The 4th Industrial Revolution & the Future of Jobs

Prof. Dr. Nick H.M. van Dam

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The 4th Industrial Revolution & The Future of Jobs
1st edition

ISBN 978-87-403-1883-8

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ABOUT THE AUTHOR

PROF. DR. NICK VAN DAM is full professor CORPORATE LEARNING & LEADERSHIP DEVELOPMENT.

Nick has a passion for people development and is excited about helping individuals to reach their full potential. He strongly believes that lifelong learners are more successful professionally and lead happier, more fulfilling lives. Nick is keenly interested in the emerging insights from the fields of positive development including: Psychology, Sociology, Cognitive Neuroscience, Andragogy and Philosophy. These all have enormous potential to transform people development and to lead to the creation of healthy, humanly sustainable organizations. Nick studied Economics, Business Economics and Pedagogy (Vrije Leergangen – Vrije Universiteit van Amsterdam), Organizational Sociology (Universiteit van Amsterdam) and earned his Doctorate of Philosophy (Ph.D., Human Capital Development).

He started his career in 1986 as a training consultant at (Siemens-) Nixdorf. In 1995, he joined Deloitte Consulting in the USA and served for 19 years in international Consulting/Learning & Development/Human Resources executive roles. Currently he is a partner, Global Chief Learning Officer and Client Advisor at McKinsey & Company. Nick is a visiting professor and advisory board member at the University of Pennsylvania's, PennCLO Executive Doctorate Program. In 2016, he joined the Corporate Advisory Board of edX which is a non-profit organization founded by Harvard and MIT, with a mission to bridge the gap between education and employment.

Nick has (co)authored 17 books and is an internationally known thought leader in Human Capital Development. His latest book: YOU! The Positive Force in Change. Nick has written many articles and has been quoted by *The Financial Times, The Wall Street Journal, Fortune Magazine, Business Week, Harvard Business Review, The India Times, Information Week, Management Consulting, CLO Magazine, and T+D Magazine.* Under the patrons of the European Parliament Federal Ministry of Education & Research, he received 'The 2013 Leonardo European Corporate Learning Award' for *shaping the future of organizational learning and leadership development.*

He is the Founder and Chairman of e-Learning for Kids (www.e-learningforkids.org), a global non-profit foundation that offers free, digital lessons for underserved elementary school aged children worldwide.

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1 DISRUPTION AHEAD

I am proud to be the second generation of my family who has worked in the township 'Breukelen – Nijenrode'. My great-great-great grandfather Matijs van Dam (1763–1823) who lived about 200 years ago, was a so called *day labourer* (in Dutch *dagloner*) and was paid for each day that he worked in agriculture. In the Netherlands today, we would have called him a *zzp-er* or in English a contractor or free agent. Matijs grew up in a largely agricultural society. Around 1810 in the Netherlands, an estimated 45% of a population of 2 million people worked in agriculture. The Netherlands had been one of the wealthiest modern economies of the world, but due to a crippling public debt and geo-political factors it lost this position between 1800–1850.

FIGURE 3: NYENRODE AT THE TIME OF MATIJS VAN DAM (1763–1824)
Source: Jacobus Schijnvoet

Matijs lived during a time of significant change. He was the witness of six tumultuous historical stages of governance, including:

- De Republiek van de Zeven Verenigde Nederlanden (1588–1795);
- De Bataafse Republiek (1795–1801)
- Het Bataafs Gemenebest (1801–1806)
- Het Koninkrijk Holland (1806–1810)
- Het Eerste Franse Keizerrijk (1810–1813)
- Het Koninkrijk der Nederlanden (1813/1815–today)

Relatively shortly after the establishment of the Kingdom of the Netherlands, Matijs also experienced a development that we would have called *Bexit*, when in 1830 Belgium separated from the Kingdom of the Netherlands.

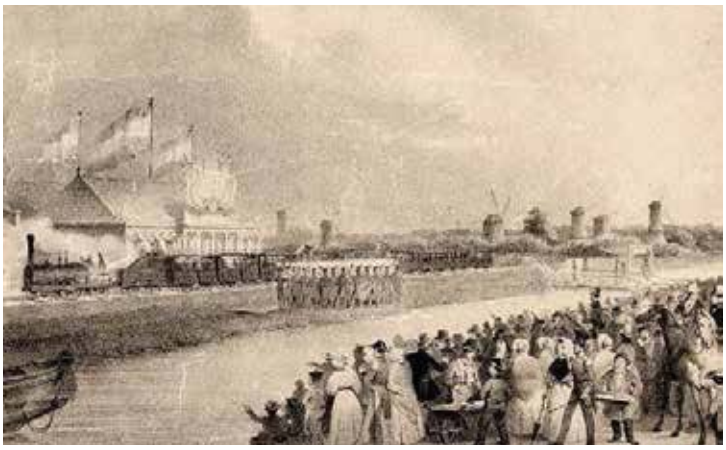

FIGURE 4: THE FIRST INDUSTRIAL REVOLUTION: MECHANIZATION & STEAM POWER

Matijs lived at the beginning of the *First Industrial Revolution in Britain* (est. 1760–1840), which spread internationally.

This period was driven by technology inventions, particularly the steam engine, which improved the way that machines could be operated. A strategic application of the steam engine was the steam locomotive which was invented in 1804. The first railway line opened in the Netherlands in 1839 and the expansion of the railway net was another motor behind industrialization. The mechanization of agriculture resulted in a growth of a number of new factories for example: sugar factories, potato factories, flour factories, and strawboard factories. Agriculture continued to be the biggest economic sector in the Netherlands during the 19th century. However the industrialization also fueled the rise of other industries such as the textile industry, machine industry, leather-shoe industry, and the cigar industry, to name a few. And these developments demanded new skill sets from the labourers.

A consequence of the First Industrial Revolution in the Netherlands was that handmade crafts businesses could not compete with the products from the factories and closed down. Former craft workers (including women and children) tried to find jobs at factories. Thus, the supply of labour exceeded the demand which resulted in very low wages for long hours of work. And this produced a growing gap between the rich and the poor.

FIGURE 5: THE SECOND INDUSTRIAL REVOLUTION:
MASS PRODUCTION & ASSEMBLY LINE
Source: Movie *Modern Times*, Charlie Chapin, 1936.

The Second Industrial Revolution (1870–1914), also known as the Technological Revolution started in the final third of the 19th century, when new technologies brought mass production and rapid industrialization accompanied by the introduction of assembly lines and electrification.

Many more factories were built during the Second Industrial Revolution and new jobs were created for people to work on machines. However, existing work was replaced as well. For example, agriculture machines increasingly replaced the work formerly done by people and animals.

Workers in factories experienced a challenging life. They typically worked 10 hours a day, 6 days a week, and the working conditions were often unsafe and most work was drudgery. In the famous movie *Modern Times* (1936), Charlie Chaplin portrays the manic pace of the factory worker on an assembly line. The film well depicts the employment conditions that were created by the Second Industrial Revolution.

FIGURE 6: THE THIRD INDUSTRIAL REVOLUTION: COMPUTER & AUTOMATION
Source: picture Steve Jobs and Steve Wozniak

The Third Industrial Revolution (1960–1990) brought mainframe computers (1960), personal computing (1970s and 1980s), and the Internet (1990s). This revolution altered the interaction between individuals and companies. Technological advancement placed pressure on the traditional middle class who worked in *transaction* jobs. For example, the following jobs declined between 1970–2010 because of automation: general clerks (-37%); bookkeeping jobs (-43%); secretaries (-59%); typists (-80%); and telephone operators (-86%).[2] On the other hand, a lot of non-transactional and non-production jobs were created that required complex problem solving skills, significant experience, and specific contextual knowledge, e.g. software developers, computer designers, pc network specialists, printer technicians, and IT consultants.

FIGURE 7: THE FOURTH INDUSTRIAL REVOLUTION: CYBER PHYSICAL SYSTEMS
Source: www.jllrealviews.com.

Today, we are at the beginning of the Fourth Industrial Revolution (*2012–*), which can be described as the advent of "cyber-physical systems" involving entirely new capabilities for people and machines. A cyber-physical system can be defined as a mechanism controlled or monitored by computer-based algorithms, tightly integrated with internet and its users. This revolution is fueled by smaller and more powerful sensors, the mobile internet, machine learning, and artificial intelligence.

The Fourth Industrial Revolution was the theme of the 2016 World Economic Forum (WEF) in Davos. Professor Klaus Schwab, the founder and executive chairman of the WEF, has published a book on this topic.

Some people refer to this revolution as a combination of Industry *4.0* and Smart Services. Others combine the trends of the Third and Fourth Industrial Revolution and continue to call it the Third Industrial Revolution or the Digital Revolution.

Schwab (2016) identified three reasons how the Fourth Industrial Revolution is different from the Third Industrial Revolution:

- *Velocity* – This revolution is exponential rather than linear.
- *Breadth and depth* – It builds on the Third Industrial Revolution and combines multiple technologies that are leading to unprecedented paradigm shifts in the economy, business and society.
- *System impact* – It involves the transformation of entire systems, across and within countries, companies, industries and society as a whole.

The Fourth Industrial Revolution is driven by advancements in technologies that have a significant potential to cause disruption. Over history we have seen that technological breakthroughs are speeding up.

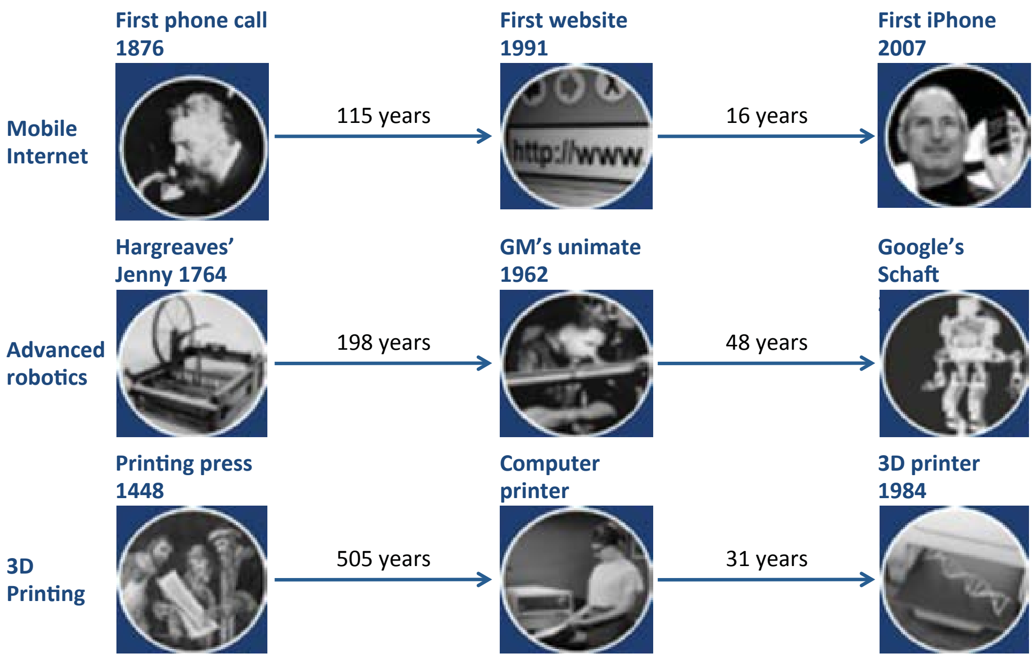

FIGURE 8: THE BREAKTHROUGH OF TECHNOLOGIES IS SPEEDING UP
Source: McKinsey Global Institute analysis, 2016.

The adoption of new technologies is also accelerating. For example, the time it took for an invention to reach 50 million users globally was for radio 38 years, TV (13 years), iPod (4 years), Internet (3 years), Facebook (1 year), Twitter (9 months), Angry Birds (35 days) and Pokémon GO (19 days).[3]

McKinsey Global Institute (2013) researched and identified twelve potential economically disruptive technologies.

TECHNOLOGY	ILLUSTRATED GROUPS, PRODUCTS AND RESOURCES THAT COULD BE IMPACTED
Mobile Internet Increasingly inexpensive and capable mobile computing devices with Internet connectivity	**4.3 billion** People remaining to be connected to the Internet, potentially through the mobile Internet. **1 billion** Transaction and interaction workers, nearly 40% of the workforce
Automation of Knowledge Work Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments	**230+ million** Knowledge workers, 9% of global workforce **1.1 billion** Smartphone users, with the potential to use automated digital assistance apps
The Internet of Things Networks of low cost-sensors and actuators for data collection, monitoring, decision making, and process optimization	**1 trillion** Things that could be connected to the Internet across industries such as manufacturing, health care, and mining **100 million** Global machine to machine device connections across sectors such as transportation, security, health care, and utilities
Cloud Technology Use of computer hardware and software resources delivered over a network or the Internet, often as a service	**2 billion** Global users of cloud-based email services like Gmail, Yahoo, and Hotmail **80%** North American institutions hosting or planning to host critical applications on the cloud
Advanced Robotics Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augmented humans	**320 million** Manufacturing workers, 12% of global workforce **250 million** Annual major surgeries
Autonomous and Near-autonomous Vehicles Vehicles that can navigate and operate with reduced or no human intervention	**1 billion** Cars and trucks globally **450.000** Civilian, military, and general aviation aircraft in the world
Next-generation of Genomics Fast, low cost gene sequencing, advancing big data analytics, and synthetic biology	**26 million** Annual deaths from cancer, cardiovascular disease, or type 2 diabetes. **2.5 billion** People employed in agriculture
Energy Storage Devices or systems that store energy for later use, including batteries	**1 billion** Cars and trucks globally **1.2 billion** People without access to electricity
3D Printing Additive manufacturing techniques to create objects by printing layers of material based on digital models	**320 million** Manufacturing workers, 12% of the global workforce. **8 billion** Annual number of toys manufactured globally

TECHNOLOGY	ILLUSTRATED GROUPS, PRODUCTS AND RESOURCES THAT COULD BE IMPACTED
Advanced Materials Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality	**7.6 million** tons Annual silicon consumption 45,0000 metric tons Annual global carbon fibre consumption
Advanced Oil and Gas Exploration and Recovery Exploration and recovery techniques that make extraction of unconventional oil and gas economical	**22 billion** Barrels of oil equivalent in natural gas produced globally. **30 billion** Barrels of crude oil produced globally
Renewable Energy Generation of electricity from renewable sources with reduced harmful climate impact	**21,000** TWh Annual global electricity consumption **13 billion** tons Annual CO_2 emissions from electricity generation, more than from all cars, trucks and planes

In 2016, The World Economic Forum published the top technological drivers of change including the expected timeframe of impact.[4]

The list overlaps significantly with the technologies mentioned before and includes:

1. Mobile Internet and cloud technology (2015–2017)
2. Advances in computer power and big data (2015–2017)
3. New energy supplies and technologies (2015–2017)
4. The Internet of Things (2015–2017)
5. Crowdsourcing, the sharing economy and peer-to-peer platforms (impact felt already)
6. Advanced robotics and autonomous transport (2018–2020)
7. Artificial intelligence and machine learning (2018–2020)
8. Advanced manufacturing and 3D printing (2015–2017)

Advanced materials, biotechnology and genomics (2018–2020) It is important to understand the timing at what time technology applications will have a major impact. These tipping points are *"moments when specific technology hits mainstream society shaping the future digital and hyper-connected world."*[5]

The list of expected tipping points in application of different technologies that are expected to occur by 2025 include, for example (WEF, 2015):

PREDICTION	LIKELIHOOD THAT THIS WILL HAPPEN AS A %
10% of people wearing clothes connected to the Internet	91.2%
90% of people having unlimited and free storage of data	91.0%
1 trillion sensors connected to the Internet	89.2%
The first robotic pharmacist in the USA	86.5%
10% of reading glasses connected to the Internet	85.5%
5% of consumer goods printed in 3D	81.1%
90% of the population using smartphones	90.7%
Driverless cars equalling 10% of cars on US roads	78.2%

New technologies can have an impact on economic growth, as well as having the capacity to disrupt. The early 20th century economist Joseph Schumpter (1883–1950) studied the formation and bankruptcy of companies in Europe and the United States. He concluded that significant advances in industries are accompanied by a process of *creative destruction*, which shifts profit pools, rearranges industry structures, and replaces incumbent businesses.[6] Schumpeter believed that "*economic progress, in capitalist society, means turmoil.*" Professor Richard Foster, a professor at Yale and a former McKinsey consultant, applied Schumpeter's theory to modern practices of management and innovation in his book *Creative Destruction* (2001).

Foster studied the lifespan of the most prestigious companies listed on the Standard & Poor top 500 list.

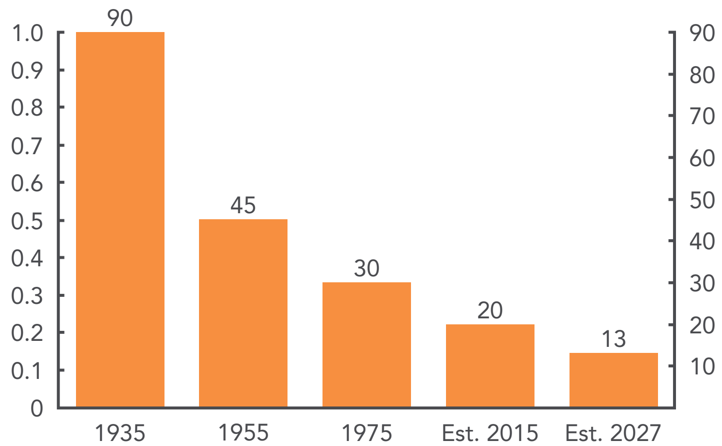

FIGURE 9: COMPANIES' LIFESPAN HAS DECLINED DRAMATICALLY OVER TIME
Source: Foster, 2012

He noticed that the lifespan of companies has dramatically declined from 90 years in 1935 to 18 years in 2011. He predicts that the lifespan of an S&P 500 company in 2027 will be 13 years or less. This doesn't mean necessarily that all companies will land in the graveyard in 13 years, but that they might split, merge or be acquired and disappear from the S&P 500.

According to Foster, (2001) the lifespan of a corporation is determined by balancing three management imperatives: 1) running operations effectively; 2) creating new businesses which meet customer needs; and 3) shedding business that once might have been core but no longer meets company standards for growth and return.

The challenge is the dilemma that corporations need to innovate in order to create new businesses, but that investment in innovation often conflicts with (short-term) operational effectiveness. The outcome is that large corporations are not aligning themselves fast enough with a changing external environment and slowly fall behind and disappear.

The implication for employees is that that concept of *lifetime employment* or just working for a few companies doesn't exist anymore. Furthermore, the Fourth Industrial Revolution will dramatically change the skills required of the workforce. People need to prepare themselves to work for a number of companies during their careers, and need to make sure that they acquire skillsets and experiences that are valuable in the market.

The greatest difference between the Fourth Industrial Revolution and the prior Third Industrial Revolution is the ubiquitous involvement of everyone and everything, and the velocity of change.

2 THE FUTURE OF JOBS

The best way to predict the future is to invent it.

– Alan Kay

"There's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots and other digital technologies are acquiring these skills and abilities at an extraordinary rate."[7]

– Erik Brynjolfsson and Andrew McAfee, MIT Initiative on the Digital Economy

Many of the new technologies are disrupting labour markets. Advancements in technologies and new business models are expected to have a profound impact on existing and future jobs, from job creation to job displacement. This has also happened during the First, Second, and Third Industrial Revolution where jobs were eliminated in one sector (such as agriculture) and new work was created in other sectors such as manufacturing and services.

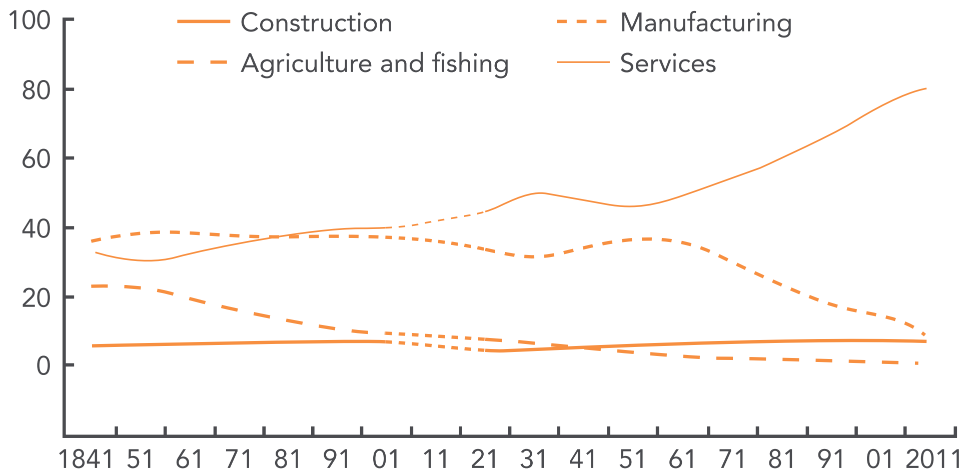

FIGURE 10: JOBS COME AND GO: SHARE OF EMPLOYMENT IN BRITAIN BY INDUSTRY, %
Source: ONS & economist.com, 2016

Internationally, jobs are not only threatened by technologies such as robotics, but also by declining demand in many industries along with outsourcing (domestic or international). For example, in 2015 about 2.3 million jobs in the US were outsourced internationally.[8] Some researchers claim that outsourcing can help retain jobs or even create new ones in the country of origin for example jobs with a higher level of complexity.[9]

During the Great Recession (2008–2010) 8,792.000 jobs were lost in the private sector in the US and 8,709.000 new jobs have been gained between 2010 and 2014. However, the middle-and higher income jobs were replaced by low-income jobs.

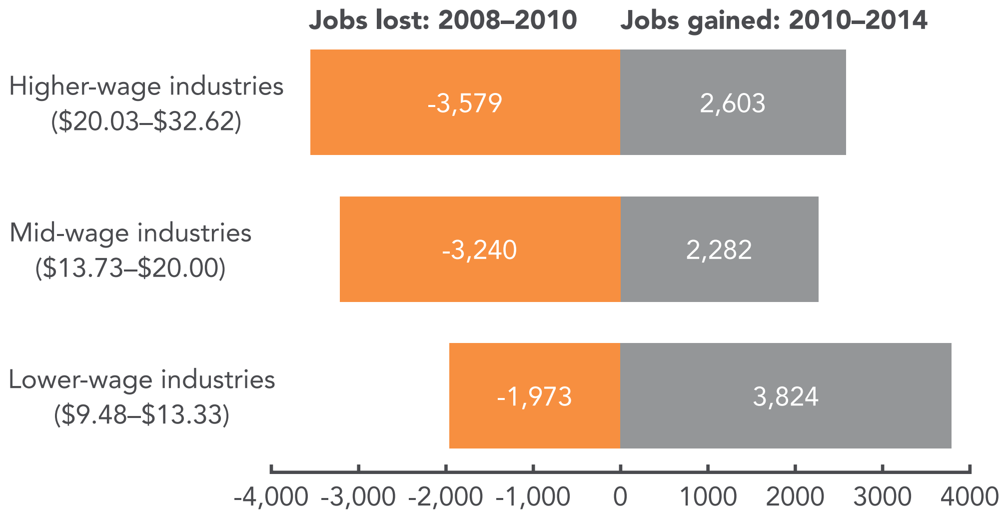

FIGURE 11: NET CHANGE IN PRIVATE-SECTOR EMPLOYMENT (IN THOUSANDS)
Source: Nelp.org, 2015.

Historically, different economists have been concerned about the impact of technology on the workforce. The economist David Ricardo (1772–1823) commented that the deployment of machinery would have a devastating impact particularly on the labouring class.

John Maynard Keynes (1883–1946) predicted widespread technology-driven unemployment "*due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour*."[10]

The new generation of technologies which are being deployed in the Fourth Industrial Revolution will have the potential to threaten jobs which previously were not impacted by technologies. A study from Oxford University (2013) predicts that 47% of all jobs in the United States have a 70% probability of disappearing over the next 2 decades.

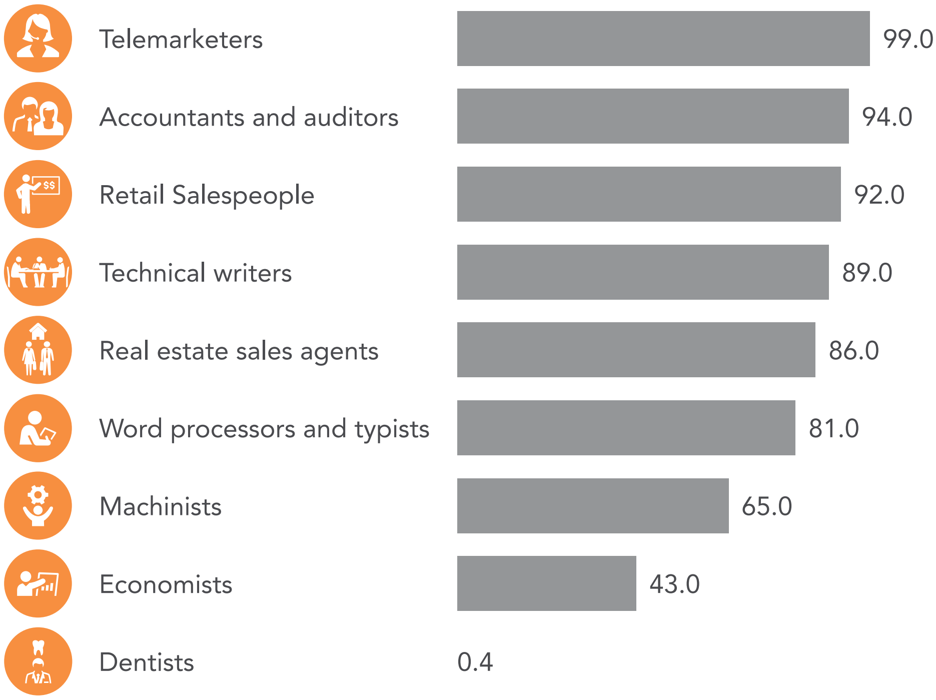

FIGURE 12: HOW VULNERABLE ARE JOBS TO COMPUTERIZATION
Source: Frey & Osborne, 2013.

Other studies (Bowles, 2014) finds the share of jobs that are vulnerable to automation in Europe ranges between 45% to more than 60%, with the Southern European workforce facing the highest exposure to potential automation. Employers in the Netherlands expect that 22% of existing jobs will be automated over the next three decades (ING, 2016). However, Dutch employees are more sombre and anticipate that 37% of jobs will be displaced by 2046. An OECD report[11] is more optimistic and predicts that just 10% of the work in the Netherlands has a high risk of being automated. The OECD researchers claim that the threat from technological advances seems less because they take into account the heterogeneity of workers' tasks within occupations, compared to using the occupation-based approach. A 2015 McKinsey Global Institute study[12] also looked at job activities versus occupations. They concluded that current demonstrated technologies could automate 45% of the *activities* people are paid to perform and that about 60% of all occupations could see 30% or more of their activities automated. The OECD signals a very high chance of automatability of jobs now held by less skilled people and people with lower incomes.

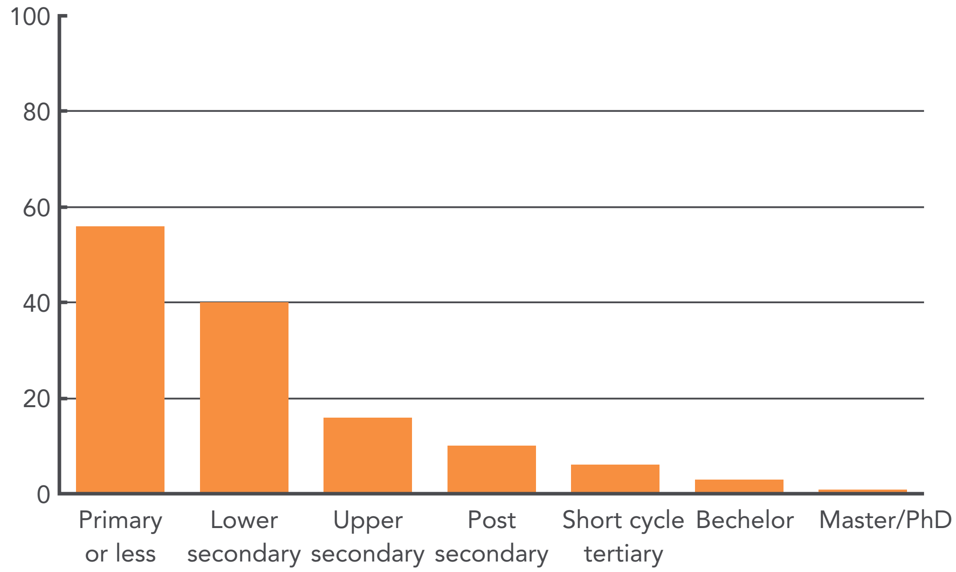

FIGURE 13: SHARE OF WORKERS AT HIGH RISK OF AUTOMATABILITY BY LEVEL OF EDUCATION
Source: OECD, 2016

The World Economic Forum conducted research (2015) of the shorter- term impact of automation and digitization on global employment. Their research among 15 major developed and emerging economies (excluding China) suggests that the global net employment outlook 2015–2020 will be negatively impacted by more than 5.1 million jobs.

Net employment will decrease by 7.1 million jobs in a number of job families while the WEF expect an increase of 2 million jobs among other job families.

NET EMPLOYMENT OUTLOOK BY JOB FAMILY, 2015–2020 (15 COUNTRIES, EXCEPT CHINA)

Employees (thousands, all focus countries)

-4,759	Office and Administrative	+492	Business and Financial Operations
-1,609	Manufacturing and Production	+416	Management
-497	Construction and Extraction	+405	Computer and Mathematical
-151	Arts, Design, Enterainment, sports and Media	+339	Architecture and Engineering
-109	Legal	+303	Sales and Related
-40	Installation and Maintenance	+66	Education and Training

Source: WEF, 2016

The McKinsey Global Institute (2016) conducted a detailed analysis[13] of 2,000 plus work activities for more than 800 occupations in the US. They examined the technical feasibility of occupational activities being automated using currently demonstrated technologies.

Managing others	Appling expertise	Stakeholder interactions	Unpredictable physical work	Data collection	Data processing	Predictable physical work
9%	18%	20%	25%	64%	69%	78%
Time spent in all US occupations, %						
7	14	16	12	17	16	18

FIGURE 14: TYPES OF ACTIVITIES THAT HAVE THE TECHNICAL POTENTIAL TO BE AUTOMATED
Source: McKinsey Global Institute, 2016

Occupations are made up of different types of activities which vary in their potential of becoming automated. Also, the total time that people spend on activities in different occupations varies. About one-fifth (18%) of the time spent in the US workplace includes predictable physical activities, which are highly vulnerable for automation. There are also significant differences by sector, e.g. performing physical activities represents one third of people's time in manufacturing. About 73% of activities workers perform in food services and accommodation industry have the potential for automation. Think about machines that can bake hamburgers, self-service ordering and robotic servers. In finance and insurance – about 50% of time is devoted to collection and processing data where the potential for automation is high. It is anticipated that there will be significant changes in employment by industry and industry sub-sector. Citigroup (2016), an American multinational investment bank, is forecasting that US and European Banks will cut staff by more than 30% over the next decade. Healthcare's potential for automation is about 36%, but this is much lower for the professionals whose daily activities require expertise and direct contact with patients.

In conclusion – the research reports indicate that the advancement of technologies will have an impact on the displacement of jobs. However, they differ in percentage of replacement (e.g. from 10% to about 49%), changes by economies (e.g. the Netherlands versus Japan), the pace of impact (short-term versus medium-, or longer-term) and entire jobs versus specific activities by job.

There are many factors which predict whether jobs can be automated including: the technical feasibility; the costs of developing and utilizing the hardware and software for automation; the costs of labour and related supply-and-demand dynamics; the benefits of automation beyond labour substitution including higher levels of output, better quality, fewer errors; and regulatory and social acceptance issues. However, it is expected that if current technology continues in its exponential development, there will be an increase in the potential of automation.

3 CHANGE IN SKILLS

Most of the technologies discussed in the prior sections, have already had a significant impact on employee skills. This is particularly true in the case of the mobile internet, cloud technology, processing power, big data, new energy supplies and technologies, the sharing economy, and crowdsourcing. Other technologies are expected to have a more profound impact between 2018–2025 including: the Internet of Things; robotics; autonomous transport; artificial intelligence; advanced manufacturing; 3D printing; advanced materials and biotechnology.

The acceleration of technology will shorten the shelf life of existing knowledge, expertise and skills, and require different competencies which need to be developed. For example, as specific activities of jobs become automated, people will be required to focus on new activities which require different skills. Technological skills will experience the fastest change.

An estimate of 50% of subject knowledge obtained during the first year of a four year technical degree program is outdated by the time of graduation[15]. Beyond technical skills or hard skills, employers are equally concerned about work-related practical skills like content creation or judging the relevance and purpose of information, which are also likely to be subject to significant change in the coming years.

THE IMPORTANCE OF WORK-RELATED SKILLS

SKILLS FAMILY	GROWING SKILLS DEMAND IN 2020	% OF JOBS WHICH REQUIRE THIS SKILL BY 2020
Cognitive Abilities	52%	15%
System Skills	42%	17%
Complex Problem Solving	40%	36%
Content Skills	40%	10%
Process Skills	39%	18%
Social Skills	37%	19%
Resource Management Skills	36%	13%
Technical Skills	33%	12%
Physical Abilities	31%	4%

Source: WEF, 2016

Over one third of jobs demand *complex problem solving* as one of the core skills. *Social skills*, which include coordination with others, emotional intelligence, service orientation, negotiation and persuasion – are required in one out of 5 jobs. *Cognitive skills*, such as creativity and mathematical reasoning see the fastest growth in demand. These skills are needed in 15% of the jobs.

The top 10 skills in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgement and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

Creativity will become one of the top three skills workers need. With the avalanche of new products, new technologies, and new ways of working, people need to become more creative in order to benefit from these changes.

It is estimated that by 2020, more than *a third* of the desired core skillsets of occupations will be comprised of skills that are not yet deemed crucial for the job today (WEF 2016).

Finally, the Fourth Industrial Revolution is also referred to as *The Digital Age* which necessitates that people develop digital competencies. The EU argues that *"there is a need for digital skills for nearly all jobs where technology complements existing tasks. In the near future 90% of jobs will require some level of digital skills"*.

In 2015, almost half (44.5%) of the EU population aged 16–74 had insufficient digital skills to participate in society and the economy. In the workforce (employed and unemployed), this figure is more than a third (37%). Not having the necessary digital competencies has direct consequences for employability.

In the EU, 42% of people with no computer skills are inactive in the labour market and many people are at risk of social exclusion and most likely deprived from e-government, e-health, e-banking, etc.[18]

The EU has developed a Digital Competence Framework which is a tool to improve citizens' digital competence, help policy makers to formulate policies that support digital competence building, and to plan education and training initiatives to improve digital literacy.[19]

The Digital Competence Framework includes 5 competency areas, 21 competencies, and descriptors of three proficiency levels (basic, intermediate and proficient).

Competence areas	Competencies	
1. Information	1.1 Browsing, searching, and filtering information 1.2 Evaluating information	1.3 Storing and retrieving information
2. Communication	2.1 Interaction through technologies 2.2 Sharing information and content 2.3 Engaging in online citizenship	2.4 Collaborating through digital channels 2.5 Netiquette 2.6 Managing digital identity
3. Content creation	3.1 Developing content 3.2 Integrating and re-elaborating	3.3 Copyright and Licences 3.4 Programming
4. Safety	4.1 Protecting devices 4.2 Protecting data and digital identity	4.3 Protecting health 4.4 Protecting the environment
5. Problem solving	5.1 Solving technical problems 5.2 Expressing needs and identifying technological responses	5.3 Innovating, creating and solving using digital tools 5.4 Identifying digital competence gaps

FIGURE 15: OVERVIEW OF A DIGITAL COMPETENCE FRAMEWORK
Source: EU, 2014.

4 NEW JOBS

The *Fourth Industrial Revolution* requires a workforce with a wide range of deep knowledge and skills which can easily transition into new jobs.

It is an interesting observation that 65% of children who are currently admitted into elementary school might ultimately work in jobs that don't exist today (WEF 2016). This illustrates that it is unknown what future jobs will look like.

A number of today's jobs did not exist 10 years ago. *App Developer* became a job after the introduction of the first smartphones in 2007. Currently over 5.7 million apps are available in different app stores (Statistita, 2016). The growth of social media applications and users has led to the role of *Social Media Manager*. Uber was founded in 2009 and now we have people who have the profession of *Uber Drivers*. Google is investing a lot in autonomous cars and they are recruiting *Driverless Car Engineers*. Since 2000, cloud computing has come into existence. Today, *Cloud Computing Specialist* is a fast growing profession. Examples of other new roles include: *Big Data Analyst/Specialist; Sustainability Manager; YouTube Content Creator; Drone Instructor and Operators; Millenium Generation Expert; Digital Marketing Specialist; Search Engine Optimizer; User Experience Specialist; 3D Designer; Offshore Windfarm Engineer; Web Analyst; Green Deal Assessor; Mobile Service Technician;* and *Robot Coordinator,* among others.

Over the next decade a number of new jobs will emerge. Futurists have developed a list with new jobs that will emerge by 2025 including (Fast Company 2016): *Virtual Reality Experience Designer; Professional Triber (freelance professional manager who specializes in putting teams together for very specific projects); Urban Farmer; End of Life Planner; Remote Health Care Specialist;* and *Smart-Home Handy Person*, among others.

The accelerating growth of new professions related to and driven by the introduction of new technologies has enormous implications for learning.

BOOKS FROM THE AUTHOR

There is no friend as loyal as a book

– Ernest Hemingway

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