science education in Europe, and the STEM Alliance, an industry and education partnership to promote STEM education in Europe.

STEM education: challenges and methods

It remains a challenge to attract sufficient students to STEM subjects, which are often perceived negatively as difficult, boring or uninspiring (European Schoolnet et al, 2013). However, students and pupils that do study STEM subjects primarily perceive the teaching methods as problematic, rather than the subject matter itself (European Schoolnet & InGenious, 2014). Until recently, education offers in STEM subjects still tended to emphasise rote learning and knowledge recall, rather than experimentation, discovery, or trial and error, which are foundational aspects of STEM disciplines and tend to be more engaging.

Current educational practices embrace new pedagogies that are more adapted to the scientific method and include observation, experimentation, collaboration and problem solving. Inquiry-based learning, which is a more engaging method that encourages student autonomy and places curiosity and questioning at the centre of the learning process, is a top priority for several ministries of education in Europe (Kearney C, 2015).

Digital technologies in STEM education

Digital technologies can also help to integrate such pedagogies and teaching methods. Through the possibilities offered by simulation tools, virtual reality or 3D printing, the teaching and learning of STEM subjects can be more hands-on and be made more attractive, enjoyable and dynamic. A more intensive use of digital technologies in class also enables the inclusion of cutting-edge topics (e.g. nanotechnology, robotics) and help to integrate content and tasks that graduates will encounter in the workplace (e.g. sensors, data loggers, online collaboration) (European Schoolnet et al, 2013).

While access to digital devices was sparse two decades ago, today it is nearly ubiquitous and devices are readily at hand in class as well as practical learning situations. But while the opportunities offered by technologies can make a significant impact, teachers and students do not need hi-tech classrooms to teach and learn effectively. Various trends such as the "tinkering movement" demonstrate that effective hands-on STEM education can also be achieved at a low-cost or low-tech level. The guiding principle behind the "tinkering movement" or the related "maker movement" is to use real tools to solve real problems. Students engage and experiment with the subject matter and are encouraged to try new things and make mistakes. A European example for STEM education through tinkering is Tinkering Europe. From creating robots to building circuits boards, such activities can create a deeper and practical understanding of digital and other technology and a spirit of innovation and invention to the everyday endeavours of students, who are engaged and motivated through active involvement.

CHAPTER 13

Building a cyber security ecosystem in Europe based on education

Introduction

The rapid digitalisation of our economies and societies and the emergence of new technologies has had a considerable impact not only on our industries, markets and innovation but also on our fundamental rights to privacy. It has produced an irreversible paradigm shift in the way we regulate and approach the world around us.

With this digitalisation has come an acceleration in the use of new technologies and solutions to safeguard our privacy and secure digital networks and applications. Due to the increasing pervasiveness and rapidly changing nature of cyber threats, cyber security has become a crucial issue not only for building a sustainable architecture for Europe's Digital Single Market but also for protecting our citizens' privacy and data. As digitalisation continues to be a dominant feature of our society, the question we should ask ourselves is: "do our societies and workforces have the necessary knowledge and skills to live and work in this digitised world?"

The general public today still regards cyber security as a complex and predominantly technical issue. The fast digitalisation of our world must be matched with a comprehensive and efficient education system. This needs to provide our workforce with the necessary skills for the current job market - preparing the next generations of professionals in the Information and Communication Technologies (ICT) sector and raising the general public's awareness, as users, of the importance of cyber security.

This chapter will provide an overview of cyber security and some of the challenges we currently face. It will also examine the actions of the new Public-Private Partnership on cyber security between the European Commission and the European Cyber Security Organisation (ECSO).

State of play and challenges

There is a need to re-think education at all levels. It is not a case of recycling what is already there – a real multi-disciplinary, coordinated and coherent approach is needed.

The consumers of education, training and skills development can be divided into:

- general population – individuals who are not cyber security experts but users of ICT technologies and services;
- students of all ages within the education system;
- experts - professionals in the high ICT dependency sectors;

While a few national and Europe-wide general public awareness campaigns exist such as the ENISA Cyber Security Month, their effectiveness has been challenged by "IT security fatigue". As Bada and Sasse put it, "people can sometimes get tired of security procedures and processes, especially if the perception is that security is an obstacle, disturbing them all the time" (Bada M & Sasse A, 2014).

At the education level, there is a lack of cyber security awareness by teachers and students and few integrated training modules on cyber security at all school levels. The same is true at university level - only a few cyber security higher education programmes exist in Europe but more and more initiatives have been set up by European Universities like Solvay Business School in Belgium or Telecom Bretagne in France.

According to an analysis made during the European Cyber Security Protection Alliance (CYSPA) project in 2014, several EU member states have included cyber security education in their national strategies (CYSPA, 2014). The report noted that the United Kingdom had put in place several innovative initiatives such as the Cyber Security Challenge UK or the eSkills UK Initiative that created the first European cyber security apprenticeship programme with partners like Atos, Cassidian (now Airbus), IBM and Capgemini in 2013. However, there has so far been only limited feedback on the efficiency and impact of national initiatives.

At the professional level, there are few accessible tools for promoting awareness, training and skills development on cyber security issues. Cyber security skills are increasingly a prerequisite of employers across all sectors. At the moment, there are more jobs than qualified candidates, while the general unemployment rate remains high in some European countries.

On the other hand, many cyber range environments (virtual environments for training on cyber attacks and testing operational solutions) have been built to enable cyber exercises and practical, hands-on training for specialists - e.g. European Agency for Network and Information Security (ENISA), NATO's Locked Shields and the Cyber Coalition. However, professional training programmes are not linked and coordinated with each other and therefore do not improve the overall knowledge of cyber threats and possible solutions.

Putting in place educational building blocks

It is clear that to reach these target audiences, it is necessary to set up new training models such as Massive Open Online Courses (MOOCs) and accessible tools to raise general awareness. Efforts are also needed to enable people to change jobs and join the cyber security field in the later stages of their careers.

The benefits are obvious:

- cyber security will produce new innovation paths and market niches such as cyber security insurance, cyber security risks and practices, security engineering, security management, and many more;

- having a coordinated overview will encourage EU member states to agree on a baseline for cyber security indicators;

- the social aspect of cyber security boosts awareness of social values through, for instance, user empowerment and control of personal data and the digital legal education (right to be forgotten, freedom of speech, anonymity versus trust and security, etc.).

The common educational requirements for the target audiences should be:

- multi-disciplinary focus;
- responsiveness to changes in technology and society;
- end-to-end skill development;
- alignment of curricula and training with demand for skills;
- using appropriate methodologies for teaching cyber security at all levels, from basic awareness to focused expertise.

Public-Private Partnership on cyber security: envisaged actions and expected impact

In 2016, the European Commission started a Public-Private Partnership (cPPP) on cyber security with a new industry-led organisation – the European Cyber Security Organisation (ECSO). This partnership is part of the Strategic Research & Innovation Agenda in Europe. One of the key pillars of this agenda will be dedicated to the development of education, training and eSkills to support the creation of a cyber security ecosystem in Europe. The cPPP has already proposed the following actions:

- establish a European cyber security academy and a network of national cyber security "academies" to provide multi-disciplinary curricula and training to be recognised at European level. This is designed for graduate students, teachers of all levels, industry including SMEs as well as cyber security specialists and researchers;

- collaborate in preparing materials and modules for professional training as well as for younger educational levels;

- generate a consensus on a core of European higher education curricula for cyber security studies at university level (both traditional and virtual education) as well as propose a plan for integrating cyber security studies modules into professional education for vital service providers and public servants. At the moment, there is a fairly sparse number of courses but not a unified approach;

- coordinate a network of PhD studies on cyber security, connected with industry using the format of industrial PhDs that already exists in the H2020 Excellence Science Pillar;

- promote creativity and innovation in young students and young researchers by proposing challenges, prizes and cyber campus activities in order to connect them with the needs of citizens and industry;

- organise cross-border exercises and training to raise awareness and enable product testing by researchers to improve the resilience of European products and services (e.g. European Bug Bounty Programme). Advanced training like bootcamps could improve specific needs at the European level.

Conclusions

The newly formed ECSO association, supported by the cPPP, will face challenges from the ongoing rapid pace of digitalisation, the constantly evolving nature of cyber security, low levels of awareness and education as well as the slow pace of decision making.

A sustainable approach to European cyber security can be developed only if it is built on a sound basis of better education, coordinated common professional cyber skills training and better awareness from decision makers. As this is critical, it needs to start now!

CONTRIBUTOR BIOGRAPHIES

Thor Berger
Associate Fellow, Oxford Martin Programme on Technology and Employment, Oxford Martin School, University of Oxford

Thor Berger is Associate Fellow of the Oxford Martin Programme on Technology and Employment at the Oxford Martin School, University of Oxford and PhD Candidate at the Department of Economic History, School of Economics and Management, Lund University. His research is focused on the role of technological change in understanding regional and urban development from a long-term perspective and how recent technological advances will shape the labour markets of the 21st century. His work is published in leading academic journals and has been widely covered in the popular press.

Laurentiu Bunescu
CEO of Telecentre Europe

Before becoming CEO of Telecentre Europe, Laurentiu worked as Grants and Campaigns Manager since 2008, running a major digital skills awareness campaign in Europe – the Get Online Week. In his new role, Laurentiu focuses on developing membership, on the strategic direction of Telecentre Europe, and on developing existing and new partnerships. With a Bachelor's degree in Economics, Laurentiu started one of the first telecentres in Romania before joining Telecentre Europe, and became a facilitator and supporter of the Romanian national network of telecentres.

Patrice Chazerand
Director in charge of Digital Economy and Trade Groups, DIGITALEUROPE

Prior to joining DIGITALEUROPE, Patrice was the Secretary-General of the Interactive Software Federation of Europe (ISFE), a trade body of PC and videogames publishers. In this capacity he established PEGI, the only pan-European system of harmonised rating of digital content. In 1999, Patrice set up the Brussels office of Viacom, which he ran as Vice President, European Affairs until 2002 and from 1989 to 1995, he was Director, Public Affairs, at AT&T France, and subsequently Managing Director from 1995 to 1999. Patrice spent the first fifteen years of his career with the French Ministry of Foreign and European Affairs, seven of which were at the Embassy of France in Washington.

Eriona Dashja
Research Consultant, empirica

Eriona Dashja is involved in various studies performed for the European Commission in the areas of digital skills and eLeadership skills. Among others, her most recent activities involve work on the development of an eLeadership scoreboard and index, analysis of higher and executive eLeadership education and training landscape as well as design and preparation of country reports.

Haluk Demirkan
Associate Professor of Service Innovation & Business Analytics, University of Washington – Tacoma

Haluk Demirkan is a recognised leader in the analytics, service innovation, digital transformation and service-oriented technology and management, with almost 20 years professional experience on maximising the return on companies' resources by effectively implementing strategic data and analytic solutions for 40+ Fortune 500 companies. His 15 years long scholar work resulted in more than 150 publications. In 2015, he received the IBM Faculty Award from IBM Cognitive Systems Institute for his research agenda "Deep Analytics and Deep Learning: Leveraging Watson's Deep Thinking and Smart Services". He is a board of director for the International Society of Service Innovation Professionals, and an advisory board member for the INFORMS Service Science Section. His doctorate is in Information Systems and Operations Management from the University of Florida.

Dr Anusca Ferrari
Digital Skills Project Manager, European Schoolnet

Dr Anusca Ferrari is managing the eSkills 2015-2016 campaign; the I-LINC project; and contributes to other activities in the digital citizenship line of work. With over 13 years' experience in education and training, Anusca has been working as a consultant, a research officer, a project manager and a teacher. Her main area of expertise is digital competence and eSkills. She is the author of several articles, papers, reports on technologies for learning and creativity.

Dr Carl Benedikt Frey
Oxford Martin Citi Fellow/Co-Director, Oxford Martin Programme on Technology and Employment, Oxford Martin School and Economics Associate of Nuffield College, University of Oxford

Dr Carl Benedikt Frey is also a Senior Fellow of the Programme on Employment, Equity and Growth at the Institute for New Economic Thinking in Oxford, and the Department of Economic History at Lund University. His research focuses the transition of industrial nations to digital economies, and subsequent challenges for economic growth, labour markets and urban development. To secure impact for his research outside academia, Carl Benedikt is widely engaged in policy, advisory and media activities. In partnership with Citigroup, he works to help global leaders navigate the rapidly changing world economy. Over the course of his career, he has also worked with governments, such as the Digitalisation Commission of the Swedish Government, and acted as a Specialist Advisor to Digital Skills Select Committee at the House of Lords. He has further engaged as an external consultant to various international organisations (e.g. OECD and UN agencies) and leading corporations (e.g. Deloitte and PwC).

Dr Meenakshi Gupta
Senior Director, Policy & Research, Information and Communications Technology Council (ICTC)

Meenakshi Gupta is Senior Director for Policy & Research at the ICTC and specialises in the areas of Education, International Development and Policy Studies. At ICTC, Meenakshi manages and provides thought leadership around measurement and analysis of the digital economy. She has led the design and development of the Occupational Standards for the eHealth, Interactive Digital Media and several other new and emerging technologies. She is responsible for leading the pathway for conducting real-time labour market research in the digital economy of Canada, and ensuring credible and robust data is available for informing multi-stakeholders including industry, education and policymakers. Meenakshi has also worked with International Finance Corporation (IFC) to help develop occupational standards for the ICT sector in Jordan. Dr. Gupta has presented at various national and international conferences and events as an invited guest speaker. She holds a doctoral degree in Education from McGill University, Canada.

Tobias Hüsing
Senior Research Consultant, empirica

Tobias Hüsing's work covers research and consulting on eLeadership and eSkills policies and labour market, as well as research, innovation and knowledge transfer policies. He currently coordinates the study on "eLeadership skills for SMEs" for the European Commission. Tobias leads the eSkills supply and demand forecasting team at empirica, analysing industry and labour market insights and the supply system for eSkills and eLeadership education and training.

Dr Māra Jakobsone
Vice-president LIKTA, Chair Telecentre Europe

Dr Mara Jākobsone is Vice-president and ICT and eSkills project manager at the Latvian Information and Communication Technology Association (LIKTA). Her responsibilities include development, coordination and implementation of information society and eSkills related policies, initiatives and projects. Mara is the Coordinator of the Latvian national eSkills partnership. Since October 2012 she has been elected as a Chair of Telecentre Europe. She has also more than 20 years' experience as a Researcher and Associated Professor at the University of Latvia, Faculty of Business Administration.

Akira Kataoka
General Manager, Planning Department, Information-Technology Promotion Agency (IPA), Japan

The IPA is a public agency under the supervision of Ministry of Economy, Trade and Industry in Japan. Akira Kataoka is responsible for leading the strategic human resource infrastructures needed to promote new industries based on sophisticated ICT. He manages and provides thought leadership for measuring and analysing ICT human resources. He has also been responsible for nurturing outstanding young talent who can create ICT innovations in various industries and have cyber security skills. Previously Akira worked for Automobile and Electronics companies. He was in charge of planning and developing of PC and UNIX server products and system development for broadcasting stations, newspapers, transportation and finance companies. He graduated from Kyoto University, Japan and lives in Tokyo.

Werner B Korte
Director, empirica

Werner B Korte is responsible for managing many of the largest research and development projects in relation to eSkills, eLeadership skills, digital entrepreneurship and policy evaluation, new forms of work, information society, statistical indicators for benchmarking eSkills and other domains. He has been and is project manager of large scale international empirica projects in these areas, providing policy evaluation and assessment to public and private customers.

Dr Bruno Lanvin
Executive Director, Global Indices, INSEAD

Bruno Lanvin is the Executive Director of INSEAD's Global Indices (GITR, GII and GTCI). Before joining INSEAD, he held senior positions at the World Bank and in the UN. Since 2002, he has been co-authoring the Global Information Technology Report, (INSEAD-World Economic Forum); he is currently the co-editor of the Global Innovation Index Report (INSEAD-WIPO-Cornell University). In 2013, he founded the Global Talent Competitiveness Index (GTCI). Dr Lanvin holds a BA in Mathematics and Physics from the University of Valenciennes (France), an MBA from École des Hautes Études Commerciales (HEC) in Paris, and a PhD in Economics from the University of Paris I (La Sorbonne) in France. He is also an INSEAD alumnus (IDP-C). A frequent speaker in high-level meetings, he advises a number of global com-panies and governments, and is a member of numerous boards, including those of IDA (Singapore), ICANN and the Tallinn e-Government Academy.

Cheryl Miller
Cofounder & Executive Director, Digital Leadership Institute

The Digital Leadership Institute is a Brussels-based, international NGO promoting inclusive digital transformation in strategic, innovative economic sectors. Cheryl is also CEO of Zen Digital Europe, a leader in bespoke change strategies. Cheryl has a twenty-year track record leading international teams in the tech and ICT sector, mainly in business functions and most recently in the public policy arena. Her work in ESTEAM (entrepreneurship, science, technology, engineering, arts & mathematics) is recognised by the United Nations, European Parliament and European Commission, and Cheryl regularly speaks and writes on topics related to digital disruption. Cheryl also coaches, promotes and invests in early-stage enterprises. Cheryl is a founding ambassador of Code Week Europe for Belgium, and of Startup Europe Week for the Brussels Capital Region. She has a degree in International Relations, Law & Organisations from the Georgetown University School of Foreign Service and a Master of International Business Studies from the Moore School of Business.

Jonathan Murray
Director of Operations, DIGITALEUROPE

Jonathan Murray joined DIGITALEUROPE in 2009 as a Director of Operations and Business Development, having previously been Director of Marketing and Sales for the Brussels based European Institute for Industrial Leadership. Prior to that, he spent eight years with Equant (now part of the orange Group) where, as Vice-President, he was in charge of business and strategic planning, business development and process re-engineering. Jonathan held senior management positions at the Financial Network Association, the world's first major international telecommunications alliance, and at Lloyds Bank International where he worked in the UK, France and Brazil. He holds an M.B.A. from Thunderbird – Global School of International Management, US and also holds a B.A. (Hons.) in politics from the University of York, UK. He has attended advanced courses in international marketing and advertising at the Escola Superior de Propaganda e Marketing, in Sao Paulo Brazil.

Adams Nager
Economic Policy Analyst, Information Technology and Innovation Foundation

Adams Nager is an Economic Policy Analyst at the Information Technology and Innovation Foundation. He researches and writes on innovation economics, manufacturing policy, and the importance of science, technology, engineering and maths (STEM) education and high-skilled immigration. Adams holds an MA in Political Economy and Public Policy and a BA in Economics, both from Washington University in St. Louis.

Luigi Rebuffi
CEO and Founder, European Organisation for Security (EOS)

Luigi Rebuffi is the CEO and founder of EOS and the Secretary General of ECSO (European Cyber Security Organisation). Having graduated in Nuclear Engineering at the Politecnico di Milano, he worked on the development of high power microwave systems for the next thermonuclear fusion reactor (ITER). He then continued his career at Thomson CSF / Thales where he took on increasing responsibilities in European Affairs (R&D) in different sectors: telecom, industrial, medical, scientific, and became in 2003 Director for European Affairs for the civilian activities of the Group. He is a Member of the Protect and Security Advisory Group on EU Security Research and President of the Steering Board of the French ANR for security research.

Gabriela Ruseva
Project manager and policy expert, Telecentre Europe

Gabriela handles EU project management and policy advocacy for Telecentre Europe. She is responsible for designing proposals and managing projects supported by a number of EU funding programmes. She is also responsible for the advocacy activities of the organisation. Gabriela's background is in education and training. Before joining the non-profit sector she was an expert in youth policy at the Bulgarian Ministry of Education, youth and science and managed research at the Research Service of the European Parliament. She has a Masters Degree in European Studies from King's College London.

Dr James C Spohrer
Director, Understanding Cognitive Systems, IBM Research - Almaden

Dr James C Spohrer is a recognised leader in the study of service science, T-shape skill sets and cognitive systems. He works to align IBM and academia globally for innovation amplifications of cognitive computing. Previously, Jim helped to found IBM's first Service Research group, the global Service Science community, and was founding CTO of IBM's Venture Capital Relations Group in Silicon Valley. During the 1990's while at Apple Computer, he was awarded Apple's Distinguished Engineer Scientist and Technology title for his work on next generation learning platforms. He has more than 90 publications and been awarded nine patents. Jim has a PhD in Computer Science/ Artificial Intelligence from Yale, and BS in Physics from MIT. His current research priorities include applying service science to study nested, networked holistic service systems, such as cities and universities.

Austeja Trinkunaite
European Policy and Communication Manager, ECDL Foundation

Austeja Trinkunaite is the European Policy and Communication Manager at ECDL Foundation, an international non-profit social enterprise dedicated to raising digital competence standards in the workforce, education and society. The ECDL certification programme has been delivered to more than 14 million people in over 100 countries and 40 languages worldwide. On behalf of ECDL Foundation, Austeja has been working on Europe-wide projects like the Grand Coalition for Digital Jobs and e-Skills for Jobs campaign. Previously she worked on the Grand Coalition project at the European Commission's Directorate General for Communications Networks, Content & Technology. Austeja also worked as a researcher at the Public Policy and Management Institute.

Niels van der Linden
Managing consultant, Capgemini Consulting

Niels van der Linden is a managing consultant for Capgemini Consulting with a background in Public Administration and State Law. His area of expertise is digital transformation in the public sector, and specifically in policy performance and implementation. He has broad experience in managing multi-stakeholder projects for the European Commission as well as national public authorities across Europe (in particular the Netherlands). He is currently responsible for, amongst others, the development and implementation of a European ICT Professional Framework (for DG Growth), as well as the eGovernment Benchmark (for DG CONNECT).

Dr Laurent Zibell PhD
Policy Adviser, industriAll European Trade Union

Dr Laurent Zibell, PhD, is the Policy Adviser at industriAll European Trade Union in charge of the investment goods sector (ICT and mechanical engineering), and of innovation and technology. His 25 year professional experience cover R&D in an electronics firm, consulting and investment in high-tech innovation, and the management of a think-tank. He is member of the French trade union CFDT. He holds MScs in Engineering from École Polytechnique and from Mines Paristech (France), a Masters in Industrial Economics from Unversité Paris 1 Panthéon - Sorbonne (France) and a PhD in innovation economics from Cranfield University (United Kingdom).

BIBLIOGRAPHICAL REFERENCES

American Physics Society (2015). "Fraction of Bachelor's Degrees in STEM Disciplines Earned by Women" (Women's Bachelor's – STEM data, 1966–2015). *http://www.aps.org/programs/education/statistics/womenstem.cfm*

Autor, D H & Dorn, D (2003). "The skill content of recent technological change: an empirical exploration". The Quarterly Journal of Economics.

Autor, D H & Dorn, D (2013). "The growth of low-skill service jobs and the polorization of the US labor market". American Economic Review.

Bada, M & Sasse, A (2014). "Global Cyber Security Capacity Centre: Draft Working Paper – Cyber Security Awareness Campaigns: Why do they fail to change behaviour?"

Bowles, J (2014). "The computerisation of European jobs – who will win and who will lose from the impact of new technology onto old areas of employment?" Bruegel blog

Broadband Commission (2013). "Doubling digital opportunities". *http://www.broadbandcommission.org/documents/working-groups/bb-doubling-digital-2013.pdf*

Bureau of Labor Statistics (2015). "Current Population Survey" (median weekly earnings of full-time wage and salary workers by detailed occupation and sex, household data annual averages).

Business Roundtable & Change the Equation (2014). "Survey on U.S. Workforce Skills: Summary of Findings". http://changetheequation.org/sites/default/files/2014%20BRT-CTEq%20Skills%20Survey%20Slides_0.pdf.

Cedefop (2012). "Preventing skill obsolesences". Briefing note. http://www.cedefop.europa.eu/en/publications-and-resources/publications/9070

Cedefop (2014). "Rising STEMs". *http://www.cedefop.europa.eu/en/publications-and-resources/statistics-and-indicators/statistics-and-graphs/rising-stems*

CEPIS (2012). "eSkills & ICT Professionalism: Fostering the ICT Profession in Europe". *http://cepis.org/professionalism*

Change the Equation (2015). "Vital Signs". *http://changetheequation.org/stemdemand*

Change the Equation (2016). "The Hidden Half". *http://changetheequation.org/hidden-half*

Chui M, Manyika J & Miremadi M (2015). "Four fundamentals of workplace automation". McKinsey Quarterly. *http://www.yourworkplace.ca/wp-content/uploads/2013/08/Four-fundamentals-of-workplace-automation.pdf*

Cisco (2011). "The Internet of Things – how the next evolution of the internet is changing everything". *https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf*

College Board (2015a). "AP Program Participation and Performance Data 2015" (AP Exam Volume Change, 2003-2013). *http://research.collegeboard.org/programs/ap/data/participation/ap-2015*

College Board (2015b). "AP Course Audit (Computer Science and Calculus, 2013-2014". *https://apcourseaudit.epiconline.org/ledger/search.php*

Computer Science Teachers Association (2015). "Running On Empty: The Failure to Teach K–12 Computer Science in the Digital Age, State-by-State Results, Concepts Adoption Rates". *http://runningonempty.acm.org/roemap.html*

CYSPA (2014). "Report D3.1 - Section 6 Cyber Security Related Training and Education". : *http://www.cyspa.eu/files/imagegallery/Reports/CYSPA_D3%201_V2.00.pdf*

Dashja, E & Hüsing, T (2016). "Assessment of e-Leadership Skills Policies, Initiatives and Partnership at European and National Level: Expert Survey Results".

Demirkan, H & Spohrer, J C (2015) "T-Shaped Innovators: Identifying the Right Talent to Support Service Innovation". Research Technology Management.

Donofrio N, Sanchez C & Spohrer J (2010a). "Collaborative innovation and service systems". In Holistic Engineering Education. Springer New York.

Donofrio N, Spohrer J, Zadeh H S (2010b). "Research-driven medical education and practice: A case for T-shaped professionals". MJA Viewpoint.

Dweck, C (2006). "Mindset: The new psychology of success". Random House.

ECDL Foundation (2016). "Perception and Reality. Measuring Digital Skills in Europe". http://www.ecdl.org/PerceptionandReality

empirica (2015a). "e-Leadership – Digital Skills for SMEs".

empirica (2015b). "e-Skills in Europe. Trends and Forecasts for the European ICT Professional and Digital Leadership Labour Markets (2015-2020)".

EurActiv.com (2015). Ansip: Europe 'still has some way to go on digital skills.

European Commission (2010). "e-Skills for Growth and Jobs". *http://ec.europa.eu/growth/sectors/digital-economy/e-skills/index_en.htm*

European Commission (2013). "Women active in the ICT sector". *https://ec.europa.eu/digital-single-market/en/news/women-active-ict-sector*

European Commission (2014). DIGCOMP: a Framework for Developing and Understanding Digital Competence in Europe.

European Commission (2014). "Innovation union competitiveness report 2013". *https://ec.europa.eu/research/innovation-union/pdf/competitiveness_report_2013.pdf*

European Commission (2015). "eLeadership skills for Small and Medium Sized Enterprises". *http://eskills-lead.eu/fileadmin/lead/reports/lead_final_report.pdf*

European Commission (2015). "EU skills panorama 2014 – focus on STEM skills". *http://skillspanorama.cedefop.europa.eu/sites/default/files/EUSP_AH_STEM_0.pdf*

European Commission (2015, 2016). "Human capital: Digital inclusion and skills". Digital Agenda Scoreboards.

European Commission (2016). "Development and implementation of a Framework for the IT profession". Estimations done by IDC and empirica

European Commission (2016). "DigComp 2.0: The Digital Competence Framework for Citizens". Update Phase 1: the Conceptual Reference Model.

European Commission (2016). "Grand Coalition for Digital Jobs." *https://ec.europa.eu/digital-single-market/en/grand-coalition-digital-jobs*

European Commission (2016). Intermediate report "The impact of ICT on job quality: evidence from 12 job profiles" (SMART 2014/0048)

European Commission (2016). "Ten actions to help equip people in Europe with better skills".

European Commission (2016). "How digital is your country?" *http://europa.eu/rapid/press-release_IP-16-384_en.htm*

European Commission (2016). "The digital economy and society index (DESI)". *https://ec.europa.eu/digital-single-market/en/desi*

European Parliament (2015). "Encouraging STEM studies for the labour market".
Study for the Employment and Social Affairs Committee. *http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542199/IPOL_STU(2015)542199_EN.pdf*

European Schoolnet & University of Liege (2013). "Survey of Schools: ICT in Education".

European Schoolnet, Engineering UK, InGenious, Intel (2013). "STEM education: overcoming the challenges in Europe." *http://www.ingenious-science.eu/c/document_library/get_file?uuid=3252e85a-125c-49c2-a090-eaeb3130737a&groupId=10136*

European Schoolnet & InGenious (2014). "A parent's guide to careers in science, technology, engineering and mathematics". *http://www.ingenious-science.eu/c/document_library/get_file?uuid=ff04ce70-ec5f-48c6-9b66-960ef9b3bba0&groupId=10136*

European Schoolnet (2014), "Computing our future. Computer programming and coding – Priorities, school curricula and initiatives across Europe".

European Schoolnet (2015). "Computing our future. Computer programming and coding. Priorities, school curricula and initiatives across Europe".

Eurostat (2016). "Census data". *https://ec.europa.eu/CensusHub2/query.do?step=selectHyperCube&qhc=false*

ETUC (2009). "Resolution on initial and continuous vocational training for a European employment strategy". *https://www.etuc.org/sites/www.etuc.org/files/Resolution_LLL_17-18032009_EN_2.pdf*

ETUC (2010). "Resolution: More investment in lifelong learning for quality jobs". https://*www.etuc.org/sites/www.etuc.org/files/Final_12-EN-LLL-for-quality-jobs_2010_2__2.pdf*

ETUC (2016). "New Skills Agenda: Improving training opportunities for workers in Europe". *https://www.etuc.org/sites/www.etuc.org/files/document/files/etuc_postion_new_skills_agenda.pdf*

Forbes (2016). "Roundup of cloud computing forecasts and market estimates". *http://www.forbes.com/sites/louiscolumbus/2016/03/13/roundup-of-cloud-computing-forecasts-and-market-estimates-2016/#38b62d0d74b0*

Fraunhofer (2016). "Trends in Industrie 4.0". *https://www.fraunhofer.de/content/dam/zv/en/fields-of-research/production/Trends-in-Industrie-40.pdf*

Frey, C B & Osborne, M A (2013). "The future of employment: how susceptible are jobs to computerisation?" Oxford Martin School Working Paper.

GE & Accenture (2015). "Industrial internet insights report 2015". *http://www.ge.com/digital/sites/default/files/industrial-internet-insights-report.pdf*

Goos M, Manning A & Salomans A (2009). "Job polarization in Europe". The American Economic Review.

Government of Canada (2016). Digital Canada 150. Building Digital Skills — By the Most Popular Ideas. *https://www.ic.gc.ca/eic/site/028.nsf/eng/h_00069.html*

Graetz, G & Michaels, G (2015). "Driving digital transformation: new skills for leaders, new role for the CIO". Harvard Business Review Analytic Services Report.

Gütl, C et al (2014). "Attrition in MOOC: Lessons Learned from Drop-Out Students". In Uden L et al. "Learning Technology for Education in Cloud - MOOC and Big Data". Third International Workshop, LTEC 2014, Santiago, Chile. Springer, 2014.

Hansen, M (2010). "DEO CEO Tim Brown: T-Shaped Stars: The Backbone of IDEO's Collaborative Culture: An Interview with IDEO CEO Tim Brown". Chief Executive Magazine. *http://chiefexecutive.net/ideo-ceo-tim-brown-t-shaped-stars-the-backbone-of-ideoae%E2%84%A2s-collaborative-culture/.*

Heitin, L (2016). "Virginia Could Be First State to Require All K-12 Students to Learn Computer Science". Education Week. *http://blogs.edweek.org/edweek/curriculum/2016/04/virginia_could_become_first_state_require_K12_computer_science.html*

Huhman, H (2011). "Skillset vs. Mindset: Which Will Get You the Job?" U.S. News & World Reports Careers. *http://money.usnews.com/money/blogs/outside-voices-careers/2011/08/26/skillset-vs-mindset-which-will-get-you-the-job.*

Hüsing T, Korte W B, Fonstad N, Lanvin B, Cattaneo G, Kolding M, Lifonti R & van Welsum D (2013). "eLeadership: e-Skills for competitiveness and innovation vision, roadmap and foresight scenarios". Empirica Working Paper.

Hüsing T, Korte W B & Dashja E (2015a). "e-Skills and eLeadership skills 2020. Trends and forecasts for the European ICT professional and digital leadership labour market". empirica.

Hüsing T, Dashja E, Gareis K, Korte W B, Stabenow T & Markus P (2015b). "e-Leadership – Digital Skills for SMEs".

International Computer and Information Literacy Study (ICILS) (2014). "Preparing for Life in a Digital Age. The IEA International Computer and Information Literacy Study. International report". Springer Open.

ITU (2015). "ICT facts and figure 2015". *https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf*

ITU (2015b). "Percentage of individuals using the Internet, by gender, latest year available, 2012-2015". ITU World Telecommunication/ICT Indicators database. *www.itu.int/en/ITU-D/Statistics/Documents/statistics/2016/Gender_2012-2015.xls*

ITU (2016). "ICT facts and figures 2016". *http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2016.pdf*

Kearney, C (2015). "Efforts to increase students' interest in pursuing science, technology, engineering and mathematics studies and careers". *http://files.eun.org/scientix/Observatory/ComparativeAnalysis2015/Kearney-2016-NationalMeasures-30-countries-2015-Report.pdf*

Lapowsky, I (2015a). "Obama Has a $100M Plan to Fill the Tech Talent Shortage". Wired Magazine. *http://www.wired.com/2015/03/techhire-initiative/*

Lapowsky, I (2015b). "So, Arkansas Is Leading the Learn to Code Movement". Wired Magazine. *http://www.wired.com/2015/03/arkansas-computer-science/*

Lazowska E, Roberts E & Kurose J (2014). "Tsunami or Sea Change? Responding to the Explosion of Student Interest in Computer Science". Presentation to the NCWIT summit. *http://lazowska.cs.washington.edu/NCWIT.pdf*

Mattern K, Shaw E & Ewing M (2015), "Is AP Exam Participation and Performance Related to Choice of College Major?" College Board. *https://research.collegeboard.org/publications/content/2012/05/info-go-summary-ap-exam-participation-and-performance-related-choice*.

Morello, D (2005). "Versatilist: Gartner Says Technical Aptitude No Longer Enough To Secure Future for IT Professionals". Gartner Press Release.

Moschella, D (2015). "The Emerging Double-Deep Economy". Leading Edge Forum. *https://leadingedgeforum.com/publication/the-emerging-double-deep-economy-2318/*

Nager, A (2014). "Everybody Needs STEM Talent." Innovation Files.

Nager, A & Atkinson, R (2015). "Debunking the Top Ten Arguments Against High-Skilled Immigration". Information Technology and Innovation Foundation. *http://www2.itif.org/2015-debunking-myths-high-skilled.pdf?_ga=1.42898860.847894678.1456315207*

Nager, A & Atkinson, R (2016). "The Case for Improving U.S. Computer Science Education".

National Association of Colleges and Employers (2014). "Salary Survey: Top-Paid Majors for the Class of 2014". *http://naceweb.org/s04162014/top-paid-majors-class-of-2014.aspx*

National Center for Educational Statistics (2014). "Digest of Education Statistics" (bachelor's, master's, and doctor's degrees conferred by postsecondary institutions, by field of study: Selected years, 1970-71 through 2012-13). *http://nces.ed.gov/datalab/tableslibrary/viewtable.aspx?tableid=8856*

OECD (2014). "Talis 2013 Results: An international perspective on teaching and learning". *http://www.oecd-ilibrary.org/education/talis-2013-results_9789264196261-en*

OECD (2015a). "Students, Computers and Learning. Making the Connection". *http://www.oecd.org/education/students-computers-and-learning-9789264239555-en.htm*

OECD (2015b). "New approach needed to deliver on technology's potential in schools". *http://www.oecd.org/education/new-approach-needed-to-deliver-on-technologys-potential-in-schools.htm*

OECD (2015c). "Digital economy outlook, 2015". *http://www.oecd.org/sti/oecd-digital-economy-outlook-2015-9789264232440-en.htm*

Open Mind (2015). "IoT: a fog cloud computing model". *https://www.bbvaopenmind.com/en/iot-a-fog-cloud-computing-model/*

Orihuela, R (2015). "Help Wanted: Black Belts in Data". Bloomberg Businessweek. *http://www.bloomberg.com/news/articles/2015-06-04/help-wanted-black-belts-in-data*

Ridge, J (2013). "Professionalism in the Information and Communication Technology Industry". *http://press.anu.edu.au/apps/bookworm/view/Professionalism+in+the+Information+and+Communication+Technology+Industry/10791/ch02.xhtml*

Stephenson, C (2015). "The Thorny Issue of CS Teacher Certification," Google Research Blog. *http://googleresearch.blogspot.com/2015/07/the-thorny-issue-of-cs-teacher.html*

The White House (2016). "President Obama Announces Computer Science For All Initiative." Press release. *https://www.whitehouse.gov/the-pressoffice/2016/01/30/fact-sheet-president-obama-announces-computer-science-all-initiative-0*

T Summit (2016). *http://tsummit.org/t*

Turkel, D (2015). "New York City's Mayor Will Require All of the City's Public Schools to Teach Computer Science". Business Insider. *http://www.businessinsider.com/mayor-de-blasio-will-require-nyc-schools-to-teach-computer-science-2015-9*

Ulicna, D & Royale, R (2015). "Does the EU need more STEM graduates?" *http://www.teknologisk.dk/_/media/64499_Does%20the%20EU%20need%20more%20STEM%20graduates.pdf*

US News Education (2015). "Best Global Universities for Computer Science." *http://www.usnews.com/education/best-global-universities/computer-science*

UK Parliament (2014-2015). Select Committee on Digital Skills, Report of Session.

Digital Skills and Jobs Coalition

THE e-SKILLS MANIFESTO

Not just in Europe, but around the world, the industrial economy and many of its institutions are beginning to fail. At the same time, the contours of new enterprises, industries and a new civilisation are becoming clear. For this reason, Europe is at a critical juncture, faced as it is with a growing digital capability gap between the demands for digital transformation on the one hand, and the skills, know-how and capability of the workforce on the other. To harness the potential of the digital revolution and to keep pace with global competition, Europe urgently needs to build an eskilled workforce. Working together, industry, education and government have the power to ensure long-term action and success that will deliver jobs, competitiveness and growth.

This Manifesto is a blueprint for making this happen. It is based on a broad cross-section of perspectives and is a must-read for those that have a stake in acquiring, nurturing and retaining eskilled talent in the 21st century.