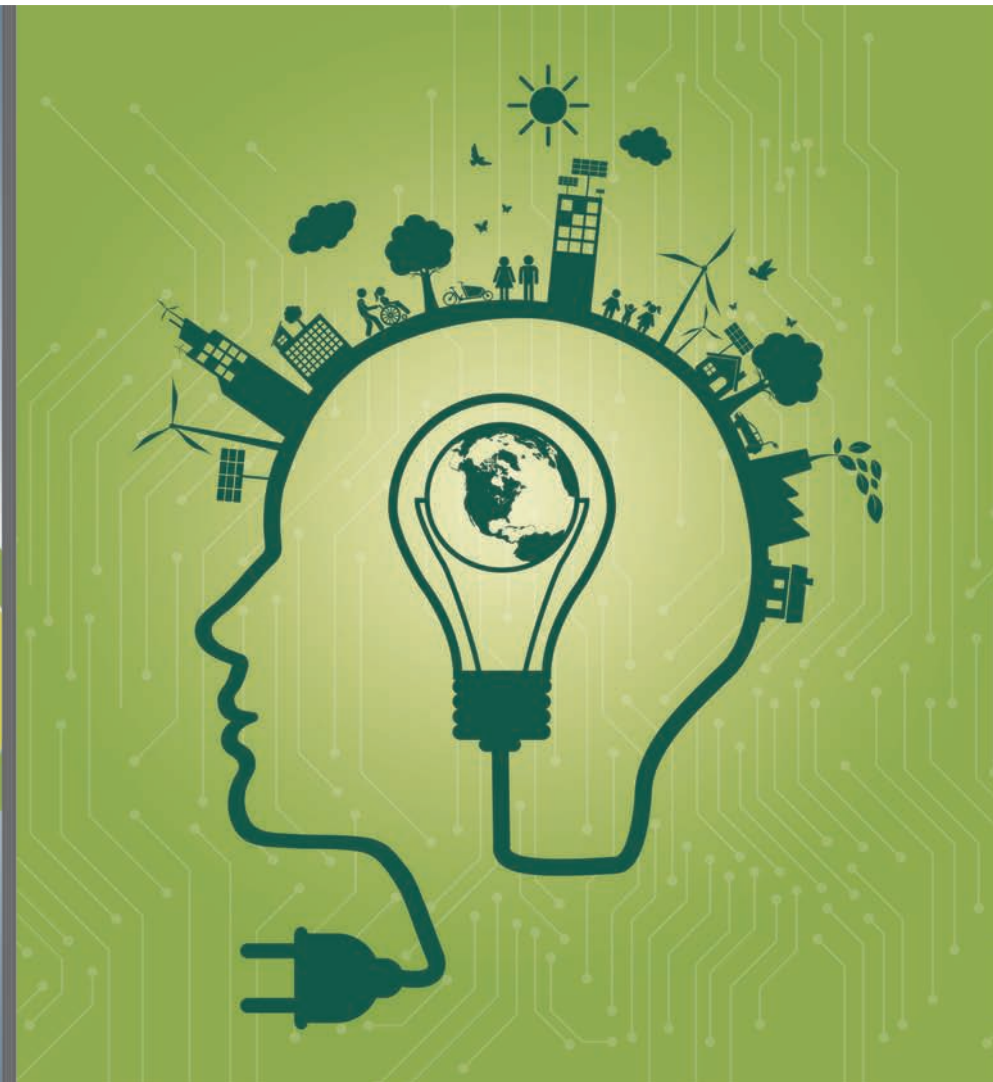# OECD Skills Outlook 2023

SKILLS FOR A RESILIENT GREEN AND DIGITAL TRANSITION

OECD

OECD Skills Outlook 2023

2023

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OECD

BETTER POLICIES FOR BETTER LIVES

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Foreword

Climate change and policy to combat it, as well as digital transformation, are the defining challenges of our time. The urgency to address climate change has never been more apparent. The consequences of rising temperatures are profound and unforgiving. Extreme weather events, raging wildfires, biodiversity loss, natural disasters and the resulting food and water insecurity are becoming increasingly commonplace. These changes are not isolated. They trigger a domino effect of economic disruption, adverse health effects, heightened conflict and forced migration. At the same time, progress in artificial intelligence (AI) and, in particular, the onset of generative AI is such that, in some areas, its output has become indistinguishable from that of humans, and in several domains, AI's capabilities are well beyond what humans can do. The AI revolution is redefining our workplaces, societies and knowledge exchange mechanisms. While AI systems bear the promise of supporting scientific discoveries that could enhance the health, productivity and well-being of many, they could also challenge many jobs and even be used to spread false and misleading information, eroding public trust, threatening security and social cohesion.

If societies are to halt environmental destruction and harness the potential of AI and robotics effectively, they must fundamentally strengthen initial education systems, provide upskilling and reskilling opportunities for adults over the life course and ensure that skills are effectively mobilised. Investments in skills are critical to building a resilient green and digital transition.

However, so far, the speed of environmental and digital transformations is outpacing the rate of change in our education and skills policies and their capacity to respond to emerging needs in society and labour markets. As new job profiles and skills requirements emerge, too few adults in OECD countries participate in the formal or non-formal learning necessary to meet these new requirements. This hampers the ability of workers to upskill and reskill, limiting their opportunities to reallocate from sectors and occupations that shrink into sectors that grow as a result of efforts to green the economy. It also limits their ability to strengthen the skills they will need to work alongside new technologies and make the most of potential productivity gains. At the societal level, lack of participation in formal or non-formal learning limits the talent pool needed to sustain the twin transition.

A key to building resilience in the face of environmental challenges and technological transformations is to empower individuals through investments in skills. Skills alone, however, do not guarantee meaningful action. Attitudes and dispositions, which are in large part shaped through education and training, play a crucial role in motivating individuals to use their skills for the betterment of society. Unfortunately, we see disparities in attitudes and dispositions that mirror inequalities in skills proficiency. Socio-economically disadvantaged young people are particularly vulnerable in this regard, and addressing this gap must become a priority for educators and policy makers alike.

This edition of the Skills Outlook brings a range of new, important insights into changes in the demand for skills resulting from the green and digital transition and the role skills policies play in ensuring resilience. Although it is important not to underestimate the challenges brought about by this twin transition, it is equally important not to underestimate societal capacity for innovation and adaptation. An important lesson that can be learnt from the COVID-19 pandemic is that societies have the capacity to adapt faster and to a larger degree than previously imagined. The ability to adapt will continue to matter as societies face

unprecedented disruptions. Whether the greening of jobs and proliferation of generative AI manifest as a societal challenge or opportunity to enhance well-being rests on policy makers' and leaders' ability to exercise foresight and leadership, with the consideration of ethics, equity and the advancement of social and economic well-being at the forefront of policy making.

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Reader's guide

Calculation of OECD and EU averages

The OECD averages include only OECD countries. Similarly, EU averages include only EU member states and are calculated as unweighted averages. OECD and EU averages are calculated for member countries with available data, and the number of countries which are part of the averages can differ. OECD and EU averages are calculated based on the OECD and EU member countries presented in the respective figure or table, with all data accessible via the OECD's StatLinks service.

In Chapter 6, "Empowering through health literacy: Skills to navigate health information and make informed decisions", data from the European Health Literacy Population Survey 2019-2021 (HLS19) are used where 15 OECD countries participated and refer to the OECD average in this chapter as "HLS19 OECD average".

Methodology and datasets

Detailed explanations of the methodology, analytical approach, and databases used in this report are available in the following working papers:

Chapter 2

Asai, K., F. Borgonovi and S. Wildi (2022), "Understanding how economic conditions and natural disasters shape environmental attitudes: A cross-country comparison to inform policy making", *OECD Social, Employment and Migration Working Papers*, No. 281, OECD Publishing, Paris, https://doi.org/10.1787/8e880ea2-en.

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Borgonovi, F., O. Brussino, H. Seitz, A. Bertoletti, F. Biagi, A. Bitat, Z. Karpinski and M. Montanari (2022), "Young people's environmental sustainability competence: Emotional, cognitive, behavioural, and attitudinal dimensions in EU and OECD countries", *OECD Social, Employment and Migration Working Papers*, No. 275, OECD Publishing, Paris, https://doi.org/10.1787/1097a78c-en.

Chapter 3

Borgonovi. F., E. Lanzi, H. Seitz, R. Bibas, J. Fouré, H. Plisiecki and L. Atarody (2023), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", *OECD Social, Employment and Migration Working Papers*, No. 297, OECD Publishing, Paris, https://doi.org/10.1787/6c16baac-en.

Chapter 4

Asai, K., F. Borgonovi and S. Wildi (2022), "Understanding how economic conditions and natural disasters shape environmental attitudes: A cross-country comparison to inform policy making", *OECD Social, Employment and Migration Working Papers*, No. 280, OECD Publishing, Paris, https://doi.org/10.1787/8e880ea2-en.

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Horvath, D. and F. Borgonovi (2022), "Global warming, pollution and cognitive developments: The effects of high pollution and temperature levels on cognitive ability throughout the life course", *OECD Social, Employment and Migration Working Papers*, No. 269, OECD Publishing, Paris, https://doi.org/10.1787/319b9a1f-en.

Chapter 6

Thomas Link, Robert Griebler, Peter Nowak, Christa Straßmayr and Jürgen Pelikan (M-POHL network, for the HLS19 Consortium) provided the analysis for this chapter.

The HLS19 Consortium of the WHO Action Network M-POHL (2021), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, Austrian National Public Health Institute, Vienna, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

Chapter 7

Borgonovi, F., J. Hervé and H. Seitz (2023), "Not lost in translation: The implications of machine translation technologies for language professionals and for broader society", *OECD Social, Employment and Migration Working Papers*, No. 291, OECD Publishing, Paris, https://doi.org/10.1787/e1d1d170-en.

Marconi, G., L. Vergolini and F. Borgonovi (2023), "The demand for language skills in the European labour market: Evidence from online job vacancies", *OECD Social, Employment and Migration Working Papers*, No. 294, OECD Publishing, Paris, https://doi.org/10.1787/e1a5abe0-en.

Chapter 8

Borgonovi, F., F. Calvino, C. Criscuolo, J. Nania, J. Nitschke, L. O'Kane, L. Samek and H. Seitz (2023), "Emerging trends in AI skill demand across 14 OECD countries", *OECD Artificial Intelligence Papers*, No. 2, OECD Publishing, Paris, https://doi.org/10.1787/7c691b9a-en.

Acronyms and abbreviations

The following are the main abbreviations and acronyms cited in the report.

Abbreviation/acronym	Full description
AI	Artificial intelligence
AWS	Amazon Web Services
BLI	Better Letter Initiative
CAD	Computer-aided design
CAM	Computer-aided manufacturing
CAT	Computer-assisted translation
CCWC	Computing and Communication Workshop and Conference
CEFR	Common European Framework of Reference for Languages
CGE	Computable General Equilibrium
CO$_2$	Carbon dioxide
CRM	Customer relationship management
EPIC	Environmental Policies and Individual Behaviour Change
ERP	Enterprise resource planning
ESCO	European Skills, Competences, Qualifications and Occupations
ESCS	Economic, social and cultural status
ESR	Effort Sharing Regulation
ETS	Emission Trading System
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
HIQA	Health Information and Quality Authority
HLS19	European Health Literacy Population Survey 2019-2021
HLS-EU	European Health Literacy Survey
IAQ	Indoor air quality
ICT	Information and communication technology
IHF	Irish Heart Foundation
IPCC	Intergovernmental Panel on Climate Change
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISO	International Organization of Standards
IT	Information technology
KAVI	Kansallinen audiovisuaalinen instituutti
LSTM	Long short-term memory
MLW	Media Literacy Week
MoH	Ministry of Health
MT	Machine translation
NALA	National Adult Literacy Agency
NGOs	Non-governmental organisations

Abbreviation/acronym	Full description
NLLB	No Language Left Behind
NMT	Neural machine translation
OCR	Optical character reader
PIAAC	Programme for the International Assessment of Adult Competencies
PISA	Programme for International Student Assessment
PM	Particulate matter
RBMT	Rule-based machine translation
REALM	Rapid Estimate of Adult Literacy in Medicine
SES	Socio-economic status
SMT	Statistical machine translation
STEM	Science, technology, engineering and mathematics
TOFHLA	Test of Functional Health Literacy
VET	Vocational education and training
WHO	World Health Organization

Executive summary

The coronavirus (COVID-19) pandemic and policy actions aimed at halting its spread profoundly impacted societies and economies worldwide. Incorporating lessons from the pandemic in policy making is crucial not only to sustaining economic and social well-being in OECD countries in the short and medium term but also to building resilience to future shocks and securing just and inclusive economic growth in the long term.

Two areas in which investments in skills and skills policies can help societies anticipate rather than react to future adverse events are promoting environmental sustainability and ensuring human-centred digital technologies that effectively support communication and information exchange. Environmental degradation and untrustworthy information landscapes challenge economies and societies worldwide and are sources of considerable worry and anxiety among populations. On average, almost seven in ten adults across OECD countries perceive climate change as a threat, and six in ten worry about receiving false information on line.

Key to building system-level resilience to environmental challenges and technological transformations applied to information exchange is empowering individuals to develop a wide range of skills – including information-processing skills, socio-emotional skills and metacognitive skills – and ensuring that individuals can effectively apply these skills.

Projections suggest that between 2019 and 2030, the demand for skills related to interacting with computers, thinking creatively, analysing data and information, and communicating with persons outside an organisation will grow the most. Making the most of interconnected labour markets also requires proficiency in language skills. Four in ten vacancies posted on line in 2021 in non-English-speaking European countries required a knowledge of English. Among vacancies for technicians and associate professionals, this figure was one in two.

Yet many people worldwide do not have baseline levels of proficiency in the set of skills needed to ensure their own and societal economic and social well-being, and to effectively contribute to a greener future. The COVID-19 pandemic demonstrated the importance of health literacy, i.e. the ability to access, comprehend, assess, and apply information to make informed decisions regarding healthcare and disease prevention. Technology gave individuals the possibility to access up-to-date scientific information in real time, but at the same time exposed them to a huge amount of false and potentially harmful information on line. During the worst health crisis in a century, over four in ten adults reported that they would find it difficult or very difficult to judge the advantages and disadvantages of different treatment options, decide how to protect themselves from illness using information from the mass media, or find information on how to handle mental health problems.

Complicating matters, individuals acquire and lose proficiency in different skills over time depending on their usage and external constraints, and rapidly evolving environmental and social conditions change the set of skills and level of proficiency demanded. Lifelong learning systems that are responsive to changing circumstances can ensure that individuals are proficient in the range of skills needed to support economic growth and social cohesion. However, although proficiency in accessing,

comprehending, and evaluating texts, and critically reasoning with mathematical content are vital skills for navigating information-rich environments, 18% of adults in OECD countries do not reach baseline levels of proficiency in all these skills.

Attitudes and dispositions drive individuals' motivation to use their skills in ways that enhance personal and societal well-being. They also boost the effectiveness with which skills are deployed. For example, young people who agreed or strongly agreed that looking after the environment was important to them were 16 percentage points more likely to save energy for environmental reasons. Worryingly, inequalities in attitudes and dispositions mirror inequalities in skills proficiency. For example, socio-economically disadvantaged young people are 25 percentage points less likely to reach baseline levels of proficiency in science than their more advantaged peers.

Reducing the social cost of policy action by ensuring adequate upskilling and reskilling efforts, as well as providing assistance for populations negatively affected by climate change mitigation policies, is critical to ensure continued support of action to halt environmental degradation. For every 1% increase in unemployment, the percentage of adults who report prioritising the environment over the economy declines by 1.7%.

Whether individuals use their skills for positive or negative transformations of their environment depends on their attitudes and dispositions. Attitudes and dispositions are key enablers of skills investments. Skills do not translate into meaningful action without the will to act. For example, individuals with higher levels of education are more likely to be aware of the dangers associated with environmental degradation. Across OECD countries, 73% of individuals with a tertiary qualification, 66% with a secondary qualification and 63% of those without secondary qualifications report perceiving climate change as a threat. Similarly, individuals with tertiary-level qualifications are considerably more likely than those without tertiary-level qualifications to indicate that they would be willing to compromise their current lifestyle for the benefit of the environment.

Despite the importance of ensuring that individuals have both the skills and the will to act, as many as seven out of ten young people do not master the emotional, behavioural and cognitive dimensions of environmental sustainability. They are thus less likely to engage in actions aimed at promoting environmental sustainability as present consumers and future citizens of the world.

Moreover, despite the increasing awareness of the importance of considering ethical aspects in artificial intelligence (AI) development and the critical role AI professionals play in economies and societies, in 12 out of the 14 countries with available information, less than 1% of online vacancies seeking professionals with AI skills in 2022 mentioned aspects related to ethics in AI.

Whereas investing in skills is paramount to empowering communities to cope with adverse circumstances, it is equally important to put support systems in place to help communities overcome the stress and difficulties they may encounter as a result of the profound transformations unleashed by the green and digital transition. In the long term, successful adaptation requires careful consideration of the direct and indirect consequences of dealing with significant social and economic upheavals. Identifying populations that lack proficiency in skills that will grow in importance and developing effective policy responses to support them in building proficiency is critical to building system-level resilience since the outcomes of social, digital and environmental transformations will be defined by the actions and behaviours of all individuals, including individuals with lower levels of proficiency.

Individuals from socio-economically disadvantaged backgrounds are less likely to gain proficiency in a range of skills during formal education, develop attitudes and dispositions that can support the twin digital and green transition, and reduce their vulnerability to environmental and technological changes. Identifying vulnerability due to a lack of proficiency in skills key to a just, inclusive and sustainable twin transition and reducing it through adequate policy action is critical to improving both equity in outcomes and overall well-being.

Infographic 1. Key facts and figures

Education is key to raise awareness of climate change threats

% of adults who perceive climate change as a threat

73%
Tertiary-educated adults

63%
Adults without secondary education
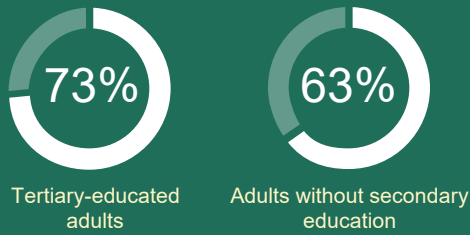
On average across OECD countries, adults with tertiary-level qualifications are more likely to perceive climate change as a threat than those without secondary education.

Disadvantaged youths are less likely to master environmental sustainability

% of 15-year-old students who reach foundational levels of competence in environmental sustainability

Low socio-economic status   High socio-economic status

Korea
Canada
Spain
OECD
Mexico
Costa Rica
Slovak Rep.

Disadvantaged students are less likely to reach foundational levels of science proficiency, be aware and care about the environment, and engage in pro-environmental actions.

Attitudes towards artificial intelligence differ by educational attainment

% of adults reporting that AI will be mostly helpful or harmful over the next 2 decades

Mostly helpful   Mostly harmful

Tertiary-educated adults   Non-tertiary-educated adults
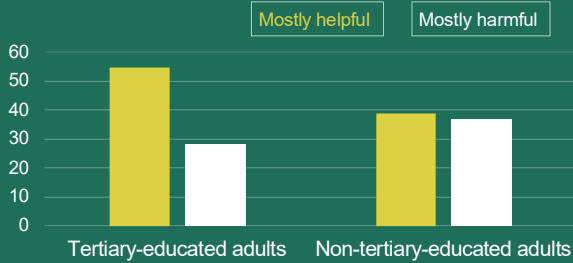
55% of tertiary-educated adults reported that AI would be mostly helpful, while only 39% of non-tertiary-educated adults said the same.

Many adults find it difficult to act on health information in the media

% of adults who report finding it difficult to protect themselves from health risks using information in the media

Germany
Hungary
Slovak Rep.
Israel
Norway
Czech Rep.
Austria
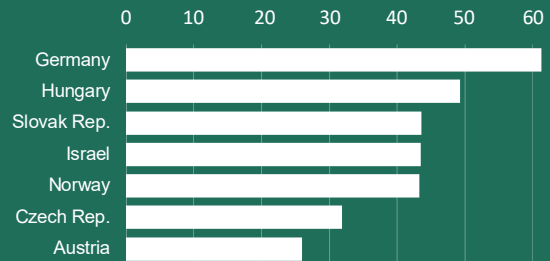
Health literacy is critical for people to make use of the large amount of information available online in order to protect their health and the well-being of their communities.

Girls have a greater fear of failure than boys in all OECD countries

% of 15-year-old students who are afraid that failing may mean that they do not have enough talent

Girls   Boys

Japan
UK
France
OECD
US
Türkiye
Germany

On average across OECD countries, 81% of girls said that failing makes them afraid they do not have enough talent, but only 65% of boys feel the same.

Overconfidence in reading skills is a challenge for many countries

% of 15-year-olds who are low-achieving and believe they can read and understand difficult text

Colombia
Mexico
Greece
US
France
Korea
Japan
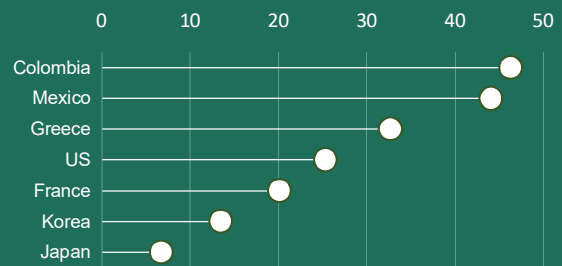
Overconfidence puts young people at risk of consuming and spreading misinformation, disinformation, and malinformation.

1 Overview

This chapter reflects on lessons from the COVID-19 pandemic that can guide reforms in skills policies to strengthen resilience and promote the twin green and digital transition. These reforms should be seen in the context of ongoing environmental degradation and the complexity of information landscapes driven by rapid technological developments. The chapter first defines resilience and then stresses that promoting system-level resilience through effective skills policies requires empowering individuals with a wide range of skills at varying levels of proficiency. The chapter also stresses that attitudes and dispositions are key enablers of skills development and effective skills use. Finally, the chapter highlights the importance of embedding skills policies in the context of comprehensive policy efforts and of monitoring the economic and social consequences of policy actions.

1.1. Introduction

The coronavirus (COVID-19) pandemic and policy actions aimed at containing its spread had a profound impact on societies and economies around the world. They are a reminder that societies can profoundly reorganise themselves if there is urgency, but also that sound policy interventions are critical to channelling the actions of economic and social actors. At the same time, the pandemic highlighted how major interventions necessary to reduce a threat – such as viral spread – can create new challenges for communities and societies. For example, however necessary they were, the closure of schools and all non-essential businesses during the pandemic came with high psychological, economic, and social costs. Building system-level resilience and reorganising societies to meet the defining challenges of our time – climate change, environmental degradation and technological developments in how information is used and exchanged (the twin green and digital transition) – requires comprehensive interventions to ensure that future economic growth is both sustainable and inclusive.

Skills policies play a key role in supporting the twin green and digital transition, contributing to system-level as well as individual resilience. In the absence of adequate investments in education and training, efforts to ensure that economic growth and development occur within the limits of planetary boundaries might not be successful and/or lead to short- and medium-term losses of labour market opportunities. Similarly, without adequate investments in education and training, digital transformations might be delayed or reduced, and existing innovations might lower social welfare.

Climate change and technological developments in information and communication exchange are the defining challenges of our time. Globally, July 2023 was the hottest month on record (NASA, 2023[1]). In particular, in that month, the global average surface temperature was 0.72°C warmer, and the global average sea surface temperature was 0.51°C warmer than the 1991-2020 average (Copernicus Climate Change Service, 2023[2]). Between 2017 and 2021, individuals in OECD countries, on average, had to endure 14 additional days of strong heat stress exposure compared to the period between 1981 and 2010 (IEA/OECD, 2022[3]). Rising temperatures are fuelling weather extremes, wildfires, biodiversity loss and natural disasters, leading to food and water insecurity, economic disruption, poor health, conflict and migration.

At the same time, progress in artificial intelligence (AI) and, in particular, the onset of *generative* AI is such that, in some areas, its output has become indistinguishable from that of humans. This suggests that OECD economies may be on the brink of an AI revolution, which could fundamentally change the workplace (OECD, 2023[4]) and society at large. Estimates suggest that ChatGPT, the chatbot released in November 2022 by OpenAI, was the fastest-growing consumer application in history after it reached 100 million monthly active users in January 2023, just two months after its launch (Reuters, 2023[5]). The use of generative AI has far-reaching implications for knowledge production and exchange: it is being increasingly leveraged in research to expedite the innovation cycle, reduce publication timelines and promote inclusivity in science by aiding individuals in expressing their ideas fluently, thereby broadening the diversity of scientific perspectives. However, these models can worsen information problems in online spaces, in part because large language models produce very convincing text that may be inaccurate and, in part, because they reduce the time and effort needed to generate fake and harmful content (van Dis et al., 2023[6]).

The speed of climate change and recent technological innovation is not matched by the speed of change in education and skills policies. Promoting environmental sustainability requires a profound rethinking of production and consumption, with important consequences for labour markets and the demand for skills. The current scale and pace of investments in skills policies are inadequate to significantly reduce the likelihood of going beyond tipping points, leading to irreversible and severe changes in the climate system (OECD, 2022[7]), to successfully adapt to changing environmental conditions, and to leverage technological innovations such as AI and robotics to improve labour market opportunities and conditions. As AI and robotics are being increasingly deployed in a range of industries, many of the tasks

currently performed by individuals will become automatable, leading to the emergence of new jobs, the disappearance of some jobs and the transformation of many others (Lassébie and Quintini, 2022[8]).

Yet, as new job profiles and skills requirements emerge, on average across OECD countries, only around four in ten adults participate in formal or non-formal learning for job-related reasons (OECD, 2021[9]). This hampers the ability of workers to reallocate from sectors and occupations that will shrink into sectors that will grow in the near future. Moreover, across OECD countries, only three in ten young people possess at least baseline levels of the cognitive, attitudinal and behavioural dimensions of environmental sustainability competence and only seven in ten reach baseline levels in all foundational skills that are key in information-rich societies – reading, mathematics and science – by age 15. Training opportunities that respond to emerging labour market needs and efforts to facilitate their uptake can promote a just and inclusive green and digital transition. In turn, education systems that equip young people not only with skills but also with the attitudes needed to manage change can ensure that the green and digital transition is sustainable in the longer term.

Successfully building resilience through skills policies also depends on ensuring that skills development is promoted among the most vulnerable. The pandemic highlighted that social justice and equity considerations aside, the high level of interconnectedness in modern societies means that **the level of vulnerability of societies is often tied to the actions of the least informed**. It also made clear that in order for societies to reap the benefits of investments in skills development, a renewed emphasis should be put on **equipping individuals with a set of beliefs, attitudes and dispositions that are aligned with long-term individual and social welfare**.

The term "resilience" was originally used in physics and engineering to characterise the ability of materials to resume their original shape or condition after being subjected to a shock, i.e. a sudden change in circumstances (Treloar, 1975[10]). The term was later adopted to refer to an individual's or system's ability to overcome adversity and display positive adjustment (Daniel, Wassell and Campbell, 2002[11]; Howard, Dryden and Johnson, 1999[12]). In this context, **resilience refers to the phenomenon where individuals who have faced adverse experiences exhibit lower levels of vulnerability than initially anticipated.** The goal is to understand the factors contributing to this resilience, including when, how and why it manifests (Luthar, 2003[13]; Masten and Powell, 2003[14]; Rutter, 2006[15]).

External shocks cannot be altered in the realm of inorganic materials. However, in human societies, the probability of external shocks occurring can be influenced. Consequently, **building resilience involves mitigating the impact of adverse events but also reducing the likelihood of such events happening in the first place.** Furthermore, individuals can adapt to their surroundings, which means that if circumstances change over the long term, they can strive to achieve a new equilibrium through adaptation.

In the context of this report, resilience refers to the ability of societies to reorganise themselves in order to: 1) limit future environmental degradation and safeguard information exchange; 2) adapt to current and foreseen environmental conditions and level of technological development; and 3) adapt to structural changes in labour markets that will result from the adoption of new technologies and from efforts to reach climate neutrality. Critically, **resilience entails ensuring that such transformations do not create new forms of labour market and social vulnerability.**

1.2. Towards a sustainable and inclusive twin green and digital transition

Estimates suggest that, compared to those born in the 1960s, on average around the world, children born at the onset of the COVID-19 pandemic in 2020 may experience 6.8 times more heatwaves during their lifetimes (Luten, Ryan and Wakefield, 2021[16]). However, limiting global warming to 1.5 C above pre-industrial levels could reduce this additional exposure to heatwaves by 45% (Global Commission on Adaptation, 2019[17]). Given this outlook, it is critical to not only establish ambitious

strategies to mitigate global warming but also to empower future generations by providing them with the necessary skills to adapt to evolving environmental conditions and make decisions that foster sustainable growth.

Decoupling economic growth from emissions growth and addressing the extent to which energy extraction and human production generate pollutants and create a loss of biodiversity is within the grasp of our societies. However, decarbonising the economy will profoundly impact labour markets worldwide in the coming years and decades. The green transition could boost economic growth, but the speed and efficiency with which the transition will occur depends on individuals having the right set of skills to sustain and power green innovations. Moreover, and equally important, unless all individuals have the right set of skills, labour market transformations due to the transition to net-zero emissions could create social tensions and ultimately derail or at least slow down progress towards a new growth paradigm that does not depend on environmental degradation. **Education and training systems can support resilience by ensuring that most people possess the right skills needed to adapt to existing environmental changes, to create the technologies that will propel the green transition, to work in the new jobs that will be created as a result of the green transition and to adopt behaviours better aligned with the achievement of environmental objectives.**

Human action also drives the quality of the information landscape. Throughout history, technological innovations have profoundly impacted individuals' capacity to acquire, use and exchange information. From the invention of writing to the printing press, from the advent of the Internet to the onset of generative AI, technological developments have facilitated new possibilities for individuals to connect and interact with others. At the same time, alongside benefits arising from cheaper and faster information exchange, societies have had to develop ways to adapt to such technological advances. For instance, the advent of the printing press and the subsequent proliferation of printed materials facilitated the dissemination of misinformation and thus posed a challenge in terms of ensuring the accuracy and reliability of information. Developments in social media and AI are creating similar problems.

Information is critical to enable individuals to make informed decisions. Technology plays a fundamental role not only in giving people access to information but increasingly in directly extracting and generating the information that is exchanged. During the pandemic, information allowed individuals to safeguard their health and the well-being of others. However, the pandemic also demonstrated that unless people have **adequate levels of skills to access, filter, assess and process information,** exposure to misleading, inaccurate, and false information can lead communities to experience worse rather than improved outcomes.

Communication is key in today's interconnected world. Of the estimated 8 billion people who lived in the world at the end of 2022, about 5 billion were connected to the Internet (World Bank, 2021[18]). The Internet dramatically increased the amount of information that is accessible and exchanged around the world. But quantitative increases in the amount of information that is available on line have not necessarily been accompanied by increases in the quality of such information, and the emergence of generative AI systems is changing yet again how information is extracted and generated. To reap the benefits of emerging information societies, countries need to have an adequate pool of individuals who possess the skills to develop, adapt and maintain AI applications since these underpin how information is collected, used and exchanged. In addition, countries need to ensure that, whether on or off line, populations have the full set of skills that allow them to integrate new technologies into their work and everyday lives to improve their productivity and well-being.

1.3. Skills for a resilient green and digital transition

Reorienting the economy so that economic growth occurs within planetary boundaries and ensuring that rapid technological developments do not create new social and economic vulnerability may change the set

of tasks individuals will have to perform. Such change is likely to require individuals to rely on a renewed set of skills in their work and everyday life. As a result, education and training systems will have to adapt to align skills development opportunities with emerging skills needs in labour markets and society more widely. Emerging skills needs that are critical to build system-level resilience to the green and digital transition at the population level require:

- **Focusing efforts to improve information-processing skills among low-proficiency adults.** Skills such as literacy, numeracy and digital literacy allow individuals to access, analyse, interpret, summarise, organise, store, retrieve and communicate information. The emergence of knowledge-rich societies in which value rests on the ability to gather, use and exchange information effectively means that individuals without at least baseline levels of proficiency in information-processing skills will increasingly be at risk of economic and social exclusion. Increases in the complexity of the information landscape result in more information becoming available from a variety of sources, heightening the need for all individuals to be able to analyse, interpret, and organise information. Similarly, the growth of job profiles resulting from the green transition in service industries and industries with a high technological content increases the demand for workers who possess skills to effectively manage quantitative and narrative information.

- **Prioritising the acquisition of socio-emotional and communication skills for all.** Skills such as the capacity to collaborate with others, manage emotions, persevere in difficult circumstances and effectively communicate with diverse groups enable individuals to effectively navigate their social environments and make responsible decisions. These skills are critical to building a resilient green and digital transition because these are uniquely human skills and, therefore, not easily automatable even with advances in AI in the near future. Moreover, the collective effort needed to promote the green transition rests on the capacity of communities to negotiate conflict and pool collective expertise to solve complex systemic problems.

- **Raising awareness about the role of metacognitive skills.** Metacognitive skills refer to the ability to think about and regulate one's own thinking processes, monitor and evaluate one's own learning and understanding, and plan, set goals, and adjust strategies to meet those goals. There is increasing evidence of the role played by heuristics, biases and cognitive profiles in shaping decision making. Metacognitive skills are critical if individuals are to regulate their behaviour. In the face of uncertainty induced by climate change and technological developments, metacognitive skills allow individuals to recognise the role of heuristics and biases in shaping decision making and make more informed use of knowledge and information. Metacognitive skills, in fact, empower individuals by helping them characterise knowledge and knowledge generation processes and can help individuals effectively work alongside others – whether humans or machines. They help individuals and communities solve complex problems and develop reasonable risk mitigation strategies both at individual and societal levels.

1.4. Adapting investments in skills development to a changing context

The speed and complexity of changes associated with green and digital transition require profound transformations in how education systems equip young people with the skills, as well as the knowledge and attitudes, to thrive in the future. At the same time, they require adults to continuously adapt to match new labour market and social demands through a renewed commitment to adult education and training in all its forms – including formal, non-formal and informal learning.

Recognising the range of skills individuals have and valuing the potential of individuals to become proficient in different domains widens the scope for greater participation in training programmes. Skills can be acquired through experience and lost through lack of use. Therefore, the level of skills of workers is not just about individual workers; it is also a reflection of how production processes are

structured and whether individuals have been given the opportunity to build their skills or not. Recognising the potentially wide range of skills and levels of proficiency workers possess can, in turn, motivate both employers and employees to invest in skills development: workers because they are empowered in their capacity to acquire skills, and employers because they can see the potential returns associated with investments in skills development.

One step for skills policies to promote resilience and a lifelong learning culture, as well as support the green and digital transitions, is to advocate for a change in how workers are classified. **Workers in blue-collar occupations are generally referred to as being "unskilled" or "low-skilled" and managers and professionals as "high-skilled".** However, high and low are adjectives that classify skills depending on the level of proficiency, not the type of skills individuals possess. This means that, for example, a blue-collar worker may have high levels of fine motor and problem-solving skills and low levels of programming skills, whereas the opposite may be true of a professional. The fact that certain skills may be more relevant than others in specific contexts – and therefore yield a comparative advantage and are therefore in high demand – says as much about the context individuals operate in as about the skills individuals possess.

Standard characterisations of manual workers as being "unskilled" or "low-skilled" and professionals as being "high-skilled" reduce the incentives individuals with different occupations have to invest in lifelong learning. Manual workers may be led to believe that acquiring proficiency in a wider range of skills is beyond their capacity, and professionals may be led to believe that they do not need to invest further in skills development. As such, they limit the scope of skills policies and potentially create labour market inefficiencies. This characterisation arises from a traditional view of skill acquisition focused solely on educational qualifications acquired through formal schooling. To an extent, this is due to the fact that educational qualifications are the only information available in labour force or other social surveys used to map and study labour markets. At the same time, because of historical developments in education systems, focusing on educational qualifications in most contexts has the unintended consequence of leading to a hierarchical vision of education systems in which academically oriented programmes command a higher status than vocationally oriented programmes.

Effectively promoting system-level resilience first requires identifying emerging skills needs and prioritising investments to ensure that support reaches those vulnerable to changing conditions. Second, it requires identifying what proficiency benchmarks in a given skill individuals need to reach to be able to behave at work and in everyday life in ways that align with the achievement of such objectives. Third, it requires policy makers to ensure that individuals are able to progressively reach such benchmarks as labour market and social arrangements evolve, prioritising skills investments to meet the demands of vulnerable populations.

Promoting a culture of lifelong learning goes hand in hand with fostering equal access to education and training opportunities (OECD, 2023[19]). Lifelong learning opportunities should be created to fulfil the needs of a diverse set of individuals. Policy makers should create flexible education and training opportunities that take into account individuals' unique barriers to participation (including lack of time or financial resources, caring responsibilities, lack of prerequisites, lack of knowledge about opportunities) and target groups in greatest need of support. Examples of efforts aimed at empowering individuals and reducing financial barriers to participation include individual learning accounts – such as the French *Compte Personnel de Formation* (OECD, 2019[20]) – or vouchers, coupons provided to individuals or companies to cover direct training costs, as for example, the *Bildungsprämie* in Germany (OECD, 2021[21]). Pre-apprenticeship programmes can facilitate the integration of migrants into regular vocational education and training (VET) programmes, such as the case of *Integrationsvorlehre* in Switzerland (OECD, 2023[22]). Flexible measures have been used in Denmark to allow learners who already fulfil specific requirements to skip parts of their VET programme, thus shortening the length of training significantly and increasing motivation to learn during the programme (Ministry of Children and Education, n.d.[23]).

This report maps the distribution of skills that are key for the twin green and digital transition across and within countries and for different population groups. Mapping these skill distributions can assist in the formulation of effective skills policies aimed at reducing vulnerability to emerging threats. Specifically, the report identifies populations with limited proficiency in key skills (such as information-processing skills), thereby enabling targeted investments in policies to address the limited proficiencies. By addressing the vulnerability of the identified populations, broader local and global communities can also benefit from reduced vulnerability.

1.5. The role of attitudes and dispositions

Decisions concerning the skills individuals and societies invest in, whether such skills are mobilised, and the goals pursued through their use depend on the attitudes and dispositions individuals hold and the values societies prioritise. Attitudes and dispositions play a pivotal role in driving individuals' motivation to utilise their skills and enhance how effectively skills are used. For instance, recognising the importance of promoting environmental sustainability is essential to motivating individuals to integrate sustainable practices into their daily lives as consumers. Attitudes are also critical if individuals are to consider strategies to enhance environmental sustainability in their workplaces and apply scientific knowledge to develop solutions in this domain. It is noteworthy that many skills that can contribute to environmental sustainability can equally be utilised for environmental degradation, with the divergence solely determined by the type of activity workers are engaged in and, to some extent, even their own attitudes and dispositions. For example, proficiency in physics and chemistry can be used to develop ways to reduce system-level dependency on energy generated through fossil fuels or, by contrast, to devise new ways to extract fossil fuels from natural reserves. Similarly, the technical skills required to develop AI systems that may propagate false information endangering public health can also be employed to facilitate health promotion and the adoption of preventive measures. Individuals' choices in utilising their skills depend on their attitudes and dispositions.

Equipping all individuals with skills is a necessary – but not a sufficient – condition to facilitate the green and digital transition. Attitudes and values are also essential. Societies must nurture in generations, new and old, not only a sound understanding of the challenges arising from climate change, environmental degradation and technological advancements in information exchange but also a deep appreciation for the fragility and intricacy of physical and digital ecosystems. Similarly, new attitudes and dispositions are needed if societies are to adapt to new digital environments. This is especially the case given very recent advances in generative AI systems and their potential to profoundly reshape information ecosystems.

Education and skills policies are crucial in tackling challenges associated with the green and digital transition and building resilience at the individual, community and system levels. Education and training systems should accompany skills development with the development of attitudes and dispositions that can sustain the effective use of skills. Attitudes and dispositions are key enablers of skills investments. Skills do not translate into meaningful action without the will to act.

1.6. The green transition and how skills policies can promote resilience

Reorienting the economy to create an environmentally sustainable future requires the adoption of environmentally sustainable production and consumption practices. Skills policies can promote system-level resilience by:

1. **strengthening the environmental sustainability competence of individuals**

2. **ensuring that achieving ambitious climate objectives does not lead to labour market vulnerability**

3. **developing the range of skills and attitudes needed to adapt to new environmental conditions.**

1.6.1. Strengthen the environmental sustainability competence of individuals

Environmental sustainability competence comprises the knowledge, skills, attitudes and values that are critical to promoting environmental sustainability. It enables individuals to tackle environmental challenges, adopt practices in their work and everyday life that promote environmental sustainability, be ready to work in future green jobs and be environmentally thoughtful consumers. Yet, this report finds that on average, across OECD countries, only 31% of 15-year-old students have foundational levels across all key dimensions of environmental sustainability competence, meaning that they achieve at least a foundational level of science proficiency; have an awareness of climate change and global warming; care for the environment; have environmental self-efficacy; and are engaged in behaviour to promote environmental sustainability. Furthermore, large disparities exist in the extent to which education systems and societies equip children with environmental sustainability competence. In particular, 21% of socio-economically disadvantaged youths, but 46% of their more advantaged peers, had mastered the foundation skills and mindsets they will need to find employment in the new green economy and to act for environmental sustainability as consumers. Although science proficiency is the key information-processing skill underpinning the capacity of individuals to contribute to and thrive in a low-carbon economy, attitudinal and dispositional components of environmental sustainability are powerful drivers of engagement in environmentally sustainable behaviours together with knowledge and skills. Worryingly, inequalities in attitudes and dispositions mirror inequalities in science proficiency – such as in the case of socio-economic inequalities – or are wider than inequalities in science proficiency – such as in the case of inequalities between genders. Given the key role played by emotional, attitudinal and behavioural dimensions of environmental sustainability competence and the fact that these dimensions can be acquired through repeated exposure to role models and long-term socialisation, environmental protection should be made a shared cultural and social norm. Investing in building environmental sustainability competence among young people and adults should thus be comprehensive and entail:

- **Ensuring that the appreciation and protection of the environment is taught and nurtured from an early age and continued over the life course.** Education systems should promote more equitable learning of environmental competence to make sure that today's marked socio-economic divide in environmental sustainability competence between students with a high and low socio-economic status is mitigated. Although this requires whole-of-society efforts between parents, the education system and other social institutions, the education system can promote early childhood education and care programmes that aim at teaching children environmental sustainability competence from the early years. Such efforts should be the foundation upon which education systems then continue to support the acquisition of environmental sustainability competence. Furthermore, since many adults remain ill-informed about the threats arising from climate change and environmental degradation, environmental awareness among adults should be expanded through sensitisation campaigns about the threats of climate change and the importance of adopting behaviours that reduce environmental degradation.

- **Empowering teachers and trainers to support the acquisition of environmental sustainability competence.** Initial teacher training programmes and professional development modules should be reviewed and updated to ensure that teachers are aware of the importance of integrating aspects related to the development of environmental sustainability competence in the curriculum and have the pedagogical and content knowledge needed to do so. Such programmes should be regularly updated to integrate new knowledge and information on environmental

challenges and on the effectiveness of different approaches to promote the development of environmental sustainability competence in the classroom.

- **Promoting the development of environmental sustainability throughout the lifecycle.** The understanding of the impact of human actions on the environment, key environmental phenomena and possibilities to promote environmental protection have evolved dramatically in the recent past. Efforts in the early years should be complemented by the opportunity to update their environmental sustainability competence later in life, as well as programmes tailoring individuals already in the labour market who did not benefit from any training in environmental sustainability early on. Whenever possible, adult training systems and sensitisation campaigns should build on early interventions by providing individuals with up-to-date information on environmental degradation. At the same time, efforts should be made to identify individuals who did not benefit from early interventions while in school and provide tailored programmes aimed at supporting their acquisition of the knowledge, skills, attitudes, and values that are critical to promoting environmental sustainability via training programmes. Furthermore, as environmental degradation has worsened, many individuals who were sceptic about the urgency of climate action have realised the need to develop and sustain initiatives to protect the environment. New generations who are working towards protecting the environment can be powerful agents of change, mobilising prior generations and helping them establish a new environmental consciousness and awareness.

1.6.2. Ensure that achieving ambitious climate objectives does not lead to labour market vulnerability

Ambitious climate mitigation policies will be needed to limit climate change and halt environmental degradation. Although these policies are essential to avert environmental collapse, they will affect labour markets and the demand for skills in the next decade. Building system-level resilience requires minimising the economic and social cost of the green transition, so anticipating possible unintended effects of efforts aimed at decarbonising economies on labour markets is critical to putting in place adequate policy responses. This report considers the effects of policies in countries in the European Union (EU) as a case study to consider how policies will have to adapt to ensure that the skills workers possess are aligned with the skills that will be demanded in the economy. The case of the EU is instructive because of the ambition of the policy package being implemented, the number of jurisdictions being affected and the availability of timely data. Projections indicate that reducing greenhouse gas emissions in the EU by 55% by 2030 through the EU's Fit for 55 policy package can be achieved without a decrease in overall labour market opportunities and, in fact, with a small gain in employment. However, according to OECD projections the policy is projected to result in overall lower employment for blue-collar workers. Minimising labour market mismatches arising from the policies is, therefore, critical to reducing delays and transition costs for individuals and businesses. Moreover, because evidence suggests that whenever in a country unemployment increases, public support for environmental action decreases, reducing the social and economic costs associated with the implementation of climate change mitigation policies is critical to guarantee sustained public support for such policies. Supporting workers in localities particularly affected by downsizing activities that generate high levels of CO_2 emissions through labour market and social policies is critical. In this regard, ensuring the effective and inclusive implementation of policies aimed at reducing greenhouse gas emissions entails:

- **Coupling climate change mitigation policies with technological adoption to facilitate a green transition that promotes employment growth.** Thanks to technological adoption and diffusion, projections indicate that climate change mitigation policies can be achieved while still promoting sectoral and employment growth. Successfully achieving decarbonisation, as well as economic and job growth, depends on ensuring the adoption of digital technologies and on improvements in labour productivity related to technology use. Many of the skills projected to increase in demand between 2019 and 2030 relate to the development and use of digital tools and applications or to

interpersonal communication, management and leadership. By contrast, many of the skills projected to decline in demand relate to using tools and machinery. This is because the implementation of Fit for 55 is expected to accelerate the existing trend, leading to a structural reallocation of employment opportunities from blue-collar and manual jobs to jobs in the service economy.

- **Considering the distributional implications of policies aimed at reducing greenhouse gas emissions.** The modelling results indicate that although overall employment is projected to grow between 2019 and 2030, even under the implementation of ambitious initiatives to reduce greenhouse gas emissions, employment is projected to shrink considerably in some sectors and for some workers. In particular, the employment of blue-collar workers is projected to shrink, and in some sectors, such as mining coal and lignite, it is projected to shrink by as much as 90%. Because the distribution of workers in different sectors and occupations differs across countries as well as across regions, within most countries, some countries/localities will be especially hard hit by job losses. The geographical distribution of workers by sector and occupation should be evaluated in the development of adequate policy responses aimed at facilitating their redeployment in sectors and occupations for which labour demand will increase. In fact, in the case of the EU the Recommendation on ensuring a fair transition towards climate neutrality was adopted in 2022 to take into account the distributional implications of the transition. The Recommendation invites EU member states to adopt measures to address the employment and social aspects of climate, energy and environmental policies, encouraging the adoption of actions to support people most affected by the green transition for instance by stimulating the creation of quality jobs and facilitating access to safe working conditions protecting health and safety in the context of this green transition (Council of the European Union, 2022[24]). The Recommendation also puts a focus on education and training measures, inviting EU member states to integrate the employment and social aspects of the green transition in the development and implementation of relevant national strategies (Council of the European Union, 2022[24]). Other proposals concentrate on fairness of tax-benefit and social protection systems and on ensuring access to affordable essential services and housing for people and households most affected by the green transition. The effects of policies aimed at decarbonising economies should be adequately and continually monitored to ensure that policies aimed at supporting displaced workers are timely and tailored to these workers' needs. Minimising transition costs (including economic costs and reduced overall well-being) requires organising social protection to support groups of individuals for which viable labour market transitions are not feasible or are too costly to be implemented and organising training for those for whom such transitions are available. In particular, anticipation efforts should consider the profile of displaced workers in order to facilitate their redeployment in sectors for which labour demand is projected to grow, with the aim of anticipating the intensity of training needs and organise both upskilling and reskilling efforts to reduce mismatches and facilitate inter-sectoral and inter-occupational mobility. Alongside the development of learning opportunities that are responsive to emerging needs, efforts should be made to improve the accessibility of such opportunities for diverse groups of learners. Even in the absence of the additional demands arising because of labour market changes induced by the green transition, participation in adult learning opportunities is low, particularly among many of those who would most benefit from taking part in lifelong learning. Efforts should reduce the effects of external barriers (for example, time, cost, lack of information, architecture) and internal barriers (for example, lack of motivation, lack of prerequisite skills) to participation.

- **Investing in career guidance and working with employers to develop new hiring practices.** Career guidance and educational orientation programmes can assist individuals of all ages in making well-informed educational, training and occupational choices and in managing their careers. At the same time, formal educational qualifications remain a key criterion guiding employers in hiring decisions. Although this may be changing due to the large and persistent skills

shortages employers face in some sectors, skills-based hiring will have to become more widespread and accepted if the deployment of workers across sectors and occupations following engagement in training courses is to be successful. Although qualifications and degrees from initial education and training will continue to play a key role, alternative credentials (including digital badges, micro-credentials, nano credentials, minor awards, etc.) will be critical to ensure that more adults engage in adult learning opportunities and to provide more adequate information on workers' skills and proficiencies to prospective employers.

- **Investing in adequate labour market and skills data.** Existing data collection instruments in many OECD countries are not well suited to mapping economic activities and employment distribution. Most of the literature overcomes these limitations by using data from the United States and assuming that the skills required of different occupations in different countries match the skills content estimated in the United States using the O*NET database. However, since an important effect of the green transition will be the reorganisation of production to reach green objectives and the fact that countries might follow different trajectories, it will be important to ensure that adequate data will be collected to support evidence-based policy making. In particular, highly detailed sectoral and occupational data are needed to identify how aligned with green objectives different labour market opportunities are.

1.6.3. Develop the range of skills and attitudes needed to adapt to new environmental conditions

Despite the most ambitious mitigation efforts, a certain degree of climate change is already inevitable due to past emissions. Therefore, it will be necessary to implement a variety of adaptation policies to reduce the vulnerability of individuals and societies to the impacts of climate change and environmental degradation. Events such as wildfires, extreme temperatures and flooding can disrupt skills acquisition directly by forcing the closure of schools and increasing absenteeism but also indirectly by reducing the potential of individuals to learn when they are in class and to achieve their full potential during high-stakes exams. Socio-economically disadvantaged children and adults are more likely to suffer the negative consequences of adverse environmental conditions. This is because they are often more exposed to poor environmental conditions and lack the resources to invest in adaptation technologies or protective behaviours. Promoting the successful adaptation of learning systems to climate change entails:

- **Preparing learning environments for extreme temperatures and destructive weather events.** Education and training systems should develop emergency protocols to protect students and staff during extreme weather events and ensure the continuity of instruction during such events. This can include measures such as installing emergency generators, establishing evacuation plans and providing training on safety and how to respond to emergencies. Schools and training institutions should also reduce their carbon footprint and increase their resilience to extreme weather events, saving on operating costs and repair work. Designing workplaces to ensure adequate environmental conditions is also key to promoting workers' safety, productivity and effective use of skills.

- **Considering the differential effects of environmental conditions on the acquisition of skills and on inequalities in skills development.** Reorganising when and where learning takes place may help reduce overall exposure and thus mitigate the largest effects on cognition. Ensuring that classrooms have cooling devices or good ventilation can also attenuate the overall effects of extreme temperatures on cognition. Furthermore, because socio-economically disadvantaged groups are often more exposed to worse environmental conditions and have less access to mitigation technologies, investments should focus on reducing inequalities.

- **Accompanying investments in adaptation infrastructures with a focus on the full set of skills needed for successful adaptation.** Infrastructural investments in adaptation should be accompanied by investments in building the full set of skills individuals need to be resilient to extreme weather events. Skills policies could include a focus on the skills necessary to keep safe under extreme weather events as well as physical skills such as the ability to swim without assistance and the ability to ride bicycles. Even though education systems in many OECD countries have prioritised the acquisition of cognitive skills and the transmission of knowledge, the green and digital transition requires a greater balance between investments in academic domains and physical education (OECD, 2019[25]). Partnerships with not-for-profit organisations could be promoted to ensure more individuals possess skills that will be needed to be safe during extreme weather events and achieve personal autonomy, safety and well-being.

- **Ensuring that public support for sustainable investments following extreme weather events translates into long-term change.** Whereas education programmes can easily reach young people with the aim of equipping them with environmental sustainability competence and the skill set needed to adapt to climate change, adults are harder to reach. Public information campaigns and initiatives aimed at empowering individuals with the knowledge and skills needed to adapt to new environmental challenges should build on public interest and support for actions prioritising the environment in the aftermath of natural disasters. Governments should provide clear and consistent messaging to the public about the need for sustainable investments in the wake of extreme weather events, explaining the link between climate change and extreme weather events and highlighting the importance of long-term sustainable investments. Sustainability plans should outline specific measures to address climate change and promote sustainable investments. They should be developed in collaboration with a wide range of stakeholders, including the public, and regularly updated to reflect changing circumstances.

1.7. The digital transition and how skills policies can promote resilience

Recent technological innovations have profoundly changed how information is collected, stored, used, generated and exchanged. Supporting further technological innovations while ensuring that technological developments enhance the economic well-being of broad populations rather than only a few, and addressing the possible negative effects of new technologies on health, well-being and social cohesion requires:

1. **identifying emerging skills needs to more effectively operate in information-rich societies and work alongside emerging generative AI systems**
2. **promoting health literacy to protect communities from infodemics**
3. **supporting language learning to facilitate interlinguistic communication**
4. **strengthening a wider set of skills and attitudes AI professionals need to be able to develop ethical and trustworthy AI systems.**

1.7.1. Identify emerging skills needs to more effectively operate in information-rich societies and work alongside emerging generative AI systems

With the rise of social media, the decline of traditional news outlets and advances in the capabilities of AI technologies, particularly generative AI, there has been a proliferation of information available to individuals around the world. However, quantitative increases in the amount of information available have yet to be accompanied by increases in the trustworthiness of such information and in an understanding of how best individuals can use the power of new technologies in making use of information and data to improve their productivity and personal well-being. On the one hand, new technologies are leading to an increase in the

amount of false or misleading information individuals are routinely exposed to and a decrease in how much individuals trust institutions. The ease with which information can be produced and shared is also leading to information overload on the part of potential users because many lack the ability to effectively manage information flows. As a result, some individuals feel overwhelmed, and others unwillingly and unknowingly spread false or misleading information. The ability to evaluate the quality of information and the ability to seek, retrieve and propagate relevant information rests on a range of cognitive and metacognitive skills, knowledge, as well as attitudes and dispositions. On the other hand, AI has the potential to profoundly impact all industries and occupations that rely on data and information, automating a wide range of tasks currently performed by humans. Many of today's political and social tensions arising in response to the automation of tasks made possible by advances in AI revolve around the questions of whether technologies will substitute or complement workers, give rise to better or worse labour market conditions, and ultimately whether they will be associated with an increase or a decrease in labour market opportunities. Ensuring that all individuals possess the full range of skills and attitudes to effectively deal with technological advances in how information is shared and used entails:

- **Integrating media literacy in education and training programmes**. Media literacy education should become part of national curricula starting in primary school years and continuing in secondary and tertiary academic and vocationally oriented programmes. Students could also be trained in lateral reading, the process of comparing untrusted information to other, more trusted sources. Studies have found that lateral reading interventions can be useful in improving information handling. Giving people the opportunity to deliberate has been found to positively impact truth discernment. If people can follow a quick evaluation of a headline with the opportunity to re-evaluate, they show less belief in false news.

- **Reorganising learning so that young people develop an understanding of the different ways in which knowledge is acquired.** Teachers can introduce students to different ways of developing knowledge, such as inductive and deductive reasoning, discuss how epistemic beliefs can influence scientific thinking, and encourage young people to explore scientific concepts through inquiry so that they can gain a deeper understanding of how scientific knowledge is constructed. Collaborative learning can also help young people develop more sophisticated epistemic beliefs by exposing them to different perspectives and ways of thinking. Finally, group work can also help students develop communication skills and improve their ability to articulate their own beliefs. Such efforts could be strengthened by programmes aimed at prompting individuals with media literacy information before they engage in social media or other online sources that might expose them to misleading or false information.

- **Including the development of metacognitive skills as part of learning objectives**. More focus should be placed on developing metacognitive and critical thinking skills: individuals' actions and behaviours are shaped by cognitive biases, which can be transitory (for example, due to fatigue) or permanent (for example, because of framing effects). Individuals should be educated about the role cognitive biases play in decision making, and their metacognitive skills should be promoted to limit the harmful effects of such biases. Teachers play an important role in developing students' awareness of their own skills and abilities, as well as their critical thinking skills. It is crucial to encourage teachers to teach critical thinking in different subjects and help young people develop an awareness of their own skills and limitations. Embedding critical thinking in all subjects is considered more beneficial than generic critical thinking interventions. For example, teachers could choose questions and tasks that put more emphasis on particular forms of reasoning and connect this reasoning to real-world use in and outside their fields. Individuals should also develop the ability to recognise the information context they are exposed to, for example, what the type of moderation specific platforms use, their policies if users break the terms of service and their policies on content removal.

- **Fostering public understanding and awareness of AI technologies and the skills to operate alongside emerging technologies.** Open dialogue between policy makers, scientists, industry representatives, trade unions and the general public can help to address concerns, gather feedback and incorporate diverse perspectives into AI governance processes. Promoting public education initiatives to enhance digital literacy can empower individuals to make informed decisions about AI-related matters. Improvements in AI technologies require prioritising investments in the development of skills, attitudes and dispositions that enhance people's readiness to meaningfully engage in tasks alongside AI systems. Critical attitudes and dispositions include risk preferences, attitudes towards failure and self-confidence. Critical skills include goal setting, the capacity to interpret information and evaluate the quality of evidence. As the capabilities of AI systems evolve, it is critical to continuously evaluate what skills and attitudes will allow individuals to make the most of AI developments in their work and everyday life. Adequate investments should be made in skills assessments, and anticipation initiatives to identify the set of skills and attitudes workers in different sectors and occupations will need to effectively integrate advances in AI capabilities. Engagement in lifelong learning will play a critical role in ensuring the alignment of people's skill sets and attitudes to a new technological reality and that new managerial practices emerge so that workers' contribution to production processes is strengthened and adequately valued.

- **Reflecting on the opportunities and threats for skills development of generative AI.** Although it is too early to evaluate the full impact generative AI will have, it is likely to profoundly impact education and training systems. Skills policies will have to integrate emerging evidence and make the most of opportunities generative AI will bring to individualised and customised learning experiences in order to match learning provision with learners' needs and cognitive profiles. This could help educators increase the accessibility of learning, for example, for neurodiverse students and students struggling with linguistic barriers. Generative AI could also allow instructors to scale constructive critiques for iterative learning and provide timely feedback. At the same time, the integration of generative AI in education and training poses safety and ethical risks that should be adequately considered and addressed, for example, through policies governing the use of generative AI by staff and learners.

1.7.2. Promote health literacy to protect communities from infodemics

Healthcare is a key area in which the outcomes of widespread use of information technologies depend on the skills of individuals. Information technologies, such as health apps, wearable devices and online health platforms, provide individuals with unprecedented access to health information and tools that allow them to monitor and manage their health and well-being. However, the effectiveness of these resources hinges on users' ability to comprehend, evaluate and apply the information they encounter. If individuals misinterpret health data or rely on inaccurate information, they can incur wrong self-diagnoses, inadequate treatment adherence or make misguided health decisions. While technological developments in generative AI might improve early disease detection and treatment options, they also run the risk of amplifying online misinformation, thereby increasing the importance for individuals to have the ability to critically evaluate and discern health information. In an era of rampant digital misinformation, individuals lacking strong health literacy skills are more susceptible to becoming the victims of false and misleading claims, potentially compromising their health and undermining the effectiveness of evidence-based medical practices. During the worst health crisis in a century, over four in ten adults reported that they would find it difficult or very difficult to judge the advantages and disadvantages of different treatment options; decide how to protect themselves from illness using information from the mass media; or find information on how to handle mental health problems. At the same time, unless healthcare providers have the ability to effectively communicate information to a range of individuals with varying levels of health literacy, they may be unable to improve patients' outcomes or engage in effective public health measures through prevention. The cost

of investments aimed at supporting health literacy development at the population level and improved communication skills among healthcare professionals should, therefore, be considered a key part of healthcare prevention strategies. As such, it should be evaluated against the cost of inaction, in particular, the fact that lower investments in preventive services often lead to greater reliance on costly emergency services as well as worse overall outcomes. Ensuring that technological innovations lead to improved health entails:

- **Promoting the development of health literacy throughout the lifecycle**. Promoting health literacy should start in childhood and continue in adolescence, adulthood and the elderly years. Adopting a lifecycle approach to the development of health literacy would entail identifying how best to equip individuals with health literacy that they can use to promote their health in the present and future. Health literacy instruction should be part of physical education in the early years. General practitioners and other healthcare professionals could work to build health literacy among adults. In particular, individuals should be supported in understanding the implications of a rapidly evolving technological landscape with the aim of empowering them to use information to enhance their own health and the well-being of their communities.

- **Improving the accessibility of health-related information by enhancing the communication skills of healthcare providers**. Healthcare professionals should receive training to ensure that health-related information is made available and communicated in ways that are comprehensible by individuals with varying levels of health literacy. Health literacy action plans should involve patient groups to ensure that health-related information is communicated in ways that are understandable for a diverse set of users. In particular, given the increase of international migration, health-related information should be made available in the languages of large migrant communities, and translators should be available for those whose low health literacy is due to an inability or limited ability to speak the language.

- **Addressing healthcare providers' biases through de-bias training.** Some healthcare providers display biases in how they communicate with and treat different population groups. In particular, in many countries, ethnic minorities and women often experience worse outcomes as a result. On top of strengthening the health literacy of these groups to empower them to more effectively advocate for their health, healthcare practitioners should be trained to identify and address the biases they and their colleagues hold.

- **Promoting the administration of health literacy surveys.** Little information exists on the levels of health literacy in populations. This may mean that the current standards applied in communicating healthcare information by providers remain ill-suited to the skill levels of end users, potentially limiting these users' ability to engage in health decisions. Administering regular population-level health literacy surveys can help to identify target groups for interventions aimed at enhancing health literacy. Such surveys can also reduce the risk that low levels of health literacy reduce people's health by giving healthcare providers an understanding of the sets of skills their patients have and how best they can tailor health-related communication given such skills.

1.7.3. Support language learning to facilitate interlinguistic communication in the digital age

Being able to accurately exchange information with others is key to being able to make the most of digital information ecosystems, and developments in AI are facilitating interlinguistic exchange although they pose significant challenges for language professionals. But whether on or off line, people's ability to access information and communicate with others depends on their proficiency to leverage technological innovations for interlinguistic exchange. This includes their own linguistic abilities, as well as the ability to understand when AI systems are hindering rather than facilitating communication because of biases and limitations. English is the most demanded language in the labour market and is widely used on line.

Moreover, English is the language that is most widely used by the technology sector, and recent advances in large language models are generally biased towards English or other languages with a large online presence upon which such models can be trained. Making the most of the opportunities afforded by information exchange at a time of rapid advances in AI entails:

- **Encouraging early language learning and increasing the amount of time devoted to language instruction, particularly in vocational education and training programmes**. Despite the importance of languages in labour markets and societies, with English conferring unique advantages, many vocational programmes do not include learning a modern language course as part of their core programme. Because the earlier a child is exposed to a non-native language, the easier it is for them to become proficient and becoming proficient in a language can take several years of consistent exposure, language instruction should start as early as possible, and students should be exposed to language learning for an adequate amount of time over an extended number of years. Although language learning is easier at a young age, adults can also acquire language skills. Adults should be informed about the labour market and employability benefits associated with having language skills, and language courses should be part of adult education programmes.

- **Educating young people and adults about machine translation (MT) technology outputs, their potential, and the threats arising from poor translations.** Given changes in how technologies afford interlinguistic communication, language learning programmes should be designed to facilitate an understanding of the challenges and opportunities for interlinguistic communication inherent in the use of AI tools and applications. Language learning courses in schools and training institutions should include modules aimed at educating learners about the limitations of MT technology, the information to seek when considering their use, the biases inherently programmed into the technology and the contexts in which the use of these tools could be especially controversial. In order to educate adults, freely accessible online MT systems could be required to provide information about their limitations and direct users to information programmes aimed at communicating the benefits and limitations of MT tools in easily accessible formats. Platforms could also be required to clearly indicate whether content is in the original language, was translated, and, if so, using which tool or translation company.

- **Recognising the importance of language professionals for effective information exchange.** Encourage the formal recognition of the work conducted by language professionals and ensure that language professionals remain involved in high-stakes settings requiring interlinguistic communication, such as the healthcare and the criminal justice system. Language professionals should receive training in how they can best engage in coproduction with machine-learning technologies and invest in continuous professional development. For example, the curricula of courses designed to train language professionals should include modules in post-editing and MT.

1.7.4. Strengthen a wider set of skills and attitudes AI professionals need to be able to develop ethical and trustworthy AI systems

The continuous evolution of AI systems brings with it different skills needed by AI workers to develop, adapt, and maintain AI applications, as well as different attitudes populations should have to live and work in the age of AI. Although the number of individuals with the skills needed to develop, maintain and adapt AI systems remains small, there has been a very marked increase in the demand for workers with such skills and countries' economic competitiveness rests on their ability to have a suitable pipeline of individuals with such skills. Although the deployment of AI systems poses critical ethical dilemmas, ethical considerations remain largely ignored in job postings for individuals involved in the development, maintenance and adaptation of AI tools and applications. Ensuring an adequate talent pool of individuals who are able to develop, adapt and maintain AI systems and who prioritise ethical considerations in their work, as well as populations that have the attitudes needed to work and live with AI, entails:

- **Promoting the development of skills to develop, adapt and maintain AI tools and applications.** Encourage the development of AI skills through educational programmes and training, ensuring that an adequate pipeline of learners acquire solid technical skills that would allow them to use new tools and applications as they emerge and become widely demanded in AI-related jobs while acknowledging the importance of a broad skills mix in the AI field. In particular, educational and training programmes aimed at forming AI professionals should adopt an interdisciplinary approach to skills development, combining technical expertise with leadership, management, innovation and problem-solving abilities. Given the rapidly evolving nature of the field, ensuring that education and training programmes respond to labour market needs requires fostering collaborations between education institutions and industry and creating ample opportunities for workers to engage in professional development through timely and flexible professional development opportunities.

- **Including ethical aspects of AI development and use in education and training programmes leading to AI jobs.** Despite strong commitments regarding the importance of promoting responsible AI development and use, only a small minority of employers seek AI talent with skills related to ethics in AI. Education and training programmes on data science, data analytics and similar modules that usually lead into AI professions should be required to include courses in ethics and responsible AI. Efforts should also be made to foster international collaboration and knowledge exchange to learn from best practices and experiences in different countries. Developing common frameworks, sharing insights and aligning policies can support the responsible and inclusive development and adoption of AI.

1.8. Report roadmap

This report details key results that can help OECD countries build system-level resilience by supporting a new vision for skills policies to promote an inclusive twin green and digital transition. Although the report details the interconnected nature of policies aimed at promoting environmental sustainability and using technological innovations to facilitate effective information exchange, the material is organised into two main sections:

- **The first considers the role of skills, attitudes and dispositions in promoting adaptation to environmental changes and shaping a greener future**.
- **The second considers the role of skills, attitudes and dispositions in promoting adaptation to complex information landscapes and in shaping the quality of information exchange through technological development**.

The report reviews the experiences of countries and jurisdictions that have successfully developed skills policies to empower people for the green and digital transition over the life course. As such, the report considers interventions tailored both at young people and adults and that take place in schools, workplaces and wider society. The report presents seven analytical chapters featuring detailed results and examples of policy initiatives implemented in different countries or national sub-regions. For analytical purposes, different chapters focus on different sets of countries for which data were available, with the aim of enriching the knowledge base upon which OECD countries can develop reform initiatives. A wide range of data sources and analytical techniques were also used to reflect the role of skills, attitudes and dispositions in supporting system-level resilience. These range from international, large-scale assessment initiatives of young and adult populations, such as data from the Programme for International Student Assessment (PISA) and the Survey of Adult Skills (a product of the Programme for the International Assessment of Adult Competencies [PIAAC]); data from social surveys such as the Lloyd's Risk Poll, the Wellcome Global Monitor, the World Values Survey, the European Social Survey, the OECD's Environmental Policy and Individual Behaviour Change (EPIC) Survey, the European Health Literacy

Population Survey, Ipsos Cycling Across the World Survey, the Adult Education Survey; key data on teaching languages at school in Europe; the European Labour Force Survey; the International Disasters Database; as well as data from vacancies posted on line by prospective employers. Data analysis was complemented with systematic reviews of the literature and modelling.

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2 From awareness to action: The role of attitudes and dispositions for mobilising environmental sustainability skills

This chapter combines data on the attitudes and behaviours of adults and young people in OECD countries to consider their readiness to support the green transition in the workplace and in their daily lives. Results reveal most adults in OECD countries consider climate change a "major threat". Educational attainment, gender and sectors in which individuals work are strong predictors of climate change perceptions. At the same time, on average across OECD countries, only around one in three students, by age 15, achieve at least foundational levels of science proficiency in the Programme for International Student Assessment (PISA); are aware of climate change and global warming; care for the environment; have high levels of environmental self-efficacy; and engage in behaviours to promote environmental sustainability.

Key messages

The success of the green transition hinges on implementing significant changes in individual behaviours and consumption choices alongside the reorganisation and regulation of production processes. To successfully implement these changes, as well as broader climate change mitigation policies, it is crucial to foster a strong awareness and willingness among populations to promote environmental sustainability. This chapter maps climate change perceptions among adult populations and young people's environmental sustainability competence – the knowledge, skills, attitudes and values that are critical to promoting environmental sustainability.

Key findings include:

- Across OECD countries, 68% of adults perceive climate change as a threat. This percentage varies across countries, however. For example, in Italy and Mexico, nearly 90% of adults perceive climate change as a threat, whereas in the Czech Republic, 44% do.

- Educational attainment and gender are strong predictors of climate change perceptions. For example, 73% of individuals with a tertiary qualification but 63% without secondary qualifications perceive climate change as a threat, and women are eight percentage points more likely to perceive climate change as a threat than men.

- Individuals facing different levels of economic vulnerability and working in different sectors express different attitudes towards climate change. For example, on average, 31% of individuals working in the least carbon dioxide (CO_2)-emitting industries indicate being very or extremely worried about climate change compared to 27% working in the most CO_2-emitting industries. Similarly, the higher the CO_2 emissions in a sector, the lower the support for a range of policies promoting environmental sustainability among workers in such sectors.

- On average, across OECD countries, 31% of 15-year-old students achieved foundational levels in environmental sustainability competence, meaning they had mastered the areas of environmental sustainability competence, which are: reaching at least foundational levels of scientific literacy (achieving at least proficiency Level 2 in the PISA science test); having an awareness of climate change and global warming; caring for the environment; self-efficacy about explaining environmental phenomena; and behaviour to promote environmental sustainability. However, only 13% achieved advanced levels of environmental sustainability competence, meaning they had advanced levels in scientific literacy (achieving at least proficiency Level 4 in the PISA science test); and were aware of climate change and global warming; reported that looking after the environment was important to them; had environmental self-efficacy; and engaged in pro-environmental behaviours.

- Large disparities exist in the extent to which education systems and societies equip children with environmental sustainability competence. In particular, 21% of socio-economically disadvantaged youths, but 46% of their more advantaged peers, had mastered the foundational skills and mindsets they will need to act for environmental sustainability.

- Individuals' attitudes and dispositions are more powerful drivers of engagement in environmentally sustainable behaviours than their knowledge and skills. For instance, on average, across OECD countries, students who agreed or strongly agreed that looking after the global environment was important to them were 16 percentage points more likely to save energy for environmental reasons. Similarly, students with different levels of science achievement were equally likely to engage in energy-saving behaviours.

- Within families, values, attitudes and behaviours may be passed on, resulting in an alignment of attitudes, values and behaviours between generations.

- Combining strong environmental sustainability competence with solid digital skills is key to the profound rethinking and retooling necessary to adapt the energy, urban, transport, housing, agriculture and clothing industries so that they reach climate change goals.

2.1. Introduction

Transitioning to low-carbon economies will require significant changes in how individuals act as consumers, as well as structural reforms in how production is organised. The success of the green transition requires drastic changes in how individuals behave in their daily lives and in their consumption decisions (voluntary bottom-up changes), as well as drastic changes in how production is organised and regulated (policy-driven top-down changes). Both changes – voluntary behavioural changes and changes that stem from modifications made in regulations and public policies, including local economic development policies – rest on a strong awareness and willingness of populations to promote environmental sustainability. Lack of awareness of the economic and social consequences associated with climate change reduces individuals' willingness to take action. Similarly, a lack of understanding of the threat posed by climate change and environmental degradation reduces support for structural transformations needed to protect the environment in the long term.

Developing an awareness of the threats posed by climate change and environmental degradation, a sense of urgency and agency about the importance of acting for environmental sustainability, and the willingness and capacity to act for sustainability are critical components of the green transition. Skills policies can play a key role in this respect, ensuring that adults and children alike have both the skills and the will to act for environmental sustainability. An extensive review of the literature on environmental attitudes and dispositions among adults and young people, as well as detailed descriptions of the data used in the analyses presented in this chapter, are available in the following technical working papers, which were developed to support the preparation of this chapter: Asai, Borgonovi and Wildi (2022[1]); Borgonovi et al. (2022[2]); and Borgonovi et al. (2022[3]). Readers interested in the extensive set of analyses and indicators on the role of education systems in developing environmental sustainability competence and on the determinants of environmental attitudes and dispositions among adults can consult these.

Promoting the shift towards a green economy depends on developing new technologies and infrastructures that will facilitate reducing the environmental footprint of human activities. The development of such technologies will rest on scientists and entrepreneurs to see the protection of the environment as a key goal of their activities, and this, in turn, depends on their attitudes towards environmental protection. Similarly, the rapid development of such technologies at scale will depend on public investments, which, in turn, depend on public support for prioritising environmental protection. Finally, behavioural change at the level of individuals and households will be critical for the widespread adoption of such technologies and their use in ways that are most aligned with environmental goals.

In the early 2020s, the coronavirus (COVID-19) pandemic and then the Russian Federation's war of aggression against Ukraine led to economic instability, disruption of supply chains and steep increases in energy and food prices. On the one hand, geopolitical instability and economic concerns may divert attention from the climate emergency towards economic concerns. On the other hand, they amplify the need for modern economies to reduce their reliance on fossil fuels, invest in renewable energy sources and protect the environment as a way to reduce the risk of geopolitical unrest in the coming years.

The chapter identifies the role of education and training systems in building the capacity and willingness of current and future generations to act in ways that protect the environment. This, in turn, is seen as a key goal of skills policies more generally to ensure that in the future, both consumption and production are better aligned with the achievement of environmental sustainability. Analyses presented in this chapter map climate change perceptions among adult populations as well as young people's environmental

sustainability competence. Environmental attitudes can influence consumption behaviours, policy support, voting behaviour, labour market decisions, and the willingness of individuals to develop and use their skills in ways that reduce the environmental impact of production processes.

Given this context, it is crucial to understand adults' attitudes towards climate change and the environment more generally because they influence consumption, policy, and labour market decisions. Similarly, it is critical to understand if young people have acquired the skills and the will to act for environmental sustainability. Climate change and the policies needed to mitigate it are key variables that will affect the labour market and career decisions available to individuals. In particular, the economic and lifestyle changes needed to address climate change will profoundly impact the distribution of industries, occupations, jobs and, ultimately, the demand for skills (Vona et al., 2018[4]).

2.2. Many adults perceive climate change as a threat

Recent data suggest that most adults in OECD countries consider climate change a "major threat" (Figure 2.1). On average, 68% of adults across OECD countries report that they perceive climate change as a threat, though threat perception varies significantly across countries.[1] In Mexico and Italy, for instance, nearly 90% of adults regard climate change as a major threat, but only around 44% of adults report the same in the Czech Republic. The considerable country variation in climate threat perceptions can partly be explained by a country's experience with natural disasters. Research suggests that the more familiarity and experience individuals have with extreme weather, the less psychological distance they have from the threat of climate change (Spence, Poortinga and Pidgeon, 2011[5]). According to the World Bank, Mexico is "highly vulnerable", and Italy is "particularly vulnerable" to the adverse impacts of climate change (World Bank Group, 2021[6]; 2021[7]). In addition, they both experienced significantly more natural hazards between 1980 and 2020 than the Czech Republic, which comparatively is considered "vulnerable" (World Bank Group, 2021[8]; 2021[7]; 2021[6]). The fact that Mexico and Italy have experienced more extreme weather can, therefore, help explain why the threat perception among adults in these two countries is much higher than the threat perception in the Czech Republic, a country that has had comparably few extreme climate events in the same period.

Figure 2.1. Percentage of adults who perceive climate change as a major threat in OECD countries, 2020
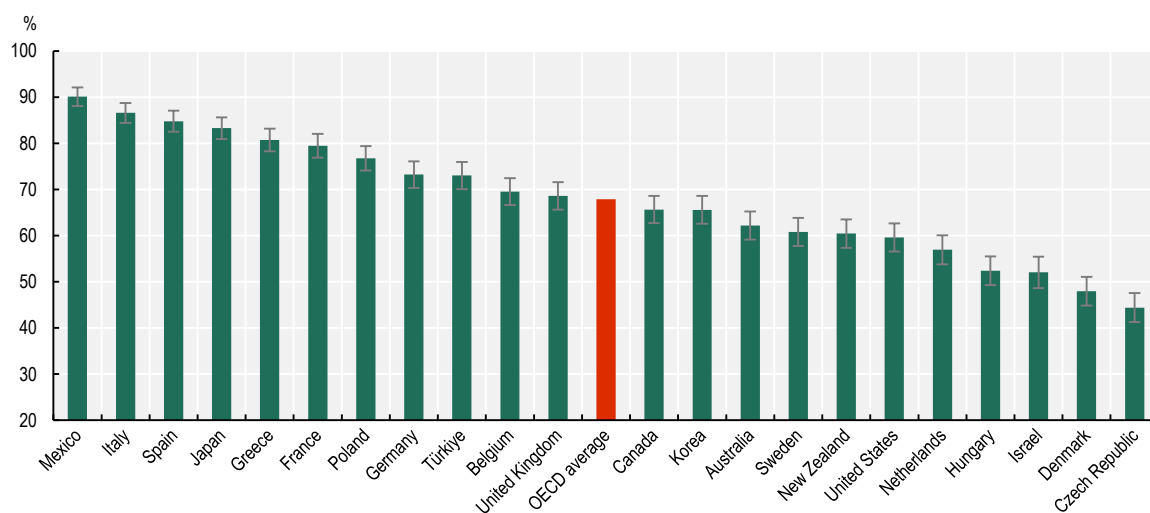
Note: Countries are ranked in descending order based on the percentage of the population aged 16 years or older who reported that they believe climate change is a major threat with the question item "Threat of Climate Change/Global Warming to People". Grey spikes in the figure indicate the 95% confidence interval.
Source: Calculations based on Wellcome (2020[9]), *Wellcome Global Monitor 2020: COVID-19* (dataset), https://wellcome.org/reports/wellcome-global-monitor-covid-19/2020#downloads-6b45.

StatLink 🔗 https://stat.link/kbx584

2.2.1. Women are more likely than men to consider climate change a threat

Women are more likely to consider climate change a major threat than men (Figure 2.2). On average, across OECD countries, women are 8 percentage points more likely than men to perceive climate change as a major threat, but gender differences are as large as 15 percentage points in Israel. The gender gap in threat perceptions is also larger than 10 percentage points in Japan, New Zealand, the United States, Sweden, Australia, Greece, the Czech Republic and Poland (listed in ascending order by gender gap in threat perception). Cross-country differences in the size of the gender gap in perceived threat are not driven by the differences in mean value across countries. That is, correcting for differences in mean value does not alter the magnitude of gender differences or the rank order of countries.

Figure 2.2. Gender differences in the perception of climate change as a major threat in OECD countries, 2020
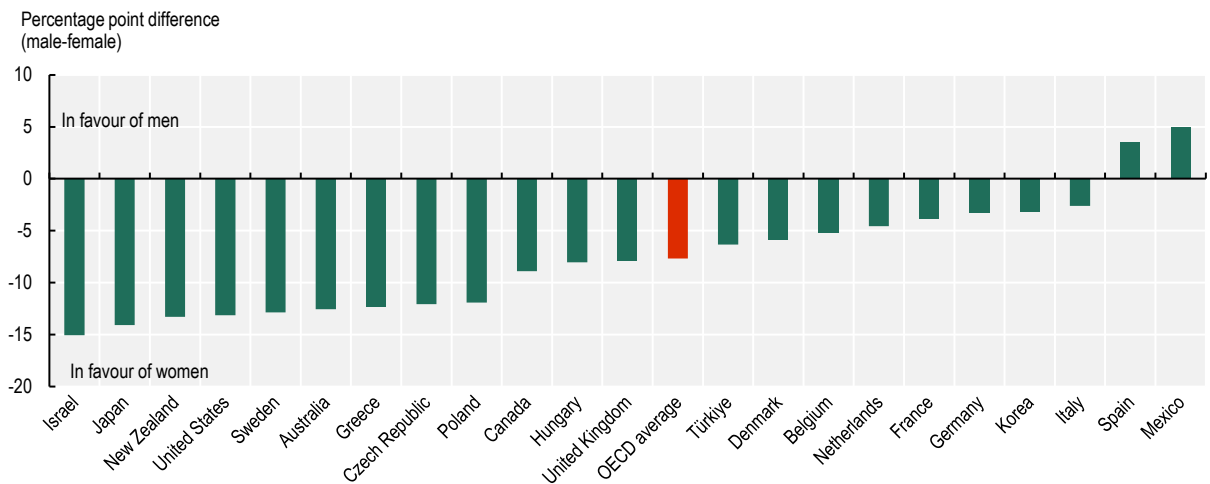
Note: Countries are ranked in ascending order based on the percentage-point difference between men and women who reported that they perceived climate change to be a major threat.
Source: Calculations based on Wellcome (2020[9]), *Wellcome Global Monitor 2020: COVID-19* (dataset), https://wellcome.org/reports/wellcome-global-monitor-covid-19/2020#downloads-6b45.

StatLink https://stat.link/7gf3k5

2.2.2. Climate change perceptions vary little across age groups

Despite widespread perceptions of young generations being more sensitive to environmental concerns, (Figure 2.3) indicates that different age groups tend to have similar perceptions about the threat posed by climate change and global warming. For example, on average across OECD countries, 66% of 16-29 year-olds perceive climate change as a threat and 69% of individuals aged 50 or over also perceive climate change as a threat. In many countries, older people seem to be only marginally more worried about potential climate threats than younger people. Japan is the only country where the age difference is pronounced: 71% of 16-29 year-olds perceive climate change as a threat, in contrast to 88% of individuals aged 50 or over – a difference that is statistically significant at conventional levels ($p<0.05$).

Figure 2.3. Differences in the perception of climate change as a major threat across age groups in OECD countries, 2020
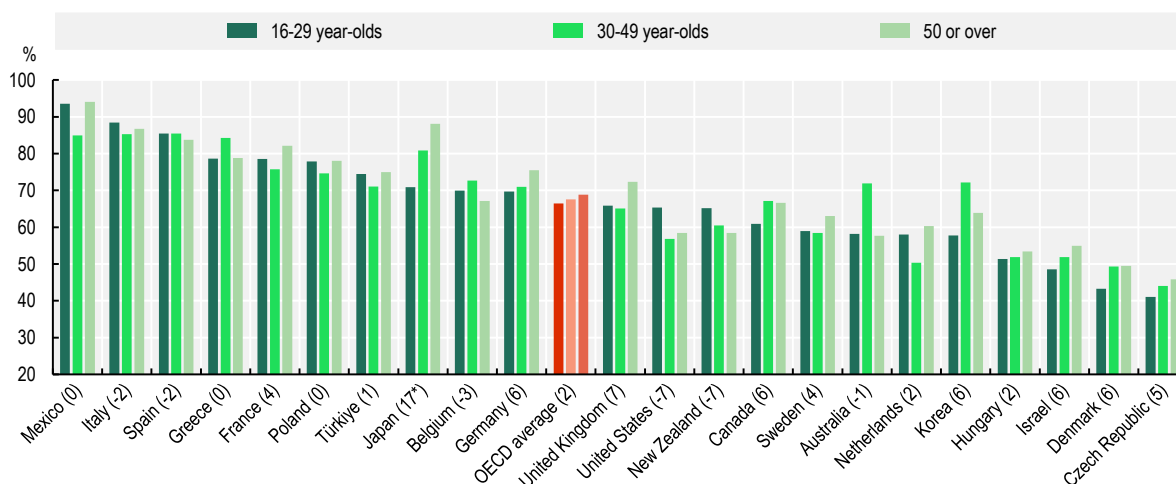
Note: Countries are ranked in descending order based on the percentage of those aged 16-29 years who reported that they perceive climate change to be a major threat. The number in brackets next to the country name represents the difference between the percentage of individuals aged 50 or above and those between the ages of 16 and 29 who report perceiving climate change as a major threat. The asterisk (*) in the bracket indicates that the difference is statistically significant at the 5% level.

Source: Calculations based on Wellcome (2020[9]), *Wellcome Global Monitor 2020: COVID-19* (dataset), https://wellcome.org/reports/wellcome-global-monitor-covid-19/2020#downloads-6b45.

StatLink 🖳📊 https://stat.link/71lacq

2.2.3. Individuals with higher levels of education are more likely to consider climate change a major threat

The literature indicates that education is positively correlated with environmental attitudes in general and towards climate change specifically and can cause individuals to behave in a more environmentally friendly manner. In fact, it has been argued that education has the strongest effect on environmental concern and is the single, most stable variable that explains environmental concern.

Education promotes an understanding of a wide range of issues, including the scientific phenomena surrounding climate change. Information – both general knowledge and subject-specific knowledge – is a crucial component in attitude formation. As a result, what individuals learn in school helps shape their attitudes on a given subject – in this case, climate change. Furthermore, education is associated with people's pro-environmental behaviours. Research has also shown that individuals with secondary or tertiary education are much less likely to deny climate change than those who only completed primary school education. Thus, when children and young adults learn (and continue to learn) about the determinants and consequences of climate change at school, they then have overall higher levels of self-reported understanding of climate change and will go on to make more informed decisions in their daily lives through political and civic participation.

Figure 2.4 reveals that in the majority of countries, individuals with higher levels of education are more likely to consider climate change a major threat. In 14 of the 22 countries, tertiary-educated adults report higher perceptions of threat than those who did not complete secondary education. Across OECD countries, 73% of individuals with a tertiary qualification, 66% with a secondary qualification and 63% of those without secondary qualifications report perceiving climate change as a threat. In eight countries, perceptions of climate change as a major threat are higher among individuals without secondary qualifications than those with tertiary qualifications. The difference is statistically significant and quantitatively large in the United States. This could be a reflection of the geographic distribution of

individuals with a different level of education in areas that are more or less affected by climate change. Cross-country differences in the association between education and perceptions of threat could be due to differences in exposure to the potential impact of climate change across education groups in the different countries. Box 2.1 illustrates differences by level of education in attitudes towards climate change and environmental issues in countries that took part in the OECD Environmental Policies and Individual Behaviour Change (EPIC) Survey in 2022.

Figure 2.4. Educational attainment and the perception of climate change as a major threat in OECD countries, 2020
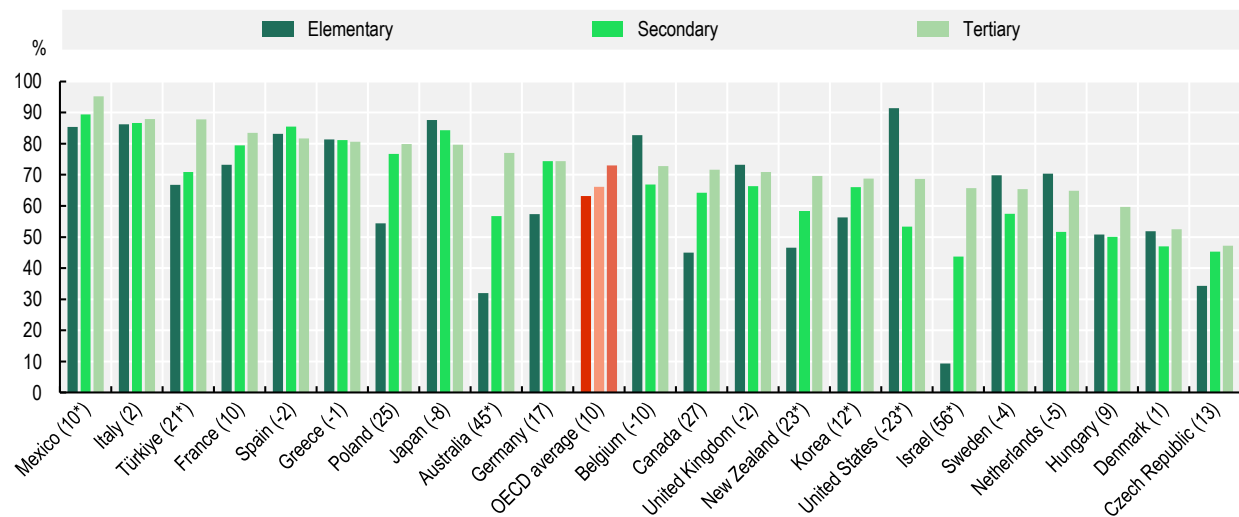
Note: Countries are ranked in descending order based on the percentage of tertiary-educated individuals who reported that they perceived climate change to be a major threat. The number in brackets next to the country name represents the percentage-point difference between tertiary-educated individuals and individuals without secondary qualifications. The asterisk (*) indicates if the difference is statistically significant at the 5% level.
Source: Calculations based on Wellcome (2020[9]), *Wellcome Global Monitor 2020: COVID-19* (dataset), https://wellcome.org/reports/wellcome-global-monitor-covid-19/2020#downloads-6b45.

StatLink 🔗 https://stat.link/pe9jug

Box 2.1. Insights from the OECD EPIC Survey on differences in attitudes towards the environment and environmental policies by level of education

The third round of the OECD's Survey on Environmental Policies and Individual Behaviour Change (EPIC) was implemented between June and July 2022. The sample included more than 17 000 households across 9 countries: Belgium, Canada, France, Israel, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States. The 2022 EPIC Survey examines household behaviour in four key areas: 1) waste generation and disposal practices; 2) transport; 3) energy use; and 4) food consumption. The survey also explores how policies may affect key consumption decisions in those four areas. The sample surveyed comprised individuals aged 18 or older with full or partial responsibility for household expenses. To ensure that the survey was representative of the population, quotas were set for age, gender, geographic region and income.

Findings from the EPIC Survey indicate that climate change and other environmental issues, such as resource scarcity and pollution, were among the top three issues of concern in five of the nine countries surveyed. The majority of respondents (65%) reported being willing to make changes to their current lifestyles in order to benefit the environment. The survey results also highlight the importance of making environmentally sustainable choices available and feasible. This includes, for example, the option for households to choose renewably generated electricity or their ability to easily charge battery powered electric vehicles.

In addition to availability, cost and convenience emerge as important factors that determine choices, even for those who report having higher levels of income and environmental concern. For instance, respondents were more likely to engage in energy conservation when this was inexpensive or easy to do: 70% of respondents indicated that they turn off the lights when leaving the room, whereas 30% indicated that they minimise the use of heating or cooling. Households are also less likely to adopt low-emissions energy technologies that have high upfront installation costs or are not well understood, and 54% of regular car users indicated they would drive a car less if public transport was improved (i.e. made cheaper, with more frequent and spatially widespread services).

Importantly, the EPIC Survey results showed that respondents were much more supportive of policies that are voluntary and that expand their set of choices, as opposed to tax-based measures or policies that prohibit certain actions or options. These findings suggest that policymakers could leverage existing policy support to advance environmental policies, e.g. by using the revenues generated from tax-based measures to improve the affordability of other sustainable options and to enhance the acceptability of tax-based measures.

Results reported in Figure 2.5 reveal that individuals who completed tertiary-level qualifications were significantly more likely to rate climate change and environmental issues as being very important to them than individuals who had not completed tertiary-level qualifications in Belgium, the Netherlands, Switzerland, the United States and the United Kingdom. In particular, differences by level of education were very pronounced in the United Kingdom, where they corresponded to 12 percentage points and Switzerland, where they corresponded to 9 percentage points. By contrast, in Canada, France, and Israel, there were no differences in ratings about the extent to which individuals with or without a tertiary degree rated climate change and environmental issues as being important to them.

Figure 2.5. Importance of environmental issues by level of educational attainment, selected countries, 2022

Percentage of respondents rating climate change and environmental issues as very important and 95% confidence intervals
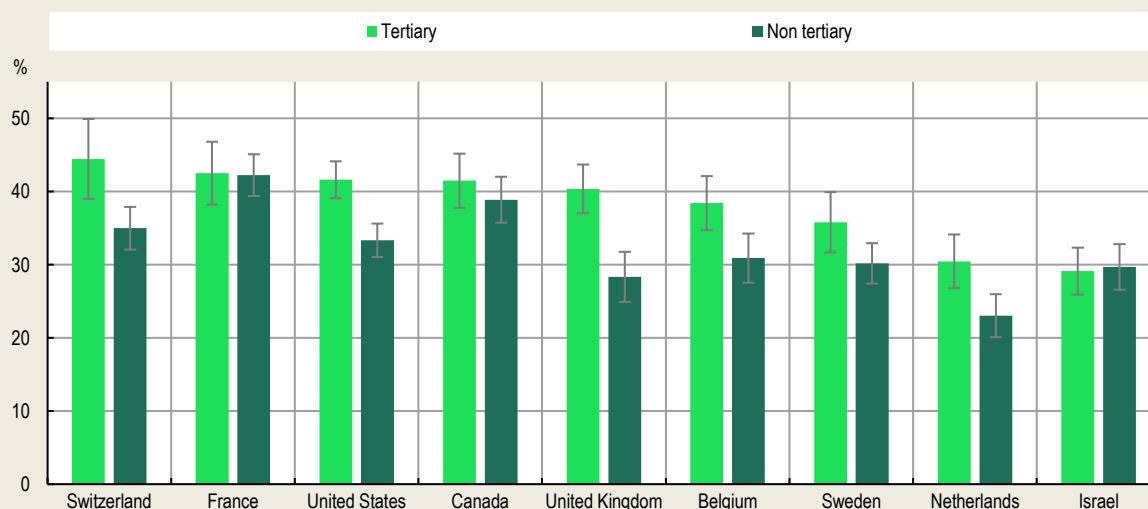
Note: Countries are sorted in descending order by the percentage of respondents rating climate change and environmental issues as very important among individuals with tertiary-level qualifications. Respondents were asked to report using a five-point scale ranging from "not at all important" to "very important" how important a series of issues were to them personally. The figure shows the percentage of respondents rating climate change and environmental issues as "very important". Grey spikes in the figure indicate the 95% confidence interval.
Source: OECD (2023[10]), *How Green is Household Behaviour?: Sustainable Choices in a Time of Interlocking Crises*, https://doi.org/10.1787/2bbbb663-en.

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Across countries examined in the EPIC Survey, 69% of individuals with and 67% without tertiary-level qualifications indicated that they expected climate change and environmental issues to negatively affect the quality of life of younger generations (Figure 2.6). Whereas similar percentages of respondents with and without tertiary-level qualifications reported expecting climate change and environmental issues to negatively affect their health (54% and 53%), individuals without tertiary-level qualifications were more likely to expect climate change and environmental issues to negatively affect their job security and less likely to expect them to affect miscellaneous aspects of their lives. In particular, only 18% of respondents with, and 22% without, a tertiary-level qualification, indicated that they expected climate change and other environmental issues to negatively affect their job security.

Figure 2.7 suggests that individuals with tertiary-level qualifications are considerably more likely than individuals without tertiary-level qualifications to indicate that they would be willing to make compromises in their current lifestyle for the benefit of the environment (71% of individuals with tertiary-level qualifications, but 61% of those without reported the same); that protecting the environment can boost the economy (71% of individuals with tertiary-level qualifications, but 59% of those without reported the same); that environmental issues should be resolved mainly through public policies (62% of individuals with tertiary-level qualifications, but 51% of those without reported the same); and that environmental issues will be resolved primarily through technological progress (52% of individuals with tertiary-level qualifications, but 40% of those without reported the same). By contrast, individuals without tertiary-level qualifications were more likely to indicate that environmental policies introduced by the government should not cost them extra money (60% of individuals with tertiary-level qualifications but 65% of those without reported the same). Although only a minority of respondents said that environmental issues should be dealt with primarily by future generations, individuals with tertiary-level qualifications were more likely than those without to report this (29% of respondents with tertiary-level qualifications, but 25% of respondents without did).

Figure 2.6. Share of respondents perceiving negative impacts of climate change or other environmental issues, 2022

Percentage of respondents stating that climate change or other environmental issues will negatively affect aspects of their life and 95% confidence intervals
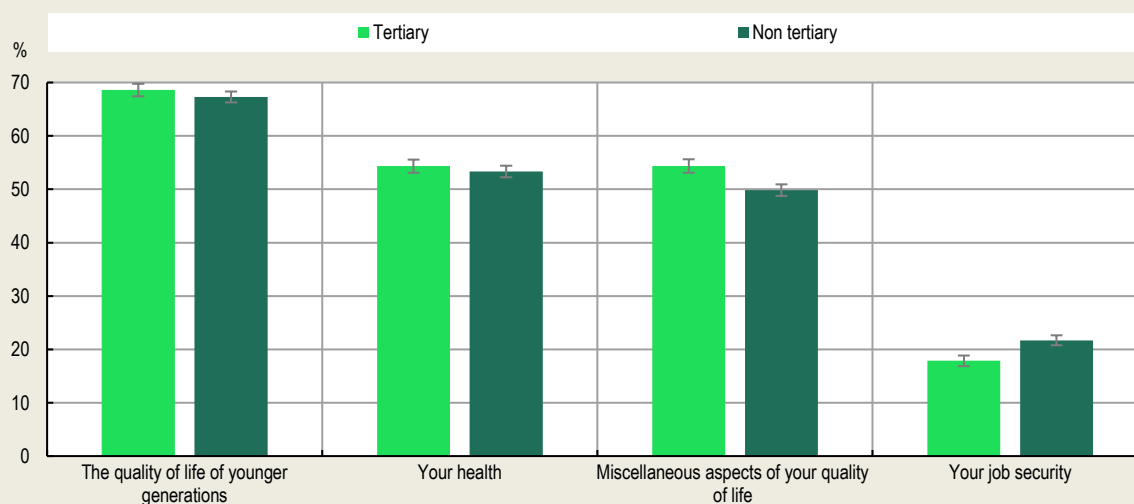
Note: This survey item asked respondents, "How do you expect climate change (e.g. rising average temperatures, changes in extreme weather events) or other environmental issues to impact the following?" Respondents rated the impact on a five-point scale from "very negatively" to "very positively". Grey spikes in the figure indicate the 95% confidence interval.

Source: OECD (2023[10]), *How Green is Household Behaviour?: Sustainable Choices in a Time of Interlocking Crises*, https://doi.org/10.1787/2bbbb663-en.

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Figure 2.7. Respondents' opinions on addressing environmental issues, 2022

Percentage of respondents agreeing or strongly agreeing with statements
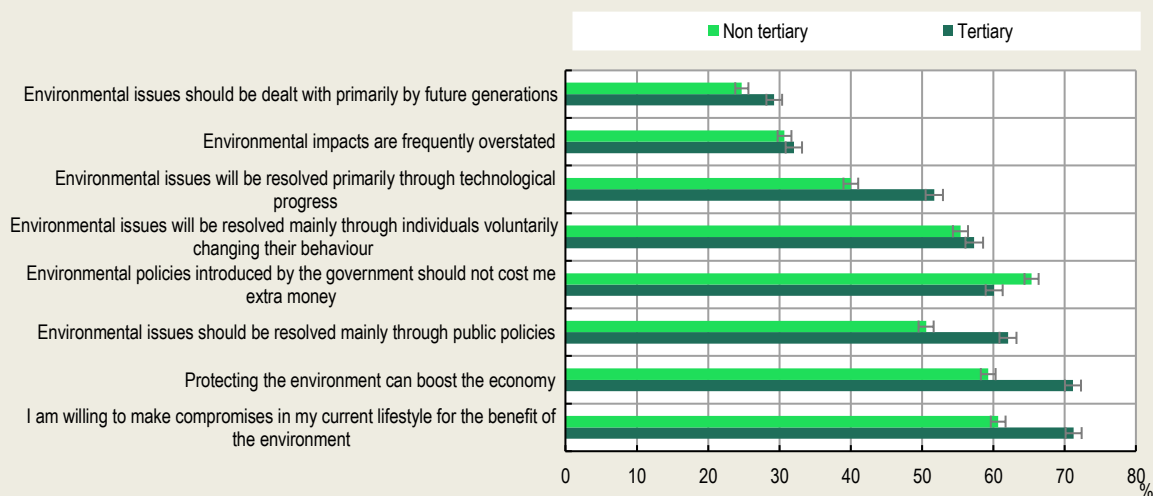
Note: This survey item asked respondents, "To what extent do you agree with each of the following statements?" Respondents stated their level of agreement on a five-point scale from "strongly disagree" to "strongly agree". Grey spikes in the figure indicate the 95% confidence interval.

Source: OECD (2023[10]), *How Green is Household Behaviour?: Sustainable Choices in a Time of* Interlocking *Crises*, https://doi.org/10.1787/2bbbb663-en.

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Education not only helps shape attitudes towards the environment in general, and climate change in particular, and subsequently pro-environmental behaviour, but it is also key in equipping students with a solid foundational understanding of environmental phenomena and fostering the desire to learn more about and engage with environmental problems. Individuals who continue their studies and pursue higher educational qualifications generally acquire skills and habits that allow them to search for and understand information about environmental issues. In fact, educational attainment has been found to be one of the strongest predictors of the willingness to learn (OECD, 2021[11]). Given this, more educated individuals are more likely to continuously seek out relevant information and update their beliefs and understanding, even with regard to climate change, which could result in an even larger gap in environmental awareness over time. The implication is that obtaining a higher education may not only provide additional environmental information but, more importantly, it may prepare individuals to be lifelong learners, capable of constantly updating their knowledge and understanding.

2.2.4. Attitudes towards climate change differ depending on the sector in which individuals work

Results presented in Figure 2.8 indicate that in many countries, individuals working in industries that are among the 25% heaviest emitters of CO_2 are less likely to believe in climate change than individuals working in industries that are among the 25% lowest emitters of CO_2. Examples of most-emitting industries include coal and refined petroleum products; mining and quarrying, non-energy producing products; and water transport. The least-emitting industries include information technology and other information services; human health and social work activities; and administrative and support services. For example, in Ireland, 60% of individuals working in high CO_2-emitting industries report believing that climate change is definitely happening, while this is the case for 72% of those working in low CO_2-emitting industries. Similarly, in Switzerland, the Netherlands, Belgium, Germany, France, the United Kingdom, Sweden,

Poland, Hungary, Austria, Norway, Israel, Estonia, the Czech Republic and Finland (ranked in descending order based on the percentage of the population that believe climate change is definitely happening), individuals working in high greenhouse gas (GHG)-emitting industries were less likely to report that they believe that climate change is definitely happening than individuals working in low CO_2-emitting industries. Note that this relationship does not necessarily indicate a causal effect of sectoral CO_2 emissions on attitudes towards climate change but may reflect the different sorting of workers into different sectors.

Figure 2.8. Climate change belief and CO_2 emissions per output in OECD countries, 2020

Percentage of the population who believe that climate change is definitely happening
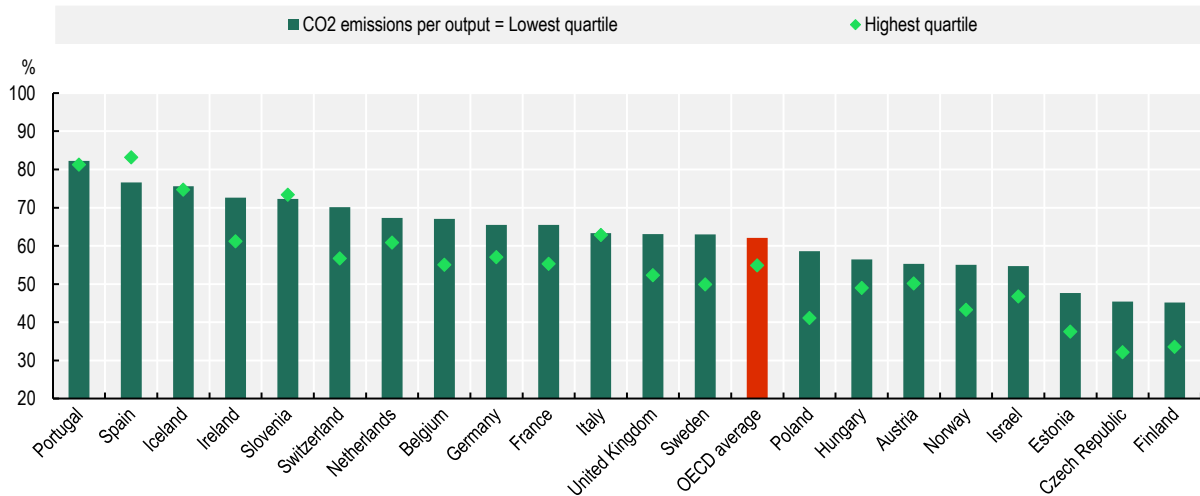
Note: Countries are sorted in descending order of the percentage of the population aged 16 years or above who believe that climate change is definitely happening and work in the sectors with the lowest quartile of CO_2 emissions multiplier within each country. The figure also shows the same outcome for the individuals working in the sectors with the highest quantile in terms of CO_2 emissions multiplier.
Source: Calculations based on European Social Survey (2020[12]), *European Social Survey (Round 8)* (dataset), https://doi.org/10.21338/ESS8E02_2.

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Figure 2.9 also shows that in the majority of countries, the percentage of individuals who are "very" or "extremely worried" about climate change is lower among individuals working in the most CO_2-intensive sectors than among individuals working in the least CO_2-intensive sectors, although differences are generally not very pronounced. On average, 31% of individuals working in the least CO_2-emitting industries report being "very" or "extremely worried" about climate change, in contrast to 27% of individuals working in the most CO_2-emitting industries.

Figure 2.9. Climate change concern and CO_2 emissions per output in OECD countries, 2020

Percentage of the population who are "very" or "extremely worried" about climate change
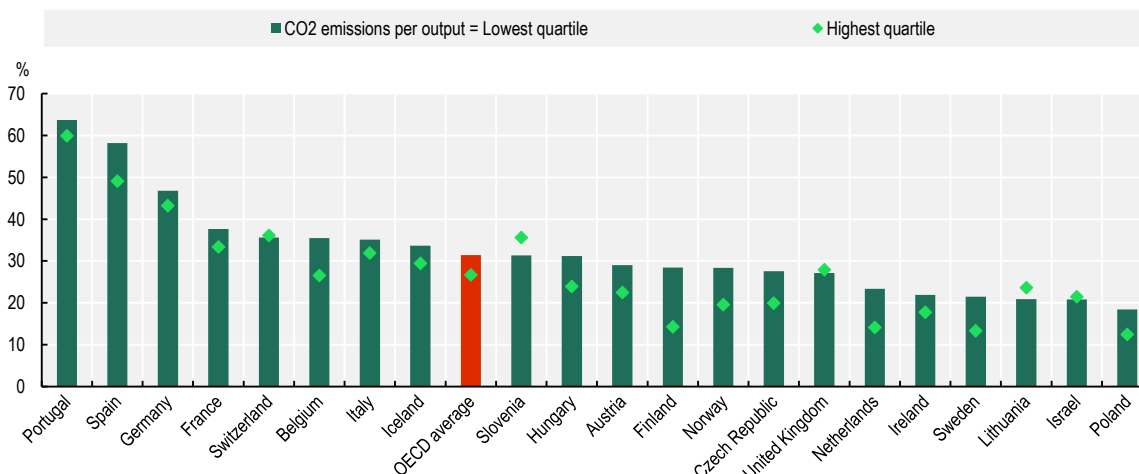
Note: Countries are sorted in descending order of the percentage of the population aged 16 years or above who are "very" or "extremely worried" about climate change and work in the sectors with the lowest quartile of CO_2 emissions multiplier within each country. The figure also shows the same outcome for the individuals working in the sectors with the highest quartile in terms of CO_2 emissions multiplier.
Source: Calculations based on European Social Survey (2020[12]), *European Social Survey (Round 8)* (dataset), https://doi.org/10.21338/ESS8E02_2.

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Figure 2.10 indicates that, controlling for country-specific effects, as well as personal characteristics, such as age, gender and educational attainment, individuals who work in a more CO_2-intensive sector are less likely to believe that climate change is happening, are less worried about climate change, and have a lower willingness to engage in behaviour aimed at reducing environmental degradation, although results are imprecisely estimated. The estimated effects are significant for belief in climate change and policy support. For example, working in sectors that emit 1% more CO_2 per output is associated with a lower probability of believing that climate change is definitely happening of 0.8 percentage points. Similarly, working in sectors that emit 1% more CO_2 per output is associated with a 1.5 percentage point lower probability of supporting a fossil-fuel tax. Conversely, the estimated effects are smaller and statistically insignificant with respect to climate worry and engagement in pro-environmental behaviour. To put this into perspective, workers in the most-emitting sectors among the top quartile in terms of the average CO_2 emission per output across countries are less likely to state that climate change is definitely happening by approximately 17 percentage points, relative to workers in the least-emitting sectors among the lowest quartile.

These results could reflect that individuals more concerned about the environment work in industries and occupations less likely to contribute to environmental degradation. However, they could also imply that individuals adjust their attitudes and beliefs to the context in which they operate as a way to cognitively justify their everyday work. Finally, employment ethos, context and peer pressure could shape individuals' attitudes and dispositions. Being surrounded by individuals who express greater environmental concerns and care about environmental protection every day at work might change the environmental concerns or the pro-environmental dispositions of someone with less positive attitudes towards the environment.

Figure 2.10. The impact of working in CO$_2$-intensive industries on attitudes towards climate change and support for pro-environmental policies

Impact of 1% increase in sector CO$_2$ emissions multiplier on attitudes, behaviour and policy support
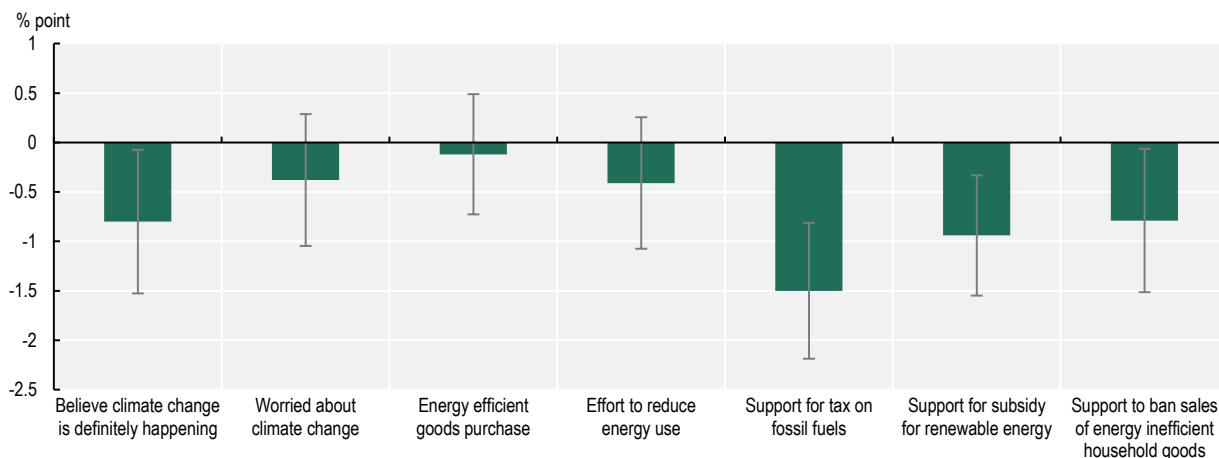
Note: The figure shows the regression coefficients on the log of CO$_2$ emissions multiplier in which individuals work on the various environmental attitudes. The regression is based on a pooled sample of countries, and the specification includes country-fixed effects and control for personal characteristics (age, gender and educational attainment). Grey spikes in the figure indicate the 95% confidence interval.
Source: Calculations based on European Social Survey (2020[12]), *European Social Survey (Round 8)* (dataset), https://doi.org/10.21338/ESS8E02_2 and on the World Values Survey (2014[13]), *World Values Survey: All Rounds - Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7).

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2.2.5. Attitudes towards climate change shape public support for environmental protection policies

Data show that individuals who are more worried about climate change tend to act more pro-environmentally and express support for pro-environment policies (Figure 2.11). For example, there is approximately a 10 percentage-point difference in the percentage of individuals who choose an energy-efficient product when purchasing a large electrical appliance between those who are more worried about climate change and those who are not. Individuals who are worried about climate change are also more likely to support pro-environmental policies, ranging from fossil-fuel taxation, renewable energy subsidies and bans on energy-inefficient household goods.

Figure 2.11 also makes clear that, in general, taxation is less favoured than subsidies and product-market interventions. One reason for this could be that fossil fuel taxes are already high in most OECD countries. For example, in 2018, OECD and Group of Twenty (G20) countries priced 80% of carbon emissions from road transport at EUR 60 or more (OECD, 2021[14]). Furthermore, research from the OECD has found that although taxes on fossil fuels appear to be among the least popular policies, what matters greatly is the use of the carbon tax revenue (Dechezleprêtre et al., 2022[15]). The study found that if carbon taxes were used to fund environmental infrastructure, subsidise low-carbon technologies or reduce income taxes, they would receive more support than if they were distributed equally to everyone (Dechezleprêtre et al., 2022[15]). The higher willingness of populations to support incentives and subsidies for low-carbon technologies over carbon taxes may have driven the adoption of the US Inflation Reduction Act of 2022. The bill includes incentives, such as tax credits, to encourage people to upgrade their homes in energy-efficient ways (Gabbatiss, McSweeney and Viglione, 2022[16]) and purchase clean vehicles (Ermey, 2022[17]).

Figure 2.11. Perceptions of climate change threat and engagement in pro-environmental behaviours and support for environmental protection policies

Percentage of the population who engage in pro-environment behaviour and support environmental protection policies
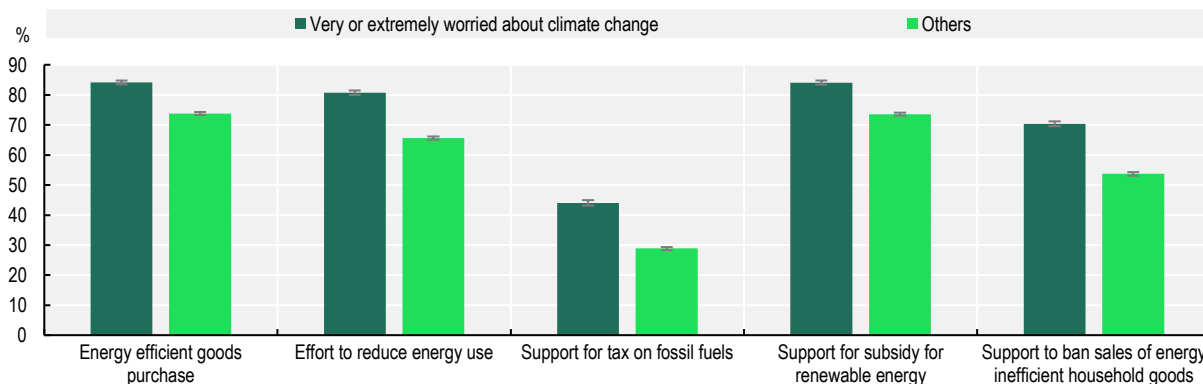
Note: Each bar represents the percentage of the population (aged 15 years or over) who engage in pro-environment behaviour and support environmental protection policies. The figure makes comparisons between those who are "very" or "extremely worried" about climate change and those who are not (i.e. either not at all worried, not very worried, or only somewhat worried). Asai, Borgonovi and Wildi (2022[1]) specify how the dichotomous variables are constructed. Grey spikes in the figure indicate the 95% confidence interval.
Source: Calculations based on European Social Survey (2020[12]), *European Social Survey (Round 8)* (dataset), https://doi.org/10.21338/ESS8E02_2.

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Overall, results indicate significant variation in adults' attitudes towards the environment and support for public policy across countries and individuals based on gender and education, as well as people's economic vulnerability and the sectors they work in. Given this context, it is crucial to further understand how environmental attitudes are developed, especially among young people. Have young people today acquired the skills as well as the will to act for environmental sustainability? The next section will address this question.

2.3. Few young people excel in all dimensions of environmental sustainability

Young people play a crucial role in protecting the environment. Their present choices and behaviours as consumers have a direct tangible impact on the success of existing efforts to protect the environment. At the same time, the choices they undertake and the knowledge they accumulate in their formative years can significantly shape whether they will decide to seek employment opportunities that align with the achievement of green objectives or not, their future consumption decisions, their engagement in grassroots initiatives aimed at promoting environmental protection and their support for climate change mitigation policies. Considering the competences pupils have is therefore critical because they are at the basis of students full and active participation as young citizens of the world. Such competences shape and determine their willingness to shape the planet's future in sustainable ways.

Environmental sustainability competence comprises the knowledge, skills, attitudes and values that are critical to promoting environmental sustainability. In order for young people to engage in meaningful action in the present and be ready to take on challenges in the future, they should have developed all areas that constitute environmental sustainability competence, including cognitive (knowledge and skills), affective (attitudes and values) as well as behavioural (engagement in activities supporting the environment) aspects. Although several theoretical and operational definitions of environmental sustainability competence exist, this report borrows the GreenComp environmental sustainability competence approach, according to which sustainability education aims "to nurture a sustainability mindset from childhood to

adulthood with the understanding that humans are part of and depend on nature. Learners are equipped with knowledge, skills and attitudes that help them become agents of change and contribute individually and collectively to shaping futures within planetary boundaries" (Borgonovi et al., 2022[3]).

The GreenComp framework identifies four areas that characterise environmental sustainability competence: 1) embodying sustainability values; 2) embracing complexity in sustainability; 3) envisioning sustainable futures; and 4) acting for sustainability. Embodying sustainability values implies that learners reflect on personal values and worldviews and compare them with unsustainability and sustainability values and worldviews. Embracing complexity in sustainability implies that learners adopt systemic and critical thinking to better assess information and frame current or future challenges as sustainability problems. Envisioning sustainable futures implies that learners can imagine alternative scenarios and identify steps to achieve a sustainable future by using creativity and adapting to change. Finally, acting for sustainability implies that learners act individually and collectively to shape sustainable futures and demand effective policy action for sustainability. Figure 2.12 details the four areas that characterise environmental sustainability competence and the indicators used to map them among young people.

Figure 2.12. Environmental sustainability competence

Embodying sustainability values	• Caring about the environment
Embracing complexity in sustainability	• Science achievement • Awareness of climate change and global warming
Envisioning sustainable futures	• Environmental self-efficacy
Acting for sustainability	• Reducing energy consumption • Participation in activities in favour of environmental protection
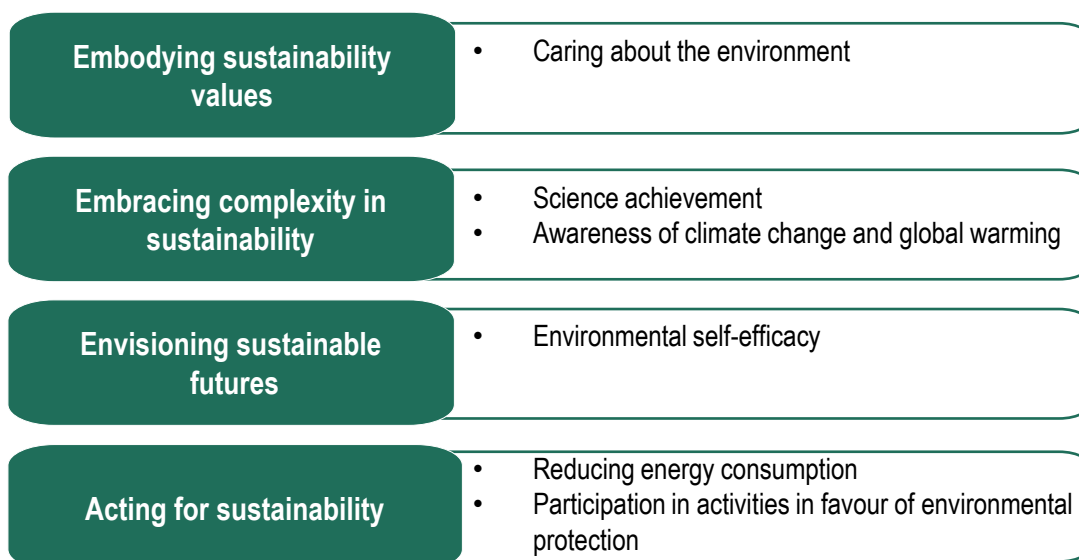
Source: Adapted from Borgonovi et al. (2022[3]), "Young people's environmental sustainability competence: Emotional, cognitive, behavioural, and attitudinal dimensions in EU and OECD countries", https://doi.org/10.1787/1097a78c-en.

2.3.1. In which countries are students prepared to tackle environmental challenges and be environmentally thoughtful consumers?

Students who, by age 15, have acquired the four key competence areas that characterise environmental sustainability are considered to have environmental sustainability competence. Environmental sustainability competence includes four areas: proficiency in science literacy, displaying an awareness of key environmental problems, having the agency to take action, caring for the environment and being willing to act to protect the environment (Box 2.2).

These two groups can be identified depending on their level of proficiency in science (Box 2.2). **Students with foundational levels in environmental sustainability competence** are those who, on top of fulfilling the other environmental competence areas, performed at least at the Programme for International Student Assessment (PISA) foundational level of science proficiency [PISA Level 2, see Section 1 in Borgonovi et al. (2022[3]) for a description]. Students with foundational levels in environmental sustainability competence can be expected to have acquired the level of skills that will enable them to become thoughtful

citizens, to be engaged in protecting the environment through their consumption decisions and lifestyle choices and to have the emotional, cognitive and behavioural mindset to be able to consider the environmental consequence of their actions. The second group is that of **students with advanced levels in environmental sustainability competence**, students who mastered the science skills needed to have a strong performance in PISA (defined as achieving at least proficiency Level 4) and who, in the future, could engage more directly in shaping the green economy by developing new technologies, innovating in the use of existing technologies in environmentally sound ways or by developing new solutions to reduce the environmental footprint associated with producing goods and services.

Box 2.2. Definition of environmental sustainability competence groups

Students with foundational levels in environmental sustainability competence achieve at least at proficiency Level 2 in the PISA science test and:

- **Are aware of climate change and global warming.** Students report either "I know something about this and could explain the general issue" or "I am familiar with this and I would be able to explain this well" about the environmental issues of climate change and global warming.

- **Care for the environment**. Students agree or strongly agree that looking after the environment is important to them.

- **Are self-efficacious about being able to explain environmental phenomena.** Students who reported that they could easily perform at least one of the three tasks, or reported that they could perform all three with a bit of effort, were considered to display high levels of environmental self-efficacy [for the tasks, see Box 1.5 in Borgonovi et al. (2022[3])].

- **Behave to promote environmental sustainability.** Students report engaging in either energy-saving or collective action to protect the environment.

Students with advanced levels in environmental sustainability competence are those who satisfy the same conditions but instead of achieving at least Level 2, achieve at least at Level 4 in the PISA science test.

Figure 2.13 and Figure 2.14 illustrate the distribution of 15-year-old students who, in 2018, had acquired the full range of cognitive, affective and behavioural dimensions of environmental sustainability to exert positive change in the future, i.e. those with advanced levels of competence.

Figure 2.13 illustrates the percentage of 15-year-old students who, in 2018, had foundational levels in environmental sustainability competence. On average, 31% of 15-year-old students across OECD countries had foundational levels. These students achieved at least PISA Level 2 in science; reported being aware of climate change and global warming; felt confident about discussing or explaining environmental problems to others; reported that caring for the environment was important to them; and engaged in pro-environmental behaviour by either saving energy or participating in environmental groups. In Korea, one in two 15-year-old students in 2018 had foundational levels in environmental sustainability competence, the largest share across OECD countries with available data. In Canada, Portugal and Malta, over 40% of 15-year-olds had foundational levels. By contrast, in Bulgaria, Italy, Romania and the Slovak Republic, only one in four 15-year-old students or less had foundational levels. Results presented in Figure 2.13 indicate that, on average across OECD countries, only around one in three students, by age 15, mastered the emotional, cognitive and behavioural areas of environmental sustainability competence that represent a solid foundation upon which to build their future and the future of the planet. In other words, the vast majority of 15-year-old students in 2018 failed to acquire the entire environmental competence toolbox.

Figure 2.13. Distribution of students with foundational levels in environmental sustainability competence in OECD countries (PISA 2018)

Percentage of 15-year-old students who achieved at least foundational levels in the four environmental sustainability competence areas
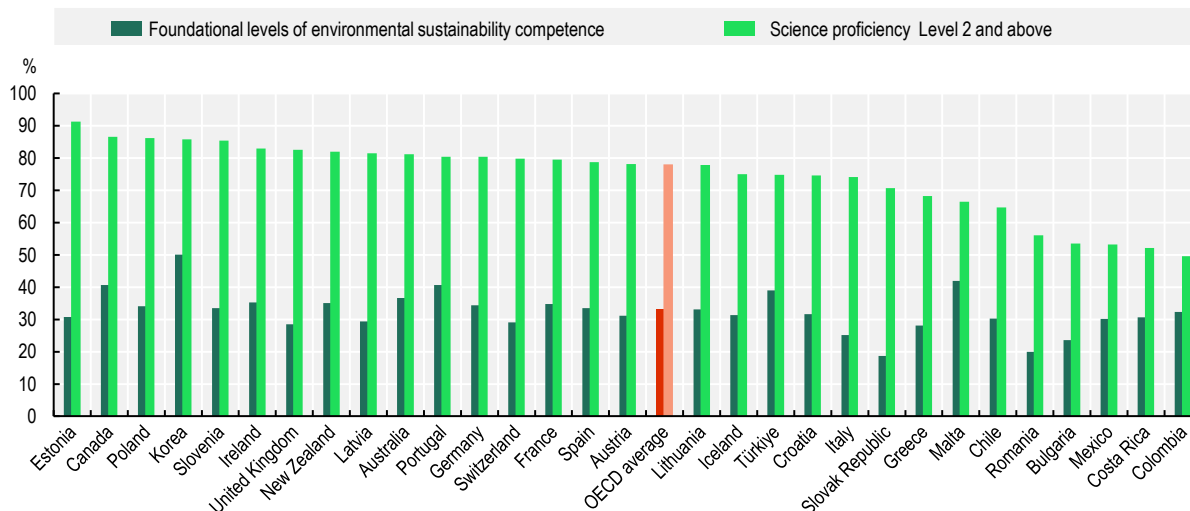
Note: Countries are sorted in descending order of the percentage of students who achieved foundational levels in environmental sustainability competence. Results were obtained from the sub-sample of students with valid information on all areas. The figure presents the percentage of students who reported that looking after the environment was important to them; who achieved at least the foundational proficiency Level 2 in the PISA science assessment; who indicated being aware of climate change and global warming; who reported high levels of environmental self-efficacy [see Section 1 in Borgonovi et al. (2022[3]) for a full description]; and who reported either reducing energy consumption for environmental reasons or participating in activities in favour of environmental protection.
Source: Calculations based on OECD (2018[18]), *PISA 2018 Database*, www.oecd.org/pisa/data/2018database/.

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Figure 2.14 illustrates the distribution of 15-year-old students who, in 2018, had advanced levels in environmental sustainability competence. It indicates that, on average across OECD countries, 13% of 15-year-old students in 2018 achieved advanced levels in environmental sustainability competence, meaning that they were strong performers in the PISA science test, achieving at least proficiency Level 4; as well as reporting that looking after the environment was important to them; being aware of climate change and global warming; having high environmental self-efficacy; and engaging in pro-environmental behaviours. Only in Canada, Germany, and Korea did at least one in five students satisfy all conditions to be considered as having advanced levels of environmental sustainability competence, reflecting the high number of students who, at age 15, achieved only foundational proficiency levels in science. In nine countries – Bulgaria, Chile, Colombia, Costa Rica, Greece, Italy, Mexico, Romania, and the Slovak Republic – less than one in ten students achieved advanced levels of environmental sustainability competence. This is despite the fact that in order to ensure an economy-wide effort to meet ambitious climate targets, OECD countries will have to re-orient production to satisfy net-zero requirements, and such re-orientation requires labour market re-allocation towards jobs in the green economy. Such jobs require strong technical skills, which most 15-year-olds in OECD countries lack.

Figure 2.14. Distribution of students with advanced levels in environmental sustainability competence in OECD countries (PISA 2018)

Percentage of 15-year-old students who achieved high levels in the four environmental sustainability competence areas
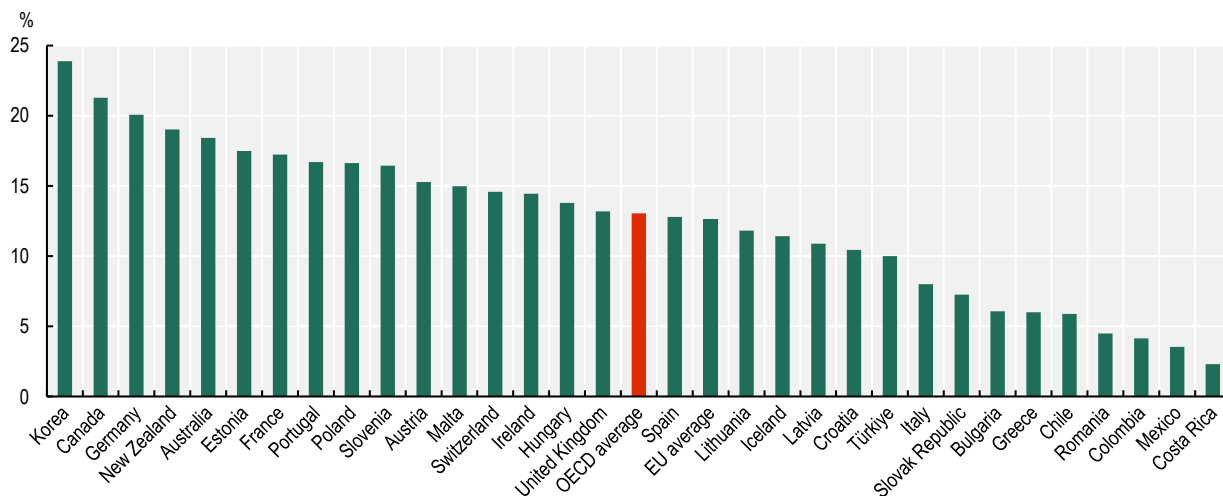
Note: Countries are sorted in descending order of the percentage of students who achieved advanced levels of environmental sustainability competence. Results were obtained from the sub-sample of students with valid information in all areas. The figure presents the percentage of students who reported that looking after the environment was important to them; who achieved at least the foundational proficiency Level 4 in the PISA science assessment; who indicated being aware of climate change and global warming; who reported high levels of environmental self-efficacy [see Section 1 in Borgonovi et al. (2022[3]) for a full description]; and who reported either reducing energy consumption for environmental reasons or participating in activities in favour of environmental protection.
Source: Calculations based on OECD (2018[18]), *PISA 2018 Database*, www.oecd.org/pisa/data/2018database/.

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Figure 2.15 shows gender and socio-economic status data for this population (OECD average): the percentage of boys and girls who had foundational and advanced levels in environmental sustainability competence and the percentage of socio-economically disadvantaged and advantaged students who had foundational and advanced levels in environmental sustainability competence.

Results indicate that in 2018, more girls than boys achieved foundational levels: 35% of girls but 31% of boys had foundational levels in environmental sustainability competence across OECD countries. Detailed country analyses reveal that gender differences in favour of girls were especially pronounced in Korea, Lithuania and Poland, where the gender gap was 7 percentage points; Bulgaria and Malta, where the gap was 8 percentage points; and the Republic of Türkiye (hereafter "Türkiye"), where the gender gap was 9 percentage points. By contrast, Figure 2.15 shows that in 2018, there was no gender difference in the percentage of boys and girls who achieved advanced levels in environmental sustainability competence: 13% of boys and girls across OECD countries could be classified as having advanced levels. Country-specific analyses reveal that in Estonia and Korea, girls were considerably more likely than boys to be classified as having advanced levels in environmental sustainability competence (in Estonia, 19% of girls but 16% of boys, and in Korea, 25% of girls but 23% of boys). Differences in the percentage of girls and boys who achieved foundational and advanced levels in environmental sustainability competence are due to differences in the likelihood that boys and girls will be high and low achievers in science. Box 2.3 discusses in detail gender differences in science achievement by level of achievement and by science domain.

Figure 2.15 also provides, for the OECD average, the percentage of socio-economically disadvantaged and advantaged students who achieved foundational levels in environmental sustainability competence. Socio-economically disadvantaged students are students in the bottom quartile of the national distribution of the PISA index of economic, social and cultural status (ESCS). Socio-economically advantaged students are students in the top quartile of the national distribution of ESCS. On average, across OECD countries, 21% of socio-economically disadvantaged but 46% of socio-economically advantaged students had foundational levels in environmental sustainability competence, a difference of 25 percentage points. Country-specific analyses reveal that socio-economic disparities in the percentage of students with foundational levels were larger than 30 percentage points in Bulgaria, Hungary and Portugal and were below 20 percentage points only in Italy (16 percentage-point difference) and Türkiye (17 percentage-point difference).

Figure 2.15. Distribution of students with foundational and advanced levels in environmental sustainability competence by gender and socio-economic status, OECD average (PISA 2018)

Percentage of 15-year-old boys and girls who achieved foundational and advanced in the four environmental sustainability competence areas and percentage of socio-economically advantaged and disadvantaged 15-year-old students who achieved foundational and high levels in the four environmental sustainability competence areas
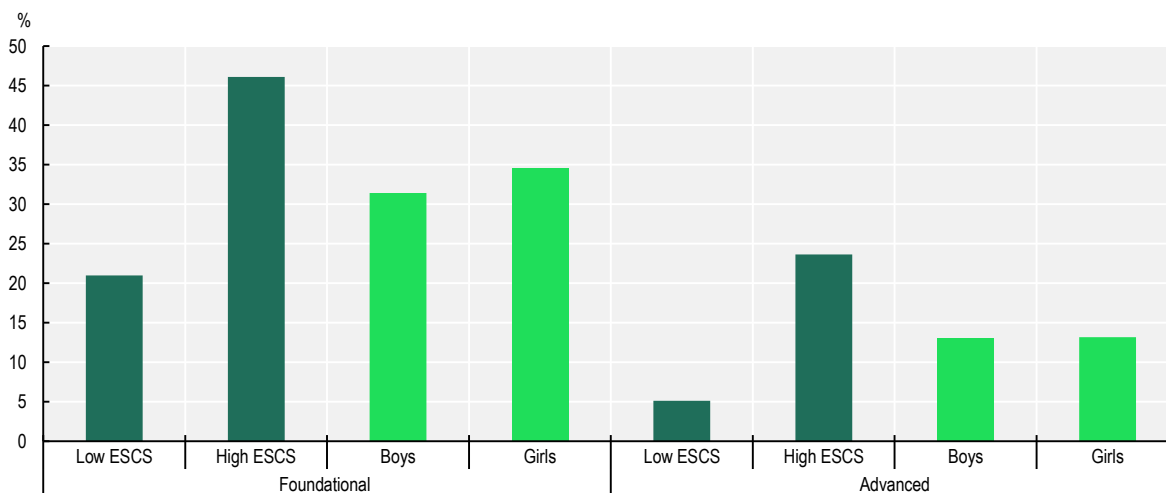
Note: The figure presents the percentage of boys and girls who reported that looking after the environment was important to them and the percentage of socio-economically advantaged and disadvantaged students who reported that looking after the environment was important to them; who achieved at least the foundational proficiency Level 2 (students with foundational levels in environmental sustainability competence) and Level 4 (students with advanced levels in environmental sustainability competence) in the PISA science assessment; who indicated being aware of climate change and global warming; who reported high levels of environmental self-efficacy [see Section 1 in Borgonovi et al. (2022[3]) for a full description]; and who reported either reducing energy consumption for environmental reasons or participating in activities in favour of environmental protection. Socio-economically disadvantaged students are students in the bottom quartile of the national distribution of the PISA index of economic, social and cultural status (ESCS). Socio-economically advantaged students are students in the top quartile of the national distribution of ESCS.
Source: Calculations based on OECD (2018[18]), *PISA 2018* Database, www.oecd.org/pisa/data/2018database/.

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Figure 2.15 also shows that there are large differences per socio-economic status in the likelihood that 15-year-old students will have advanced levels in environmental sustainability competence. On average, across OECD countries, 5% of socio-economically disadvantaged, but 24% of socio-economically advantaged students, had advanced levels of competence, a difference of 19 percentage points. Country-specific analyses reveal that socio-economic disparities in the percentage of those who had advanced levels in environmental sustainability competence were larger than 25 percentage points in France, Germany, New Zealand, Portugal and Switzerland. These results are especially concerning because PISA reveals that students with a socio-economically disadvantaged background are less likely than their more advantaged counterparts to expect to continue their studies (OECD, 2021[11]), and individuals from disadvantaged backgrounds are more likely to work in jobs that are likely to be displaced by the twin digital and green transition (Box 2.4). These results suggest that initial education systems are currently failing to equip many youngsters, and socio-economically disadvantaged youngsters in particular, with the foundation skills and mindsets they will need in order to be open to finding employment opportunities in the new green economy.

Box 2.3. Gender differences in science differ by level of proficiency and science competency subscale

Although at age 15, boys and girls perform at similar levels in science (OECD, 2019[19]), in many countries, boys are over-represented among students with the highest levels of achievement. Moreover, boys and girls are not equally likely to perform at similar levels in different areas of science. In particular, boys and girls are not equally likely to achieve high levels in areas of science that pertain to physics, biology or geoscience.

Figure 2.16 illustrates the gender gap (measured in percentage-point difference) in PISA 2015 in different areas of science among students with different levels of achievement. Boys were over-represented among the highest achieving students (defined as students performing at or above proficiency Level 5 in PISA 2015) in all science tasks but, in particular, in science tasks requiring them to explain phenomena scientifically or in tasks related to physics (the difference in the percentage of boys and girls who performed at this level in these tasks was 3 percentage points). By contrast, the gender gap among the highest achievers was less pronounced when considering science tasks requiring students to evaluate and design scientific enquiry or tasks requiring students to display their procedural and epistemic knowledge (the difference in the percentage of boys and girls who performed at this level was 1 percentage point). By contrast, Figure 2.16 reveals that in many areas, 15-year-old girls are more likely than boys to perform at least at foundational levels (defined as achieving at least proficiency Level 2). In particular, Figure 2.16 reveals that boys are over-represented among young people who fail to reach foundational levels of proficiency in science tasks requiring them to evaluate and design scientific enquiry or display their procedural and epistemic knowledge (the difference in the percentage of boys and girls who performed at this level in these tasks was around 3 percentage points). Similarly, boys were over-represented among young people who failed to reach at least foundational levels of proficiency in tasks related to biology (living systems) and earth and space.

Figure 2.16. Gender differences by science competency subscale (PISA 2015)

Percentage-point difference between 15-year-old boys and girls in science proficiency Level 5 and above and science proficiency Level 2 and above by science competency subscale
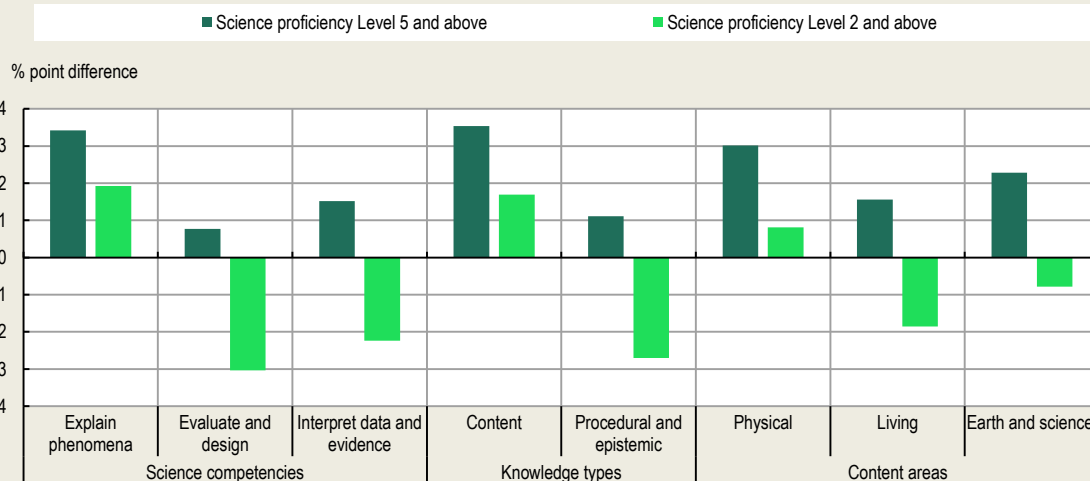
Note: The figure shows the percentage-point difference in science proficiency Level 5 and above of 15-year-old boys and girls by science competency subscale and the percentage-point difference in science proficiency Level 2 and above of 15-year-old boys and girls by science competency subscale.
Source: Calculations based on OECD (2018[18]), *PISA 2018* Database, www.oecd.org/pisa/data/2018database/.

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Box 2.4. Twin green and digital transition

"Enabling competences" are competences that are not directly related to environmental sustainability competence per se but allow environmental sustainability competence to be developed and effectively used in the labour market and society.

Among this set of enabling competences, digital skills can play a major role in promoting young people's acquisition of environmental sustainability competence and engagement in a green economy. For instance, digital skills could contribute to establishing circular economies and cleaner production processes. The 3R practice (Reduce, Reuse, Recycle) is a prime example of how the use of digital technologies for industrial symbiosis, i.e. outgoing flows from one manufacturing facility are used by another, can help reduce and, potentially, replace reliance on virgin raw materials. Digital efficacy and the ability to manage digital systems and processes are also considered essential to facilitating the decoupling of economic growth and climate change, as many of these green technologies rely on and are enhanced by digital ones.

Examples of the intrinsic relationship between digital and green skills abound. For instance, in the energy sector, digital skills are used to improve efficiency by maximising quality while minimising energy use, thus contributing to the green energy transition. According to the IEA (2017[20]), digitally enabled tasks (such as data processing, modelling, simulation and optimisation) have been pivotal for the energy sector since the 1970s and have progressively acquired prominence in other environmentally sensitive domains, such as transport, buildings and industry. The cases of the photovoltaics and biofuel regional clusters in Wales (United Kingdom) and the Cleantech platform in central Israel provide other relevant illustrations of regions in which pre-existing specialisations and digital capabilities have facilitated the development of new green specialisations (Cooke, 2010[21]).

To some extent, digitalisation may accelerate the transition towards a greener economy and digital competences could play a prominent role in green ones (Cecere et al., 2014[22]). Research, for example, reveals that the use of digital media such as Science, Camera, Action! (SCA) facilitates children's constructive climate change engagement by combining educational activities with digital photography to facilitate individual and collaborative climate change action (Trott and Weinberg, 2020[23]). Similarly, digital storytelling has been successfully used to raise children's environmental attitudes (Theodorou et al., 2018[24]). In fact, students' exposure to digital social stories through the web application "Pixton" to educate them on recycling, reusing and reducing influenced not only children's environmental knowledge but also their willingness to change their behaviour. A sustainability app has been shown to positively affect environmental awareness and users' pro-environmental behaviours (D'Arco and Marino, 2022[25]).

Digital technologies have also been used in buildings to encourage occupants to engage in pro-environmental behaviours when prompted by their computers (Khashe et al., 2017[26]). Such smart digital monitoring tools led to high levels of engagement and compliance. "Digital nudging" has been identified as effective in guiding people's behaviour in a digital choice environment and promoting individual pro-environmental behaviour (Henkel et al., 2019[27]). Digital nudging can support individuals' pro-environmental behaviour and lead to changes in individual behaviours, such as using energy more efficiently, consuming less water or increasing the use of renewable energy sources. Thus, digital nudging can potentially prevent further environmental damage and provide a cost-effective way to encourage pro-environmental behaviour at both macro (society and organisations) and micro (individuals) levels.

In recognition of the importance and interdependence of the green and digital transition, the European Union (EU) is resetting its growth strategy, based on sustainability, with the green and digital transition as its transformative driver. The green and digital transition – the "twin transition" – is at the top of the EU political agenda and will shape Europe and its future. On the one hand, the European Green Deal aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy in which there are no net emissions of greenhouse gases by 2050 and economic growth is decoupled from resource use. On the other hand, the EU's digital transformation aims to empower businesses and people in a human-centred, sustainable and more prosperous digital future. Both processes are taking place in parallel and influence each other. Or as the European Commission highlights: "This twin challenge of a green and digital transformation has to go hand-in-hand" (European Commission, 2020, p. 1).

To achieve the EU's objectives of becoming a greener, digitally fit and fairer Europe, the European Commission has adopted several initiatives and set clear targets to identify both green and digital interlinkages and synergies as well as tension points to ensure that the two transitions can reinforce each other (e.g. e-waste, digital carbon footprint). Such initiatives entail, for instance:

- Identifying and addressing reskilling/upskilling and (re)training needs stemming from new, green or digital products, services or technologies.
- Fostering social acceptance and/or behavioural changes for more sustainable business models, consumption patterns and/or modes of transport.
- Investing in education and training, enhancing skills and equipping people for new green and digital jobs.
- Developing readiness to build, reinforce and strengthen digital and green capacity and digital tools.
- Raising awareness of the opportunities and challenges related to the green and digital transition and contributions to their social acceptance.

2.3.2. Caring for the environment is associated with engagement in individual and collective environmental action

Acting for environmental sustainability involves acting individually and collectively to shape a sustainable future and demanding effective policy action for sustainability. Students' environmental actions at present are key to environmental welfare and, as such, describe 15-year-old students' present contribution to environmental sustainability. Figure 2.17 and Figure 2.18 consider how students' current engagement in individual and collective forms of pro-environmental behaviours depends on emotional, attitudinal and cognitive areas of environmental sustainability competence. The figures illustrate the percentage-point difference in the probability that 15-year-old students report reducing energy consumption for environmental reasons and participation in environmental groups, which is associated with a one-unit change in emotional, attitudinal and cognitive dimensions of environmental sustainability competence. Percentage-point differences represented in the figures compare students with similar gender, socio-economic status, language and migration status and attending schools with a similar socio-economic intake. Furthermore, they were estimated when comparing students with similar levels of sustainability competence on the other dimensions.

Results reported in Figure 2.17 indicate that, on average, across OECD countries with available data, students who "agreed" or "strongly agreed" that looking after the global environment was important to them were 16 percentage points more likely to save energy than those who disagreed or strongly disagreed with the statement. In particular, in Australia, France, Germany, Korea, Poland, Spain and the United Kingdom, the difference in the percentage of 15-year-old students who reported engaging in energy-saving behaviours between those who reported caring about the environment and those who did not was larger than 20 percentage points. Differences were smallest and corresponded to fewer than 5 percentage points in Bulgaria and Lithuania.

Figure 2.17 also suggests that a high level of environmental self-efficacy is strongly associated with engagement in saving energy. On average, across OECD countries with available data, students who reported high levels of environmental self-efficacy were 4 percentage points more likely to report saving energy for environmental reasons than students with low levels of environmental self-efficacy. The difference in the propensity to engage in energy-saving behaviour between students with high and low levels of environmental self-efficacy was highest in Germany, Lithuania and Romania (greater than 7 percentage points). The difference in energy-saving behaviour between students who achieved at least foundational proficiency levels in the PISA science test (i.e. achieved proficiency Level 2) and those who did not was negative but quantitatively small. On average, across OECD countries, students who achieved at least foundational proficiency levels in science were 1 percentage point less likely to engage in energy-saving behaviours than other similar students. In Italy, the difference was larger and corresponded to 7 percentage points; in Bulgaria and Romania, it corresponded to 5 percentage points. Finally, students who reported being aware of environmental problems were 4 percentage points more likely, on average

across OECD countries, to engage in energy-saving behaviours than students who reported low levels of environmental awareness.

Figure 2.17. The association between environmental sustainability competence areas and energy-saving behaviours among 15-year-olds in OECD countries (PISA 2018)
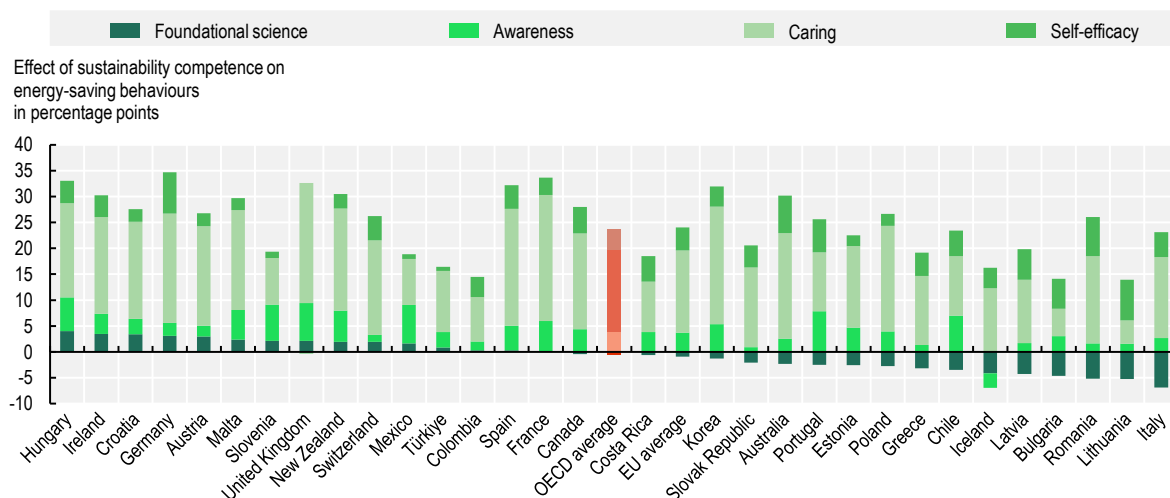
Note: Countries are sorted in descending order of the percentage-point difference in energy saving associated with students being top performers in science. Results were obtained by estimating whether a respondent reported as a function of the four dimensions of environmental sustainability competence, as well as gender, individual socio-economic status measured using the PISA index of economic, social and cultural status, an indicator of whether the respondent spoke, at home, the same language of the PISA test and whether they or their parents were born outside of the country in which they sat the PISA test; as well as the school average socio-economic status.
Source: Calculations based on OECD (2018[18]), *PISA 2018 Database*, www.oecd.org/pisa/data/2018database/.

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Figure 2.18 illustrates associations with participation in activities in favour of environmental protection. In line with energy-saving behaviour, participation in activities in favour of environmental protection varies markedly depending on whether or not students report caring about the environment and their level of environmental self-efficacy. Data from 2018 reveal that 15-year-old students who reported caring about the environment and had high levels of environmental self-efficacy were more likely to participate in activities favouring environmental protection. By contrast, in most countries, after taking into account whether students reported caring about the environment, their environmental awareness and self-efficacy, participation in activities favouring environmental protection was lower among students who achieved at least foundational levels in science. This could reflect the fact that individuals with higher levels of science achievement may be more reluctant to invest their time in such activities and invest more time in their studies or that, other things being similar, they are more pessimistic about the value of such participation. Box 2.5 illustrates the extent to which young people's engagement in activities in favour of environmental protection is related to the level of engagement of their parents.

Figure 2.18. The association between environmental sustainability competence and participation in activities in favour of environmental protection among 15-year-olds in OECD countries (PISA 2018)
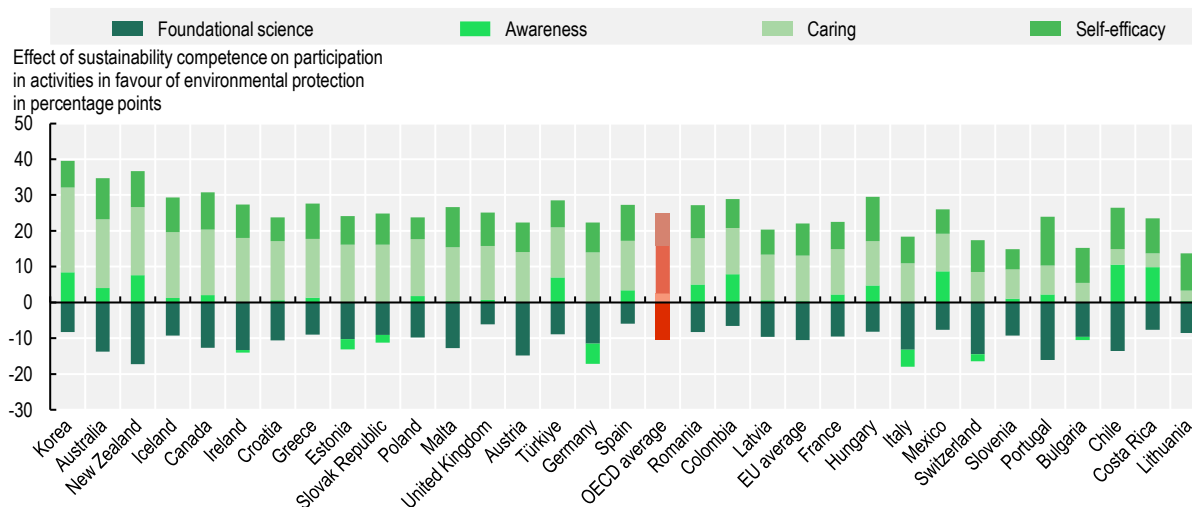
Note: Countries are sorted in descending order of the percentage-point difference in activities in favour of environmental protection associated with students who achieved foundational levels of science performance. Results were obtained by estimating whether a respondent reported as a function of the four areas of sustainability competence, as well as gender, individual socio-economic status measured using the PISA index of economic, social and cultural status, an indicator of whether the respondent spoke, at home, the same language of the PISA test and whether they or their parents were born outside of the country in which they sat the PISA test; as well as the school average socio-economic status.
Source: Calculations based on OECD (2018[18]), *PISA 2018 Database*, www.oecd.org/pisa/data/2018database/.

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Box 2.5. Children's environmental engagement is associated with their parents' level of environmental engagement

Youngsters' environmental sustainability competence, especially attitudinal and emotional aspects of such competence, are determined by a variety of factors related to the cultural setting in which they are born and raised. Among these factors, parents play a pivotal role in their children's socialisation. Children socialised into assuming a personal identity consistent with environmental protection are considerably more likely to engage in pro-environmental behaviours than children who have not developed the same identity. Although the idea that environmental values are transferred from parents to children is obvious at first, the intergenerational transfer of values resulting in within-family similar behaviours and attitudes is not necessarily unidirectional. Transfers may not only flow from parents to children but also from children to parents. Children can and do act as agents of environmental change for older generations. Supportive evidence of bidirectional influences is, for example, documented for waste-related consumption and waste management.

Figure 2.19 shows the likelihood of students engaging in a given environmental action when their parents do the same, relative to the likelihood of students engaging in environmental behaviour when parents do not (i.e. the odds ratio[1]). Almost all associations are significant at the 5% significance level; the only exception is in Malta for "boycotting products or companies for political, ethical or environmental reasons".

The magnitude of these associations differs between countries and topics. While for energy-saving behaviour, in 2018, 15-year-old students in Germany were around 70% (odds ratio = 1.76) more likely to save energy for environmental reasons when their parents saved energy compared to when their parents did not, in Malta, 15-year-old students were even more likely to engage in energy-saving behaviour (odds ratio = 3.17). However, the likelihood of engaging in pro-environmental behaviour also varies between the type of behaviour. For example, 15-year-old students in Malta are 44% (odds ratio = 1.44) more likely to sign environmental or social petitions when their parents do so as well, compared to when they do not.

1. Regarding the odds ratio, a value above (below) 1 means that students whose parents engage in a specific environmental action have a higher (lower) probability of performing the same action.

Figure 2.19. Effect of parents' environmental engagement on students' engagement (PISA 2018)

Odds ratio of students' engagement in a given environmental action when their parents do the same, relative to the likelihood of students engaging in environmental behaviour when parents do not
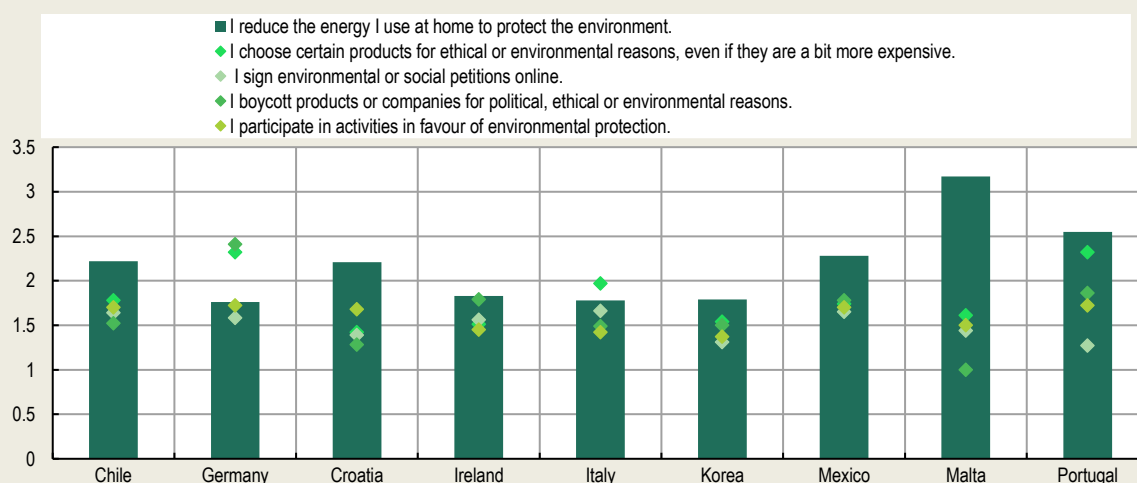
Note: Each value represents a separate estimate of students' behaviour on parents' behaviour, controlling for gender, language spoken at home, immigrant background, economic, social and cultural status (ESCS) and schools' ESCS. These are the odds ratios from logistic regressions. All coefficients are statistically significant at the 5% significance level.
Source: Calculations based on OECD (2018[18]), *PISA 2018 Database*, www.oecd.org/pisa/data/2018database/.

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On average, across OECD countries with available data, students who reported high levels of environmental self-efficacy were 9 percentage points more likely to report participating in activities in favour of environmental protection than students with low levels of environmental self-efficacy. The difference in the propensity to participate in activities in favour of environmental protection between students with high and low levels of environmental self-efficacy was highest in Chile, Hungary and Portugal. Similarly, students who reported caring about the environment were 13 percentage points more likely to have participated in activities in favour of environmental protection across OECD countries. The difference was largest in Korea – 24 percentage points – and smallest in Lithuania, where it was 3 percentage points and not statistically significant . The difference in participation in activities in favour of environmental protection between students who achieved at least foundational performance levels in science and those who did not was strong and negative. Other things being equal, throughout OECD countries, students who achieved at least foundational levels of science proficiency were 11 percentage points more likely to have

participated in activities. Finally, across OECD countries, students who reported being aware of environmental problems were 3 percentage points more likely to report participating in activities in favour of environmental protection than students who did not.

2.4. Conclusions

Successfully implementing climate change mitigation policies domestically and internationally requires understanding adults' and children's attitudes towards climate change and the environment. Attitudes drive the actions individuals take as consumers, how they use their skills in the workplace, their willingness to invest in devising new production processes or technical innovations to promote environmental sustainability, and their support for policies aimed at reducing climate change and protecting the environment.

Results presented in this chapter reveal significant variations in different groups who report being worried about climate change, both across and within countries across different groups. In particular, results indicate that educational attainment is a strong predictor of climate change perceptions, and so are gender and the sector in which individuals work. In particular, individuals facing different levels of economic vulnerability and those working in different sectors express different attitudes towards climate change as well as different levels of support for policy action aimed at reducing environmental degradation. For example, individuals who anticipate being negatively impacted by climate change mitigation policies are more likely to report a low understanding of climate change and low threat perceptions. In particular, results show a negative correlation between working in a big CO_2-emitting sector and supporting pro-environmental policies. Individuals working in industries that are among the heaviest emitters of greenhouse gases are less likely to believe in climate change and less likely to see climate change as a threat than individuals working in industries that are among the lowest emitters of greenhouse gases.

On the education front, many education systems emphasise the protection of the environment or education for environmental sustainability in their curricula and acquiring environmental sustainability competence as key for education systems to develop involved and responsible citizens. Previous empirical studies indicate that teachers and school principals endorse these policy objectives, recognise the key role education systems can play in promoting the green transition and regard the promotion of students' respect for and safeguarding of the environment as an important goal.

The foundation for this is environmental sustainability competence. Results indicate that large disparities exist in the extent to which education systems and societies generally equip children with this key foundation for their future. Disparities in acquiring different environmental sustainability competence areas are compounded, and socio-economically disadvantaged youths are, in particular, less likely to acquire environmental sustainability competence. On average, throughout OECD countries, analyses presented reveal that they are 19 percentage points less likely to have foundational levels of environmental sustainability competence and 18 percentage points less likely to have advanced levels of competence compared to their more socio-economically advantaged peers.

A second key dimension of inequality is gender. Subtle but pervasive gender differences exist when granular indicators are available and can be analysed. Delivering a just and inclusive green transition can only be achieved with the participation of all, and the barriers and stereotypes that continue to lead boys and girls, men and women, to make different educational and life choices should be dismantled. In particular, gender differences in the awareness of environmental problems differ depending on the nature of such problems. For example, across OECD countries, boys report higher levels of awareness of nuclear waste, the increase of greenhouse gases in the atmosphere, the use of genetically modified organisms and the consequences of clearing forests for other land use. By contrast, girls reported higher levels of awareness of water shortage, air pollution and the extinction of plants and animals (Borgonovi et al., 2022[3]). Similarly, while boys scored higher than girls in physical, and earth and science areas, girls scored

higher than boys in biology. These differences map onto gender differences in broad science areas in tertiary education, with few women engaged in science, technology, engineering and mathematics (STEM), while they are more likely to pursue degrees in biology than physics and engineering (Henkel et al., 2019[27]). These differences are related to gender differences in the development of numeracy skills (Borgonovi, Choi and Paccagnella, 2021[28]).

The extent to which individuals can acquire environmental sustainability competence is determined by a variety of factors, among others, the cultural setting in which students are born and raised and the school environment they are exposed to. Within schools, different potential underlying processes may shape students' environmental sustainability competence, such as formal curricula and teaching practices.

Parents play a pivotal role in their children's socialisation. Within families, values, attitudes and behaviours may be passed on, resulting in an alignment between generations. The degree of transfer may depend on the extent and type of parents' interaction with their children. On average, analyses presented in this chapter reveal a significant positive correlation between the pro-environmental behaviour of parents and children within families. The responsibility to equip new generations with solid environmental sustainability competence does not, therefore, lie solely with the formal education sector but is a shared responsibility that all families should take on themselves. Parents are the first and probably most important role models for their children, and their attitudes and behaviours have long-lasting impacts on the possibility of new generations tackling environmental degradation and propelling the green transition. At the same time, children worldwide have developed a new environmental consciousness and can stimulate their parents to modify long-held actions and behaviours to adopt more sustainable lifestyles. In this framework of mutual influence, it is even more urgent to equip youngsters with environmental sustainability competence to also create change within harder-to-reach generations.

The results presented highlight that being a top performer in some fields is not sufficient to develop greater awareness of environmental problems. Findings reveal that for the science domain only (i.e. not for reading), being a top performer is associated with greater awareness of environmental problems compared to students with lower levels of achievement. These findings suggest that it is not students' general high educational performance and the factors that generally accompany high achievement that determine environmental awareness but, rather, that the content of the educational curriculum matters. Students with high levels of science knowledge and understanding and who can solve complex scientific problems using such knowledge are likely to have acquired a greater understanding of environmental and sustainability issues, equipping them with greater environmental awareness.

Global environmental problems have become more complex and will affect economies and societies in the coming decades. While it is the responsibility of today's society to leave behind a better environmental future for today's younger generations, it will be today's younger generation that will shape future environmental policies.

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Note

[1] Note that the percentage of individuals who consider climate change to be a major threat is somewhat lower than in another OECD study, where 70% to 90% "somewhat" or "strongly agree" with the statement "climate change is an important issue" (Dechezleprêtre et al., 2022[15]). This discrepancy is due to multiple reasons, including the way in which the question was framed (threat or important problem), the answer choices, and the countries considered. In particular, the dichotomous variable constructed in this work takes 1 only if the respondent believes that climate change is a major threat, whereas Dechezleprêtre et al. (2022[15]) consider both "somewhat agree" and "strongly agree" to classify respondents who believe that climate change is an important problem. The percentage of individuals in the Wellcome Global Monitor who believe that climate change is either a major or a minor threat is high, about 90% in most countries.

3 Skills for a net-zero future: Empowering communities for the green transition

This chapter illustrates economy-wide changes in labour markets and the demand for skills resulting from implementing policies aimed at reducing greenhouse gas emissions by considering the case of the European Union's Fit for 55 policy package. Overall employment is projected to increase between 2019 and 2030. However, projections indicate declining labour market opportunities for blue-collar workers and declining demand for skills involving the use of tools and technologies adopted in traditional manufacturing processes. By contrast, the demand for skills related to interpersonal communication and the use of digital technologies is projected to increase the most by 2030. Promoting societal-level resilience by reducing the carbon footprint of production should be accompanied by skills policies aimed at reducing workers' vulnerability to related transformations.

Key messages

If countries are to achieve ambitious climate targets alongside economic growth, climate policies will need to be accompanied by strong investments in skills policies. Skills policies, which comprise education and training policies targeted at both young people and adults, can play an essential role in ensuring that greening the economy does not lead to new forms of vulnerability and deprivation. Skills policies are an important component of efforts to ensure that the transition will be just and inclusive, leading to improvements in working conditions and minimising widespread job losses and contractual instability. Skills policies can facilitate the reallocation of workers away from sectors that will shrink because they are responsible for a large share of carbon dioxide (CO_2) emissions into sectors that will expand. To help workers effectively transition requires identifying not only economy-wide changes in skills demands but also the degree of similarity in the skill sets needed to perform different jobs, as well as projected trends in employment and the relative size of different employment opportunities.

This chapter considers the case of the European Union's Fit for 55 policy targets aimed at reducing greenhouse gas (GHG) emissions and, by employing novel data and methodologies, develops projections of the impact of the policy package on labour markets and the demand for skills. The case of the European Union (EU) is instructive because of the ambition of the policy package being implemented, the number of jurisdictions being affected and the availability of timely data to evaluate the potential impact of the policy on employment and the demand for skills. In particular, the chapter explores the effect of the Fit for 55 policy targets on five occupational categories: 1) technicians and associate professionals; 2) managers and professionals; 3) service and sales workers; 4) clerical workers; and 5) blue-collar and farm workers.

Key empirical findings include:

- Projections indicate that meeting ambitious climate targets of reducing CO_2 emissions by 55% by 2030 can be achieved, while overall employment increases by 1.3% in the Fit for 55 scenario between 2019 and 2030.

- By 2030, the employment of blue-collar and farm workers is projected to decrease by 3% in the Fit for 55 scenario (whereas it is projected to decrease by 2% in a scenario in which the policy was not implemented) and increase by 4-5% for other occupations.

- The skills categories that are projected to grow the most in demand according to the projections developed by the OECD between 2019 and 2030 with the implementation of the Fit for 55 policy include: interacting with computers; thinking creatively; analysing data and information; and communicating with persons outside an organisation, skills for which demand will grow as a result of the technological adoption.

- Other skills for which demand will increase include sales and marketing; computers and electronics; language; economics and accounting; customer and personal service; administration and management; and communications and media. Most of these skills are essential in the business services and public services sectors.

- Skills related to operating and maintaining equipment and tools are projected to decline the most in demand with the implementation of Fit for 55 targets.

3.1. Introduction

In response to deteriorating environmental conditions and mounting public pressure, in 2015, 196 Parties adopted the Paris Agreement, a legally binding international treaty on climate change with the goal to "limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels"

(United Nations Framework Convention on Climate Change, 2015[1]). Since adopting the Paris Agreement, many countries worldwide have implemented policy initiatives to reduce GHG emissions. Furthermore, the economic stimulus packages implemented to sustain economic growth following the coronavirus (COVID-19) pandemic and the energy crisis following Russia's war against Ukraine have served as a way to accelerate the twin digital and green transition.

Considering the impact of policies aimed at reducing GHG emissions on employment opportunities and skills demands is crucial to ensure long-term environmental sustainability. At the same time, if countries are to achieve ambitious climate targets alongside economic growth and high-quality working conditions, climate policies will need to be accompanied by strong investments in employment, social and skills policies to promote the socio-economic well-being of resident populations. Understanding the labour market impacts of greening policies is thus a key first step in preparing adequate policy responses to mitigate any adverse impacts the transition might have for certain population groups and ensuring that the green transition will be a just transition.

This chapter considers the role of skills policies in building resilience among affected communities based on a technical working paper that analyses the labour market and skills impacts of climate initiatives in the EU (Borgonovi et al., 2023[2]). The following countries were considered in the analysis: Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, the Slovak Republic, Spain and Sweden. Although many countries have set climate targets, the EU has also ensured that the targets are binding by translating them into a set of legislative proposals that have been integrated into the Fit for 55 policy package.[1]

The Fit for 55 policy package sets an intermediate target of reducing net GHG emissions by at least 55% by 2030 compared to 1990 levels.[2] The package also indicates that the total emission reduction of 55% should be achieved with differentiations across sectors: emissions in sectors covered by the EU Emission Trading System (ETS) need to be reduced by 61% in 2030 compared to 2005 levels while emissions in other sectors – referred to as Effort Sharing Regulation (ESR) sectors – need to be reduced by 40% by 2030 compared to 2005 levels.

The Recommendation on ensuring a fair transition towards climate neutrality was adopted in 2022 to take into account the distributional implications of the transition. The Recommendation invites EU member states to adopt measures to address the employment and social aspects of climate, energy and environmental policies, encouraging the adoption of actions to support people most affected by the green transition, for instance, by stimulating the creation of quality jobs and facilitating access to safe working conditions protecting health and safety in the context of this green transition (Council of the European Union, 2022[3]). The Recommendation also puts a focus on education and training measures, inviting EU member states to integrate the employment and social aspects of the green transition in the development and implementation of relevant national strategies (Council of the European Union, 2022[3]). Other proposals concentrate on the fairness of tax-benefit and social protection systems and on ensuring access to affordable essential services and housing for people and households most affected by the green transition.

In recent years, a growing number of studies have attempted to estimate the effects climate change mitigation policies might have on labour markets, with the aim of identifying – and eventually preventing – potential mismatches arising from the reallocation of workers from sectors and occupations that are heavy emitters of GHG emissions into sectors and occupations that emit comparatively few GHG emissions – also referred to as "green" in the literature (Biagi, Vona and Bitat, 2021[4]). Such mismatches are likely to arise not only because of the geographical distribution and occupational composition of sectors that may grow or shrink as a result of structural transformations leading to increased environmental sustainability, but also because of the difference in the skill sets required to perform tasks prevalent in economic production processes characterised by high or low levels of GHG emissions.

The degree to which initial education, further education and training, and adult education will have to adapt largely depends on the degree to which the skills required are similar to or different from those that workers possess today. Therefore, minimising reallocation costs for individuals and societies crucially depends on adequately anticipating how similar the skills demanded of workers in a low-emission economy will be compared to the skills workers currently possess. Work-based learning and lifelong learning will play a crucial role, especially in the case of most affected workers in the declining industries. At the same time, work-based learning and lifelong learning will be critical to reduce shortages of workers to fill emerging opportunities in sectors that are rapidly expanding, such as in renewable energy production. Minimising reallocation costs also depends on using such information to inform the design of programmes in education and training systems so that they will effectively develop such skills. This will require potentially wide-ranging changes in school and vocational education and training curricula and, in turn, professional development for teachers and trainers (International Labour Organization, 2017[5]).

A growing body of literature has attempted to quantify the number of jobs aligned with achieving green objectives.[3] Although results from different studies are not directly comparable, as they often adopt different estimation methodologies and definitions, they generally indicate that only a small number of workers (between 1.5% and 4%) are employed in jobs directly aligned with the achievement of green objectives, such as those in renewable energy production.

Results from these studies can be used to map the skills needed in the small number of jobs that are well aligned with the achievement of green objectives. However, the transition to net zero will require economy-wide adaptations. Such adaptations will not only reduce employment in sectors that are heavy producers of CO_2 emissions and increase employment in carbon-neutral sectors but will also change the allocation of workers across and within sectors in all economic activities. Therefore, it is essential to conduct analyses of the current skills required for jobs directly related to achieving green objectives, along with projections of the skills demanded as employment undergoes structural transformations in the broader economy to meet economy-wide climate targets. Results from past modelling exercises conducted by the OECD suggest that implementing climate change mitigation policies will determine job destruction in fossil-fuel sectors and job creation in renewable energy sectors, which currently employ few workers overall.

This chapter presents a modelling analysis of the impacts of the Fit for 55 policy targets on labour markets, driven by the policy-induced changes in the structure of the economy. It distinguishes impacts by sector for five occupational categories: 1) "managers and professionals" (comprising "managers" and "professionals" in the International Standard Classification of Occupations [ISCO] classification); 2) "technicians and associate professionals" (comprising "technicians and associate professionals" in the ISCO classification); 3) "service and sales workers" (comprising "service and sales workers" in the ISCO classification); 4) "clerical workers" (comprising "clerical support workers" in the ISCO classification); and 5) "blue-collar and farm workers" (comprising "skilled agricultural"; "forestry and fishery workers"; "plant and machine operators, and assemblers"; "elementary occupations"; and "craft and related trades workers" in the ISCO classification). The choice to consider only five occupational groups was driven by model complexity but inevitably hides potentially large differences in trajectories within each group. Therefore, projections presented in this report should be accompanied by granular analyses to reflect geographical, sectoral and occupational differences.

An empirical analysis, based on matching labour market changes and occupations to skills information from positions advertised on line for different sectors, makes it possible to quantify the effects of the policy targets on the demand for skills.[4] Given the distribution of workers in 2019 in different EU countries, sectors and occupations, this chapter considers distributional implications and key target groups for the design of upskilling and reskilling interventions to facilitate the reallocation of workers across sectors and occupations that are projected to shrink and sectors and occupation that are projected to expand.

The modelling analysis relies on the OECD ENV-Linkages dynamic global Computable General Equilibrium (CGE) model (Chateau, Dellink and Lanzi, 2014[6]) to quantify the effect of policies on structural change, with a 2030 time horizon. The analysis compares a baseline scenario reflecting current policies, such as the ETS, with a Fit for 55 scenario.[5] The empirical analysis uses the job postings database for the 2019-22 period assembled by Lightcast (formerly known as Emsi Burning Glass) (Lightcast, n.d.[7]) to map the distribution of skills across sectors and occupations.

3.2. Projected employment changes resulting from the implementation of the Fit for 55 policy targets

The analysis of changes in sectoral employment relies on the OECD ENV-Linkages model to quantify the overall economy-wide effects of the mitigation policies needed to meet the Fit for 55 emission reduction targets. The main advantage of using a CGE model is that by exploiting its sectoral and regional dimensions, the analysis can consider the interlinkages between the economy's supply and demand sides, capturing adjustments to new policies in both quantities and prices. CGE models thus capture the changes in the prices of commodities, used as production inputs and for consumers, whether produced domestically or imported, and the shifts in demand and sourcing. Different studies can yield different projections depending on the specific model specifications, which can reflect different assumptions over the way in which policies may impact labour markets and be accompanied by additional policy action (Cedefop, 2021[8]; European Commission, 2023[9]).

The modelling analysis compares two scenarios: 1) a baseline scenario reflecting the implementation of current policies; and 2) a Fit for 55 scenario. The time horizon of the analysis extends to 2030, in line with the Fit for 55 targets. Specifically speaking:

- The **baseline scenario** reflects projected socio-economic trends as well as current policies. This scenario incorporates policies that were implemented by 2021[6] as well as policies that were by then already legislated but not yet implemented.[7] This approach is applied to EU countries and the rest of the world. The baseline scenario considers the EU carbon market, the ETS, which is already in place. This corresponds to the European Green Deal pre-Fit for 55 targets.

- In the **Fit for 55** scenario, the EU meets its target to reduce CO_2 emissions by 55% in 2030 compared to 1990 levels.[8] This economy-wide target is also specified for sectoral groups: an emission reduction of -61% in 2030 compared to 2005 in ETS sectors and -40% in ESR sectors (ESR sectors including all sectors outside of ETS).[9] Given that the scenario assumes a global transition, there is very limited potential for carbon leakage, so the Carbon Borden Adjustment Mechanism (European Commission, n.d.[10]) was not included in the analysis.

To ensure that the Fit for 55 package overall target is reached while also respecting the differentiation between the two sector groups, two separate carbon markets are included in the scenario and in the ENV-Linkages model: the ETS and a market for ESR sectors, covering all sectors of the economy.[10] When a policy is introduced in ENV-Linkages, the model adjusts its sectoral production and consumption patterns, including inputs and outputs, until a new equilibrium is reached.[11]

The Fit for 55 package is more stringent on ETS sectors, which are, on average, more emission intensive. There are also differences in labour intensity across sectors and, specifically, between ETS and ESR sectors. On average, ETS sectors are less labour intensive than ESR sectors. All together, ETS sectors accounted for less than 6% of total employment in the EU in 2019 (and 64% of emissions). In ETS sectors, most people are employed in other energy-intensive industries (e.g. steel, cement, glass, paper), representing around 3% of total employment (and 1% of emissions).

The distribution of workers across the five job categories also varies across sectors (Figure 3.1). ETS sectors rely most on blue-collar and farm workers, followed by technicians and associate professionals, and managers and professionals, with the exception of "air and water transport", which rely most on clerical

workers while also having a high share of managers and professionals. In ESR sectors, a salient difference appears between services sectors and other sectors (i.e. "agriculture", "construction", "manufacturing" and "other" sectors). Services sectors rely most on managers and professionals and have a low share of blue-collar and farm workers. Other sectors rely most on blue-collar and farm workers.

Managers and professionals, technicians and associate professionals", and service and sales workers represent a larger share of total employment in ESR sectors (53% of total employment) than in ETS sectors (31% of total employment). Blue-collar and farm workers represent the largest share of employment in ETS sectors as well as a large share (24%) of employment in the construction sector (ESR sector), which has a relatively high employment level. Clerical workers represent 11% of total employment, with similar shares for ETS (9%) and ESR (11%) sectors. They are the most employed category in transport sectors, which, however, corresponds to a relatively low employment level (1.4% of total employment).

Figure 3.1. Employment level by occupational category and sector and employment share by sector, EU countries, 2019

Share of each occupational category in sectoral employment (left y-axis) and sectoral share in total employment (right y-axis)

Panel A: Emissions Trading System (ETS) sectors

Panel B: Effort Sharing Regulation (ESR) sectors
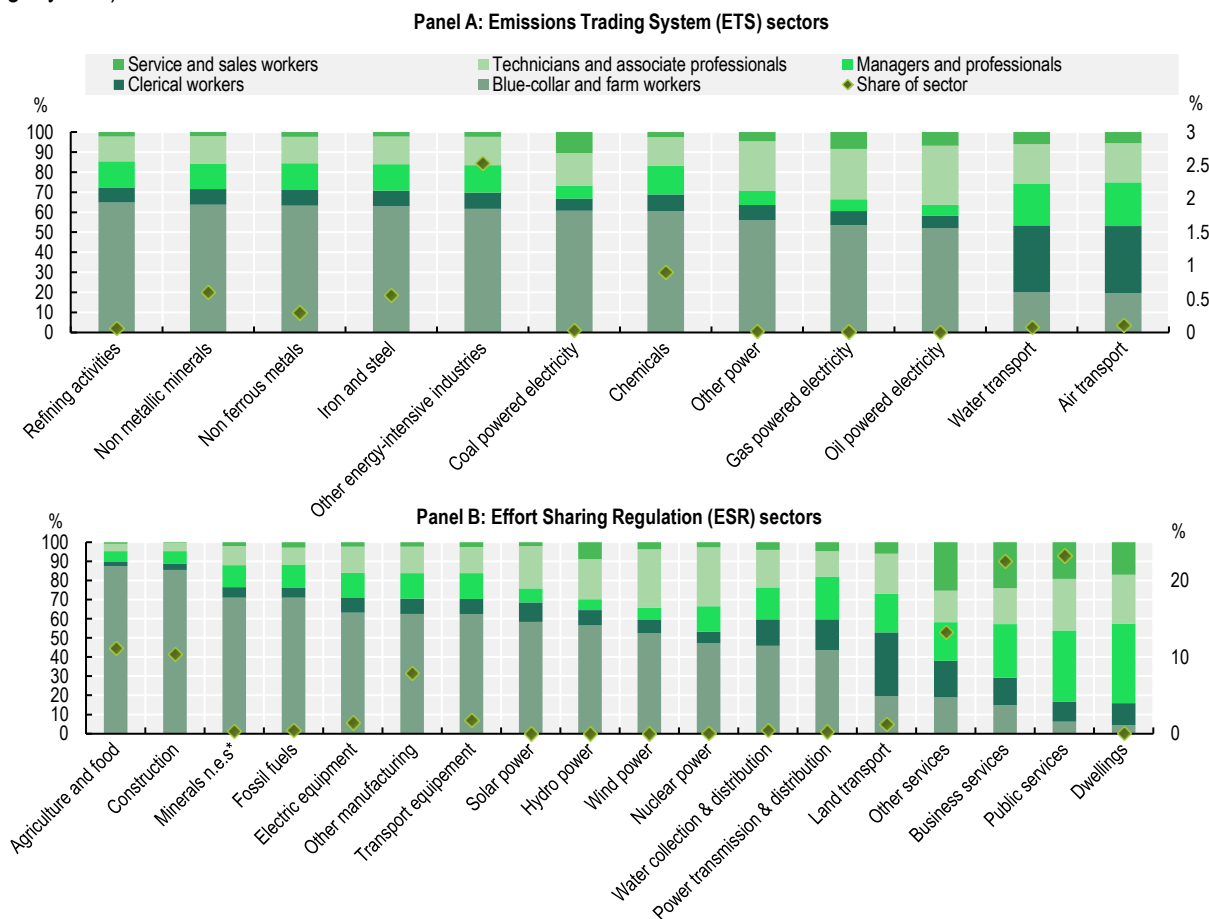
Note: The figure shows the share of the five occupational categories in employment by sector. In parallel, it also shows the share of employment of each sector in total employment. An overview of all ENV-Linkages sectors displayed in this figure and how sectors are combined is provided in Borgonovi et al. (2023[2]).
* The abbreviation 'n.e.s' in the sector 'Minerals n.e.s' means "not elsewhere specified".
Source: Calculations based on OECD ENV-Linkages model, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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3.2.1. Impact of the Fit for 55 scenario

Sectoral production and CO$_2$ emissions

The Fit for 55 scenario achieves significant reductions in CO$_2$ emissions, reducing CO$_2$ emissions to 1.7 Gt (gigatonne) in 2030 from 3.3 Gt in 2019. Emissions are reduced in both EU-ETS (0.8 Gt in 2030, from 1.7 Gt in 2019) and ESR sectors (0.9 Gt in 2030, from 1.5 Gt in 2019), but the reduction in emissions is stronger in ETS sectors, in accordance with the Fit for 55 package targets.

The Fit for 55 scenario results in continued economic growth but also in a small reduction in the gross domestic product (GDP) for the EU (-3% in 2030) compared to the baseline scenario. This decrease is due to the fact that the OECD ENV-Linkages model is conservative on assumptions related to innovation. The modelling approach reflects the technological progress projected to take place in energy production and use, following the International Energy Agency's *World Energy Outlook 2021* (IEA, 2021[11]). However, the model does not explicitly include the possibility of innovation or further development of previously marketed technologies. With additional investments in research and development and assuming that these investments would result in faster technological development and innovation, reaching net-zero emissions by the middle of the century would be less costly and possibly also boost economic growth.

Sectoral production decreases most in sectors regulated by the ETS, especially coal, oil and gas-powered electricity, and air transport (Figure 3.2, Panel A).[12] These are some of the most emission-intensive sectors; therefore, reducing sectoral production contributes strongly to abating CO$_2$ emissions. Production losses are more limited in most ESR sectors (Figure 3.2, Panel B), except for mining and fossil fuels extraction and distribution, which are also emission-intensive sectors. Production substantially increases instead in renewable energy (solar, wind and hydro-powered electricity) and nuclear-powered electricity.

The Fit for 55 scenario also reduces the CO$_2$ intensity of key sectors compared to the baseline scenario. For ETS sectors, the largest decreases in CO$_2$ intensity take place in the production of "non-ferrous metals" (-25%), "chemicals" (-19%), "iron and steel" (-17%), as well as "other energy-intensive industries" (-19%) and other energy-intensive industries ("fossil-fuel-powered electricity": -13%).[13] In ESR sectors, CO$_2$ intensity decreases particularly for "land transport" (-41%), "fossil fuels extraction and distribution" (-22%) and the "services sectors".

Sectoral employment

The changes in the structure of the economy that follow the implementation of the Fit for 55 scenario lead to a reallocation of employment across sectors, which also results in a different distribution of employment across categories (Figure 3.3). Changes in sectoral employment result from two main interacting effects. First, changes in aggregate employment affect the size of the sectoral employment effects. In the baseline scenario, employment is projected to increase by 3% overall, compared to 2019. However, the contraction in GDP in the Fit for 55 scenario results in a lower increase in employment compared to 2019 (1.3%). This implies a decrease in employment by 2% in the Fit for 55 scenario in 2030 compared to the baseline. Second, the changes in the structure of the economy that follow the implementation of the Fit for 55 scenario lead to a reallocation of employment across sectors that accentuate the changes that already take place in the baseline scenario. Specifically, these include a switch from fuel-based energy towards renewable energy and a structural reallocation towards the service sectors. Together, these effects result in changes in employment by occupational category. In particular, the reorientation of the economy towards more labour-intensive sectors, in which blue-collar and farm workers represent a lower share of employment, is a key driver of the effects by occupational category. Employment decreases for blue-collar and farm workers compared to 2019 (-3%), while it increases for other categories (4-5%).

Figure 3.2. Change in sectoral production in the Fit for 55 scenario

CO_2 intensity in ktCO$_2$/USD (left y-axis) and % change sectoral production in USD millions (right y-axis) in 2030
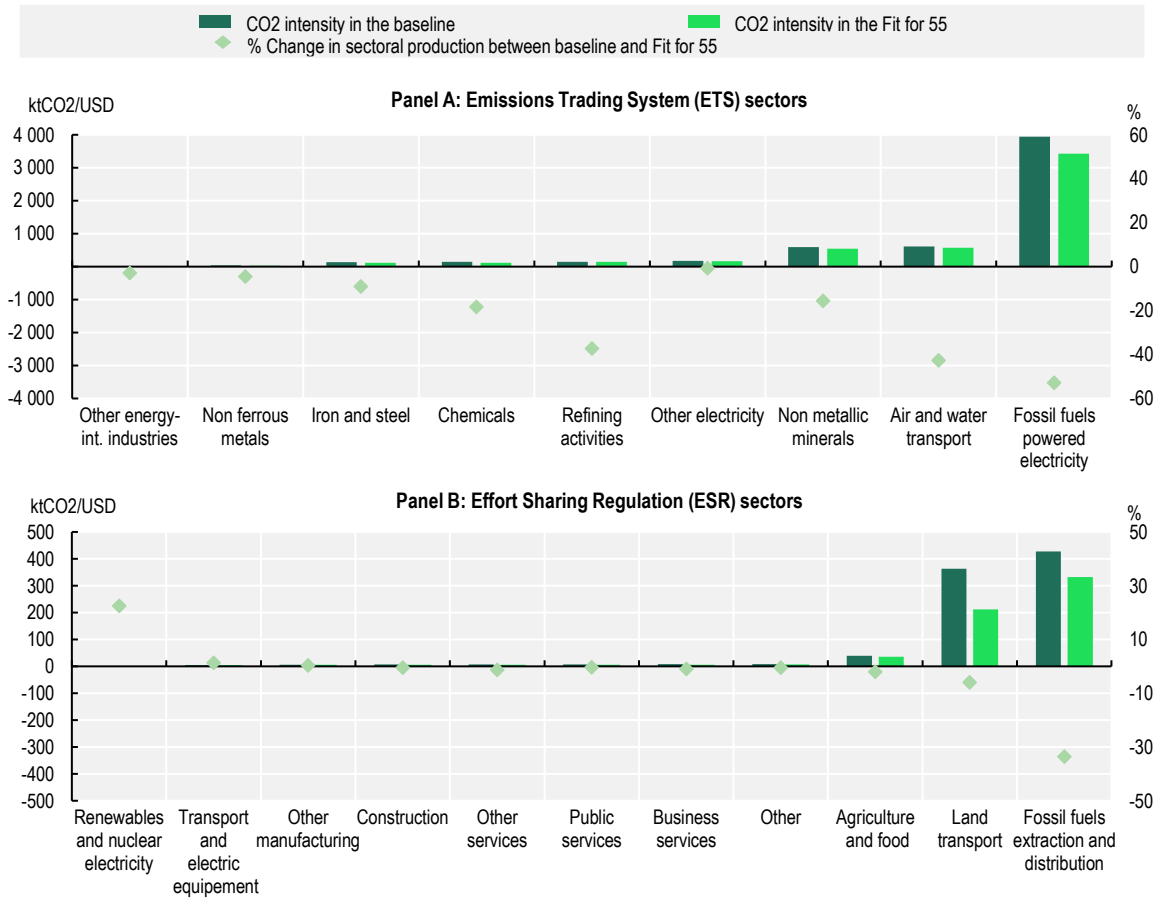
Note: Sectors are ranked by CO_2 intensity in the baseline scenario. An overview of all ENV-Linkages sectors displayed in this figure and how sectors are combined is provided in Borgonovi et al. (2023[2]).
Source: Calculations based on OECD ENV-Linkages model, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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Figure 3.3. Employment in the Fit for 55 and baseline scenarios

% changes in employment compared to 2019
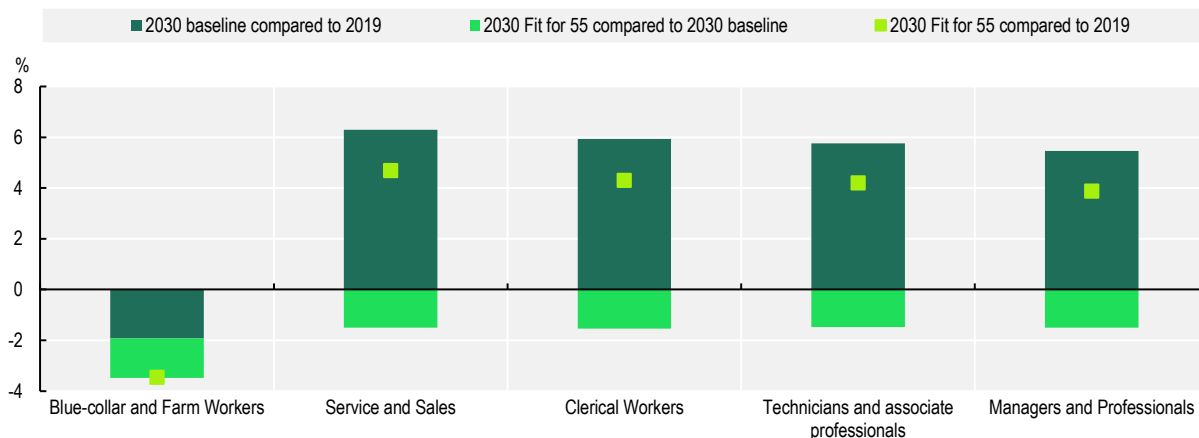
Note: The figure shows changes in employment in the baseline scenario from 2019 to 2030 (dark green bars), as well as the additional changes that take place in 2030 with the Fit for 55 scenario (light green bars). The figure also displays the overall net change in employment in the Fit for 55 scenario from 2019 to 2030 (markers).
Source: Calculations based on OECD ENV-Linkages model, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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The changes in aggregate employment result from the reallocation of employment across sectors. In particular, employment increases significantly in sectors not covered by the ETS, where it grows by 3% between 2019 and 2030 in the Fit for 55 scenario (Figure 3.4). Employment increases in ESR high-employment sectors (6% in total services which include "public services", "business services" and "other services", and by 2% in "construction" between 2019 and 2030), except for "fossil fuels extraction and distribution" (-87%), "other manufacturing" sectors (-15%), "transport and electronic equipment" (-8%) and "other services" (e.g. minerals, -1%). Employment grows the most in "renewables and nuclear electricity" (78%) as well as "other services" (10%) and "business services" (9%). Employment decreases the most in fossil-based energy sectors, which the ETS covers. However, employment in these sectors accounts for less than 1% of total employment in the EU in 2030 in the Fit for 55 scenario; this decrease has a limited impact on overall employment. Overall, employment losses and gains will not be equally distributed across different sectors and occupations. In particular, sectors that will be most severely impacted in relative terms in terms of job creation and job destruction will be concentrated in sectors that currently employ relatively few workers and that pay relatively well. In contrast, sectors that currently employ many workers will be less affected by structural transformations. Job destruction will be especially large for blue-collar and farm workers.

Figure 3.4. Evolution in sectoral employment in the Fit for 55 scenario

Legend:
- 2019 employment in million persons (left y-axis)
- ◆ % change in employment in 2030 in the Fit for 55 scenario compared to 2019 (right y-axis)
- ◆ % change in 2030 employment in the baseline scenario compared to 2019 (right y-axis)

Panel A: Emissions Trading System (ETS) sectors

Panel B: Effort Sharing Regulation (ESR) sectors
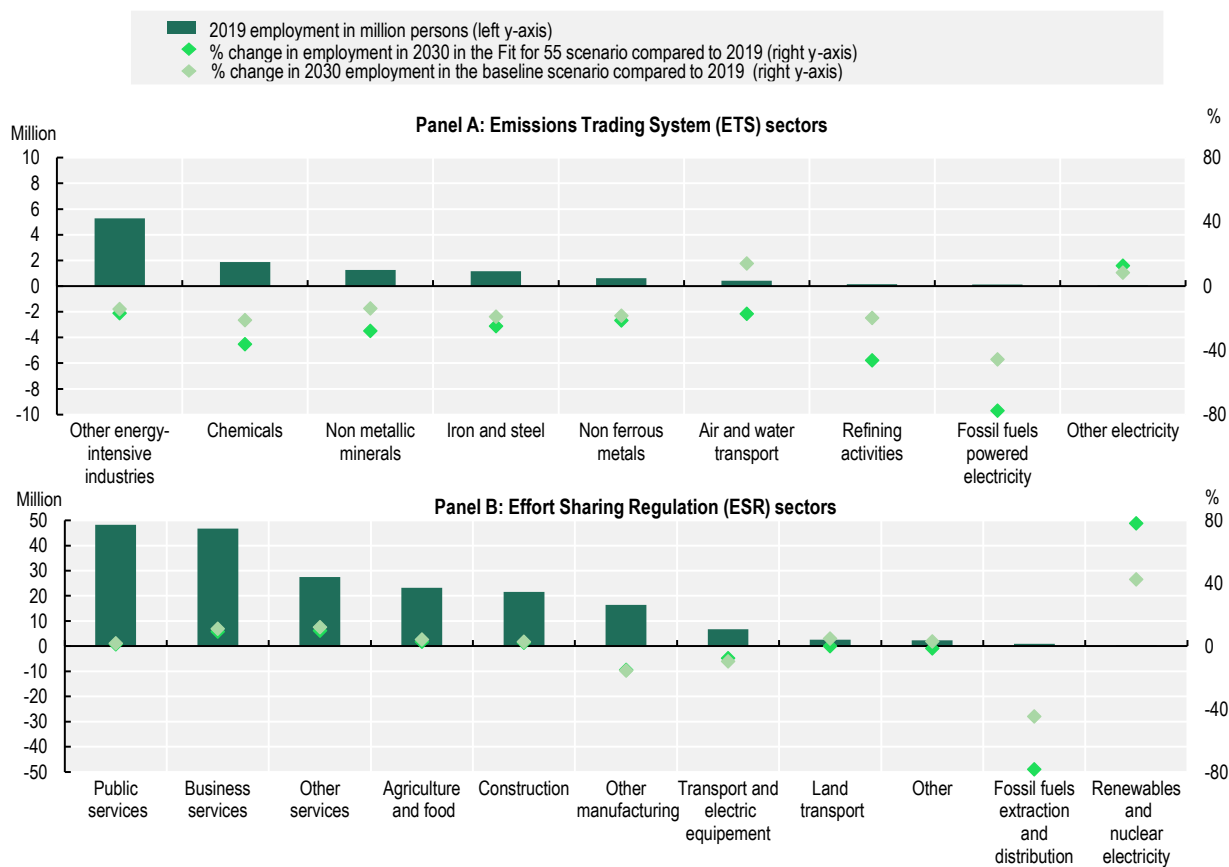
Note: Sectors are ranked by employment in 2019 (bars). The markers illustrate changes in employment in 2030 compared to 2019 for the baseline scenario (light green markers) and the Fit for 55 scenario (dark green markers). An overview of all ENV-Linkages sectors displayed in this figure and how sectors are combined is provided in Borgonovi et al. (2023[2]).
Source: Calculations based on OECD ENV-Linkages model, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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Sectoral employment by occupational category

With the Fit for 55 package, employment in the EU by 2030 increases in all job categories except for blue-collar and farm workers (Figure 3.5 provides ETS sectors, while Figure 3.6 provides ESR sectors). While employment remains at a similar level for this occupational category between 2019 and 2030 for ESR sectors (-0.1%), it decreases strongly for ETS sectors (-24%). For all other categories, the increase in employment in ESR sectors compensates for the decrease in ETS sectors. Employment increases for service and sales workers, managers and professionals, clerical workers, and technicians and associate professionals as these categories are most employed in sectors with a large share of total employment (services sectors) and/or in sectors in which employment increases the most between 2019 and 2030 (renewables and nuclear electricity).

Figure 3.5. Sectoral employment by occupational category, ETS sectors

Employment level in 2019 and in 2030 for the Fit for 55 and baseline scenarios (in million persons)
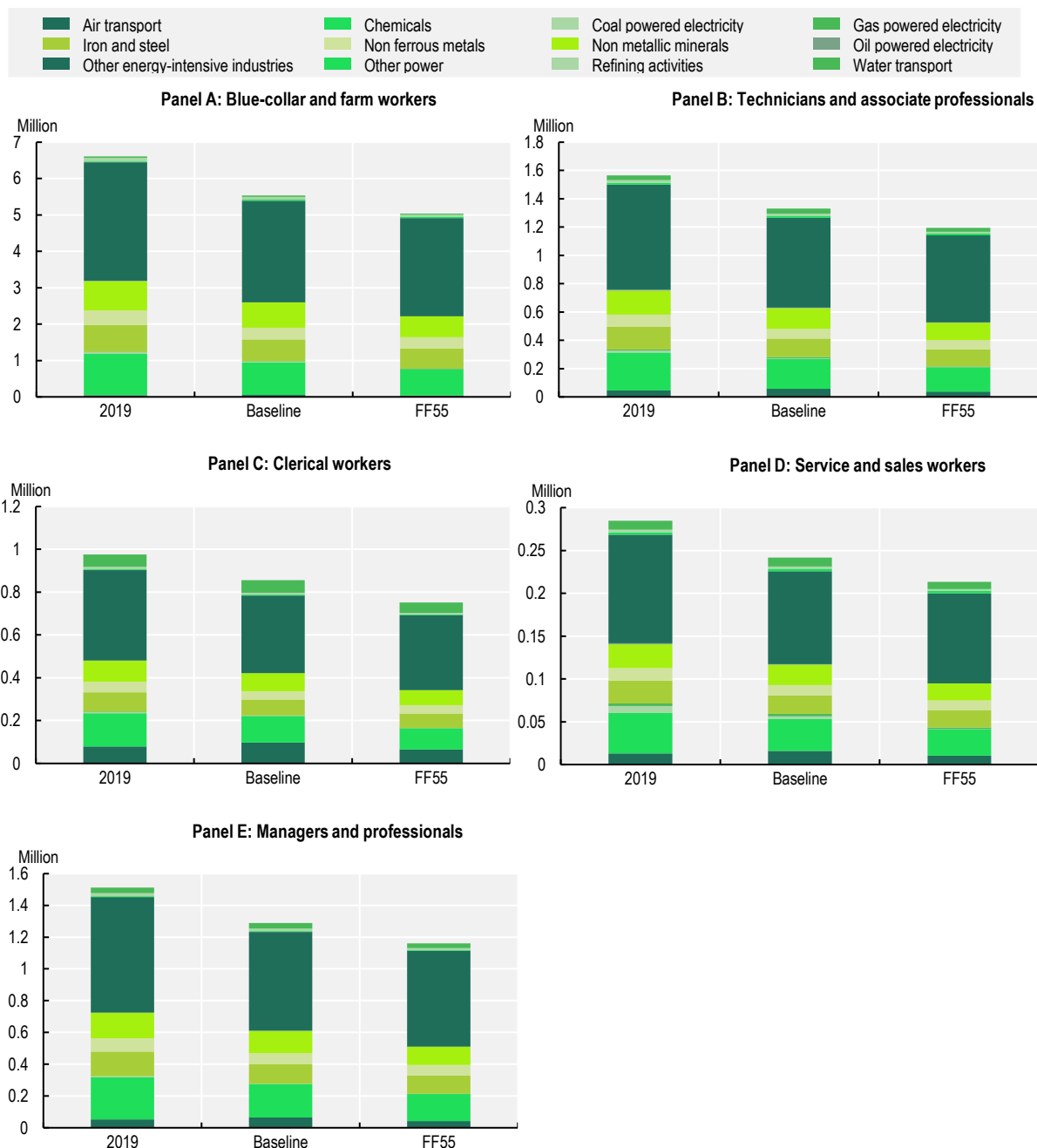
Note: For each occupational category, the figure illustrates total employment for ETS sectors, for the base year (2019), and the Fit for 55 and baseline scenarios in 2030.
Source: Calculations based on OECD ENV-Linkages model, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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Figure 3.6. Sectoral employment by occupational category, ESR sectors

Employment level in 2019 and in 2030 for the Fit for 55 and baseline scenarios (in million persons)
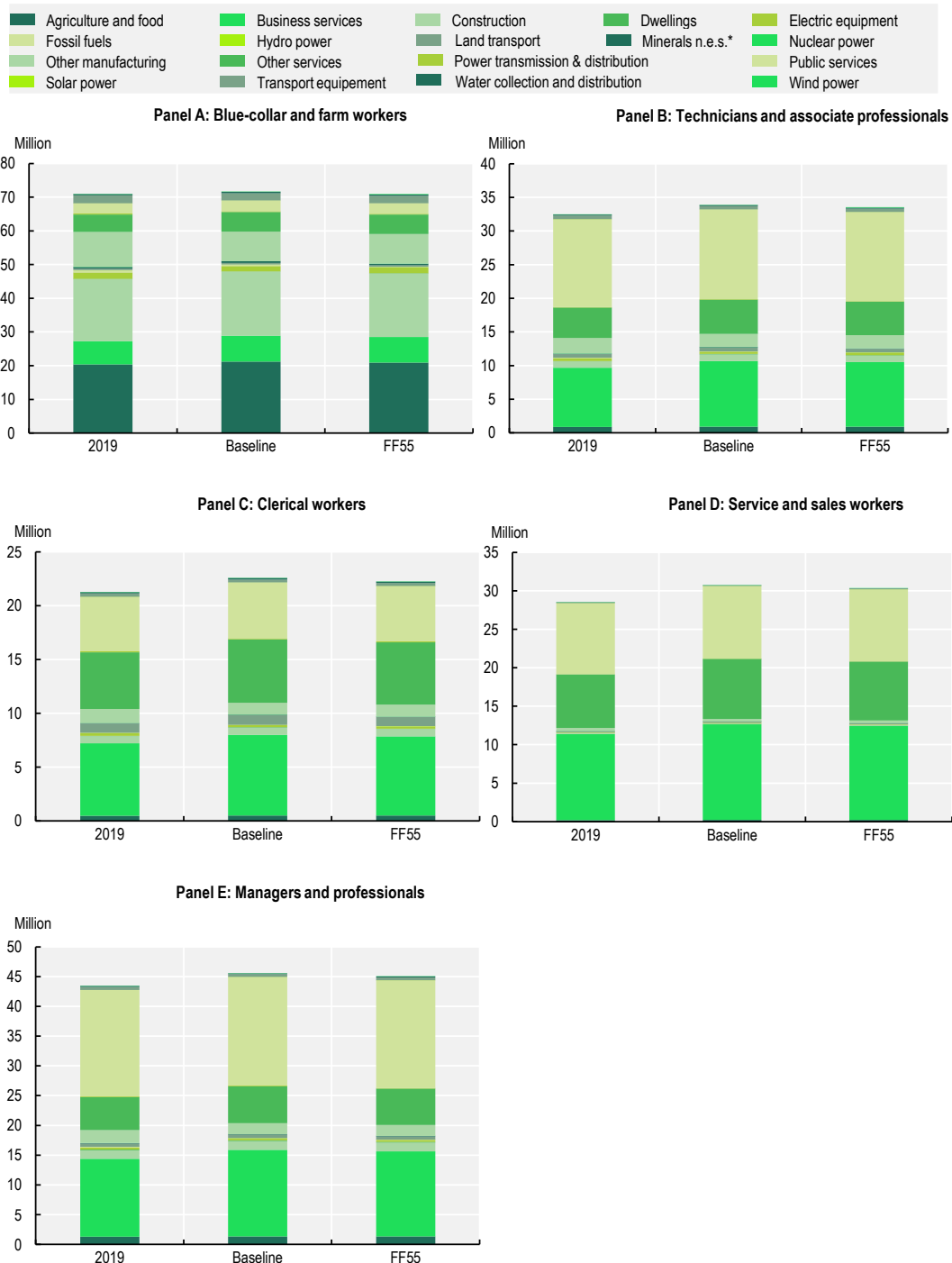
Note: For each occupational category, the figure illustrates total employment for ESR sectors, for the base year (2019), and the Fit for 55 and baseline scenarios in 2030.
* The abbreviation 'n.e.s' in the sector 'Minerals n.e.s' means "not elsewhere specified".
Source: Calculations based on OECD ENV-Linkages model, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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3.3. Projected changes in the demand for skills

Projected changes in employment across sectors and occupations will be reflected in changes in the demand for skills. Emerging skill requirements of jobs in different sectors and occupations were measured using information available in European online vacancies from Lightcast, an approach also used in other studies that consider the effect on skill demands of climate change mitigation policies in Europe (Cedefop, 2023[12]).[14] The importance of a specific skill in a specific sector-by-occupation category was inferred by considering whether such a skill was more frequently found in job vacancies in that sector-by-occupation category compared to how frequently other skills are found in job vacancies in that sector-by-occupation category and how frequently such a skill is found in vacancies in other sector-by-occupation categories. Skills requirements were then multiplied by employment numbers in different sectors and occupations in 2019 as well as projections in 2030 under the baseline and the Fit for 55 scenarios to identify overall skills demands in different scenarios.

An important caveat of estimates of the skills content of occupations is that estimates have ordinal but not numerical meaning. Therefore, whereas it is possible to describe which skills are projected to increase the most and consider if differences in projected growth under different scenarios for one skill are larger or smaller than those projected for a different skill, it is not possible to say if a skill is projected to grow by a given percentage or, for example, double in demand. However, estimates reflect that if demand is projected to increase or decrease, projected changes can be ranked and grouped into projected growth quartiles. Rank positions and quartiles of growth were used in the following analyses to describe projected changes in skills demand.

Contrary to most empirical work that assumes that the skill requirements of occupations in different countries reflect the skill requirements observed in the United States specified in the context of the O*NET database, in this work, emerging skill requirements contained in job postings for the EU region were used. The use of skills requirements specified in online job vacancies also allows for a better approximation of the emerging skills content of different occupations, given the intention of this work to consider projected changes in skills demands related to structural transformations in production processes to meet ambitious environmental policy targets rather than mapping the distribution of skill requirements in the past in different occupations. To aid comparability with other work, such as the OECD Skills for Jobs database (OECD, 2022[13]), skill requirements expressed in the European Skills, Competences, Qualifications and Occupations (ESCO) taxonomy were mapped onto the O*NET classification.

The detailed skills classifiers contained in job vacancies were aggregated into six main skills categories according to the O*NET system: *Skills*; *Knowledge*; *Abilities*; *Technology Skills and Tools*; *Work Activities*; and *Work Styles* (a detailed description of the skills categories is provided in Borgonovi et al. (2023[2])).[15] To avoid confusion between individual skills and the broad *Skills* category, whenever referring to a specific aggregate category of skills, italics are applied. By contrast, the term skills, not italicised, refers to all the categories together and general human capital.

In particular, because Figure 3.4 reveals that sectors that employ few people, such as "fossil-fuel-powered electricity" and "renewables and nuclear energy" generation, are projected to be highly impacted (some negatively and others positively) by implementing Fit for 55, two sets of analyses were developed. The first compares changes in skills demands considering the change in the absolute number of workers employed in different sectors and occupations in 2030 compared to 2019. The second compares changes in skills demands considering the percentage-point change in the number of workers employed in different sectors and occupations in 2030 compared to 2019.

Because under the Fit for 55 scenario, employment is projected to be lower (1.3% versus 3%) than in the baseline scenario (Figure 3.3), changes in skills categories based on relative and absolute changes in employment presented in the following section reveal a weaker demand for all skills categories in the Fit for 55 scenario than the baseline scenario. The difference between the two scenarios in projections for

different skills categories reflects the different demand for skills in each of the six categories in sectors and occupations with different projected growth rates in the two scenarios.

In Figure 3.7, **relative** changes in the absolute number of workers employed in different sectors between 2019 and 2030 are used to estimate changes in the demand for skills. Relative changes correspond to the projected percentage changes in employment by 2030 under the Fit for 55 and baseline scenarios over 2019 employment levels. The skills categories that are projected to grow the most in demand are *Technology Skills and Tools*, and *Work Activities*. These are the skills categories grouping a large number of skills that are used in particular in occupations and sectors that are projected to grow sharply between 2019 and 2030.

Figure 3.7. Projected change in the demand for skills between 2019 and 2030 when considering relative growth in employment, by main skill category

Estimated change in the demand for skills given projections in relative employment growth in different sectors and occupations in the Fit for 55 and baseline scenarios
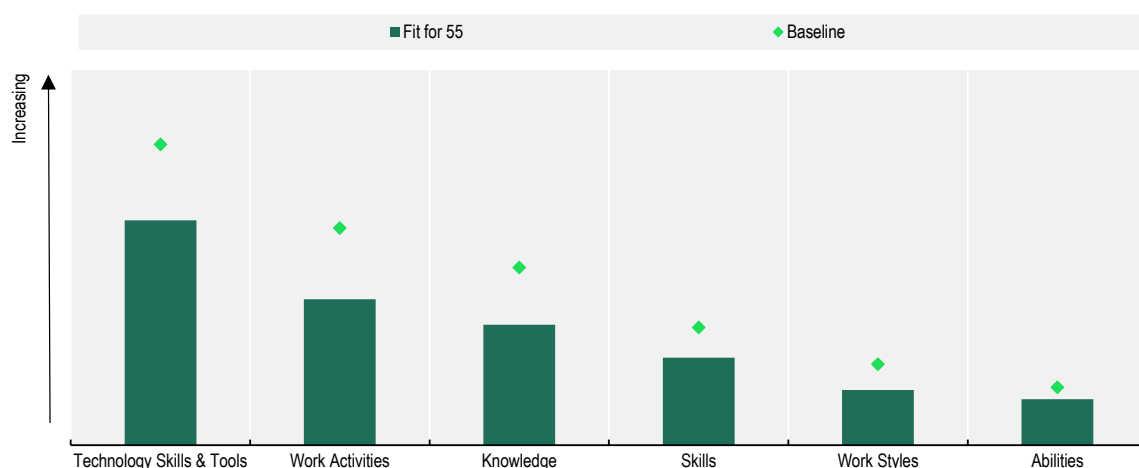
Note: The figure shows the projected change in the demand for each of the six main skills categories between 2019 and 2030 under the Fit for 55 and baseline scenarios across European Union countries when considering relative employment growth in different sectors and occupations identified in the section above, "Projected employment changes resulting from the implementation of the Fit for 55 policy targets". A detailed description of the underlying analyses is provided in Borgonovi et al. (2023[2]).
Source: Calculations based on OECD ENV-Linkages model, Lightcast (2023[14]), Lightcast™, https://lightcast.io/, (accessed April 2023), European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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Projected changes in the **absolute** number of workers employed in different sectors between 2019 and 2030 are used to estimate changes in the demand for skills in Figure 3.8. *Knowledge* and *Work Activities* are the skills categories that are projected to grow most sharply, whereas *Skills* and *Abilities* are projected to grow the least between 2019 and 2030.

Estimated change in the demand for skills given projections in absolute employment change in different sectors and occupations in the Fit for 55 and baseline scenarios
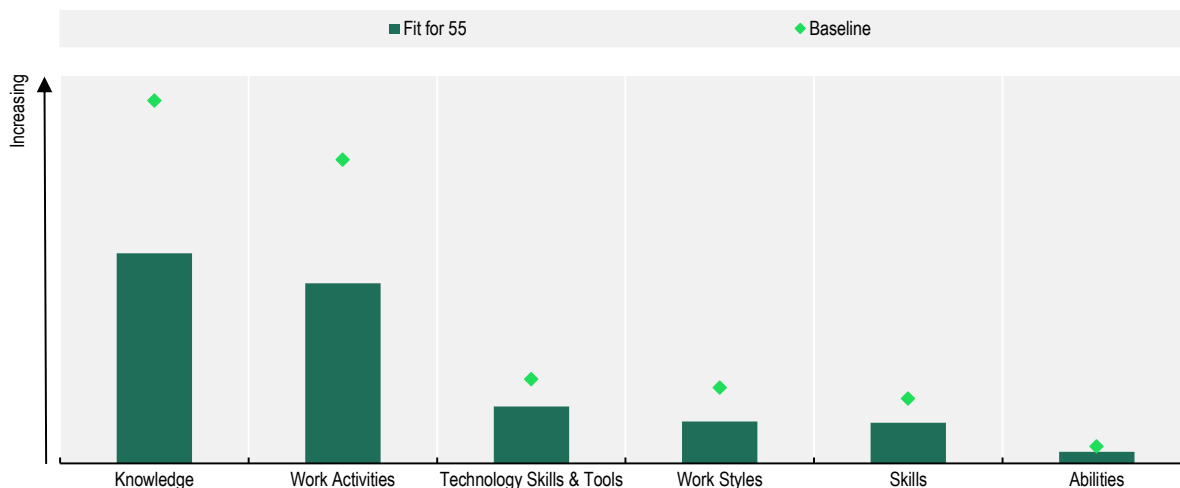
Note: The figure shows the projected change in the demand for each of the six main skills categories between 2019 and 2030 under the Fit for 55 and baseline scenarios across European Union countries when considering absolute employment growth in different sectors and occupations identified in the section above, "Projected employment changes resulting from the implementation of the Fit for 55 policy targets". A detailed description of the underlying analyses is provided in Borgonovi et al. (2023[2]).
Source: Calculations based on OECD ENV-Linkages model, Lightcast (2023[14]), Lightcast™, https://lightcast.io/, (accessed April 2023), European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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Table 3.1 categorises all skills demanded in online vacancies into five groups. The first four groups reflect quartiles of projected skills growth between 2019 and 2030 under the Fit for 55 scenario, with Group 1 being composed of the 25% of skills that are projected to increase the most in demand. Group 4 comprises the 25% of skills that are projected to increase the least in demand. Group 5 comprises all skills that are projected to decline in demand under the same scenario. Projections in demand were obtained by multiplying changes in absolute employment numbers between 2019 and 2030 in the Fit for 55 scenario.

As many as 11 skills out of the 32 skills in the *Knowledge* category (or around 34%) are projected to be in the group of skills with the strongest **estimated demand increase** (Group 1). Examples of these skills are: "sales and marketing", "computers and electronics", "language", "economics and accounting", "customer and personal service", "administration and management", "medicine and dentistry", "production and processing", "communications and media", "personnel and human resources", and "food production". Most of these skills are essential in the "business services" and "public services" sectors, which employ many workers in EU economies.

A further 11 of the 32 skills in the *Knowledge* category (or around 34%) are projected to be in Group 2. These are: "law and government", "chemistry", "biology", "public safety and security", "engineering and technology", "administrative", "mathematics", "building and construction", "psychology", "education and training", and "geography". Only four skills in the *Knowledge* category are projected to **decline in overall demand** or be in the group of skills that are estimated to grow the least in demand.

Table 3.1. Projected change in the demand for skills between 2019 and 2030 under the Fit for 55 scenarios

Group 1: Top quartile of absolute increase	Group 2: Second quartile of absolute increase	Group 3: Third quartile of absolute increase	Group 4: Bottom quartile of absolute increase	Group 5: Skills declining in demand
Oral expression	Originality	Mathematical reasoning	Memorisation	Physics
Sales and marketing	Fluency of ideas	Fine arts	Written comprehension	Mechanical
Computers and electronics	Law and government	Transportation	Information ordering	Repairing
Language	Chemistry	Philosophy and theology	Therapy and counselling	Equipment maintenance
Economics and accounting	Biology	History and archaeology	Design	Offset printing presses
Customer and personal service	Public safety and security	Telecommunications	Systems evaluation	Injection moulding machines
Administration and management	Engineering and technology	Sociology and anthropology	Service orientation	Computer-aided manufacturing (CAM) software
Medicine and dentistry	Administrative	Judgement and decision making	Active listening	Lasers
Production and processing	Mathematics	Management of material resources	Critical thinking	Milling machines
Communications and media	Building and construction	Management of personnel resources	Resource management skills (general)	Handling and moving objects
Personnel and human resources	Psychology	Monitoring	Programme testing software	Repairing and maintaining mechanical equipment
Food production	Education and training	Systems analysis	Music or sound editing software	Repairing and maintaining mechanical equipment
Programming	Geography	Graphics or photo imaging software	Metadata management software	Controlling machines and processes
Time management	Management of financial resources	Database user interface and query software	Automatic teller machines (ATMs)	
Web platform development software	Complex problem solving	Enterprise application integration software	Information retrieval or search software	
Operating system software	Quality control analysis	Web page creation and editing software	Cloud-based data access and sharing software	
Analytical or scientific software	Database management system software	Spreadsheet software	Business intelligence and data analysis software	
Interacting with computers	Object or component-oriented development software	Internet browser software	Geographic information system	
Thinking creatively	Office suite software	Desktop publishing software	Access servers	
Analysing data or information	Configuration management software	Computer-based training software	Word processing software	
Assisting and caring for others	Development environment software	Inspecting equipment, structures, or material	Computer-aided design (CAD) software	
Communicating with persons outside an organisation	Enterprise resource planning (ERP) software	Operating vehicles, mechanised devices, or equipment	Optical character reader (OCR) or scanning software	
Performing general physical activities	Customer relationship management (CRM) software	Scheduling work and activities	Network monitoring software	

Group 1: Top quartile of absolute increase	Group 2: Second quartile of absolute increase	Group 3: Third quartile of absolute increase	Group 4: Bottom quartile of absolute increase	Group 5: Skills declining in demand
Provide consultation and advice to others	Application server software	Identifying objects, actions, and events	Transaction security and virus protection software	
Guiding, directing, and motivating subordinates	Presentation software	Training and teaching others	Video creation and editing software	
Performing administrative activities	Documenting/recording information	Coaching and developing others	Object-oriented database management software	
Establishing and maintaining interpersonal relationships	Communicating with supervisors, peers, or subordinates	Getting information	Safety harnesses or belts	
Organising, planning, and prioritising work	Performing for or working directly with the public	Evaluating information to determine compliance with standards	Blow moulding machines	
Selling or influencing others	Judging the qualities of things, services, or people	Developing and building teams	Compliance software	
Monitoring and controlling resources	Staffing organisational units	Updating and using relevant knowledge	Interpreting the meaning of information for others	
Developing objectives and strategies	Monitor processes, materials, or surroundings	Stress tolerance	Processing information	
Making decisions and solving problems	Resolving conflicts and negotiating with others	Concern for others	Repairing and maintaining electronic equipment	
Dependability	Self-control	Attention to detail	Estimating the quantifiable characteristics of products, events, or information	
Initiative	Analytical thinking	Co-operation	Co-ordinating the work and activities of others	
Achievement/effort	Adaptability/flexibility	Innovation	Integrity	
Leadership			Persistence	

Note: Individual skills are grouped into five groups depending on the size of projected changes in demand between 2019 and 2030 under the Fit for 55 scenario. Each skill is assigned a colour depending on the skill category to which the skill belongs. Estimates of changes in skills demands were computed by multiplying the calculated importance of a specific skill with overall employment numbers in 2019 and in 2030 under the Fit for 55 Scenario.

- Abilities
- Knowledge
- Skills
- Technology Skills and Tools
- Work Activities
- Work Styles

Source: Calculations based on OECD ENV-Linkages model, Lightcast (2023[14]), Lightcast™, https://lightcast.io/, (accessed April 2023), European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

Many of the skills in the *Work Activities* category are also estimated to be in the **largest increase group**. Table 3.1 indicates that 15 of the 41 skills in the *Work Activities* category are in the largest increase group (around 38% of all skills in the *Work Activities* category). Examples of *Work Activities* skills that are **estimated to grow the most in demand** (Group 1) include: "interacting with computers"; "thinking creatively"; "analysing data and information"; "assisting and caring for others"; "communicating with persons outside an organisation"; "performing general physical activities"; "providing consultation and advice to others"; "guiding, directing, and motivating subordinates"; "performing administrative activities"; "establishing and maintaining interpersonal relationships"; "organising, planning, and prioritising work";

"selling or influencing others"; "monitoring and controlling resources"; "developing objectives and strategies"; and "making decisions and solving problems".

By contrast, only three skills in the *Work Activities* category out of 41 (around 10%) are projected to decline in demand. These are: "handling and moving objects"; "repairing and maintaining mechanical equipment"; and "controlling machines and processes".

Among the 44 skills identified in the *Technology Skills and Tools* category, 3 (corresponding to 7% of all skills in the *Technology Skills and Tools* category) belong to the set of skills that are projected to **grow the most in demand** (Group 1) between 2019 and 2030. These are: "web platform development software"; "operating system software"; and "analytical or scientific software". As many as 19 skills (corresponding to 43%) belong to the set of skills that are projected to grow the least in demand between 2019 and 2030, and 5 skills are projected to decline in demand (11%). These include: "offset printing presses"; "injection moulding machines"; "computer-aided manufacturing (CAM) software"; "operating lasers"; and "operating milling machines".

Among the *Skills* category, two skills, namely programming and time management (corresponding to 12% of skills in the *Skills* category), are in the group of skills that are projected to **increase the most in demand**, whereas repairing and equipment maintenance are in the set of skills that are projected to decline in demand.

"Oral expression" is the only skill in the *Abilities* category estimated to be in the group of skills projected to **increase the most in demand**. "Originality" and "fluency of ideas" are in the second group of increased demand. In contrast, "memorisation", "written comprehension", and "information ordering" are estimated to be in the group of skills projected to increase the least in demand.

Table 3.2 complements estimates in Table 3.1 by illustrating which skills will contract the most in demand with the implementation of Fit for 55 targets relative to the baseline scenario. Whereas most skills in Table 3.1 are projected to increase between 2019 and 2030, all skills in Table 3.2 are projected to decline in demand because, in virtually all sectors and occupations, Fit for 55 will determine a contraction in employment relative to the baseline scenario.

Most of the skills projected to decline the most in demand as a result of the implementation of Fit for 55 targets refers to operating and maintaining equipment and tools. They include skills such as "controlling machines and processes"; "operating injection moulding machines"; "repairing"; "physics"; "handling and moving objects"; "repairing and maintaining mechanical equipment"; "estimating the quantifiable characteristics of products, events, or information"; "equipment maintenance"; "blow moulding machines".

By contrast, many of the skills projected to be impacted the least with the contraction of employment due to Fit for 55 are: "mathematical reasoning"; "using video creation and editing software"; "programme testing software"; "network monitoring software"; "persistence"; "management of personnel resources"; "business intelligence and data analysis software"; "transaction security and virus protection software"; "co-ordinating the work and activities of others"; and "presentation software".

Although the demand for most skills is projected to increase in absolute terms between 2019 and 2030 under the implementation of the Fit for 55 targets (Table 3.1), such an increase is lower than the increase projected under the baseline scenario since overall employment projections are lower in the Fit for 55 than in the baseline scenario. At the same time, the effect of the Fit for 55 implementation is not equal across sectors and occupations, so the contracting effect of Fit for 55 on skills demand varies depending on whether skills are especially used in sectors and occupations that will be most severely impacted by Fit for 55 or not (Table 3.2).

Table 3.2. How the demand for skills will be impacted by implementing Fit for 55

Top quartile of change in demand due to FF55 relative to baseline (Skills for which Fit for 55 is projected to have the weakest negative effect on skills demand)	Second quartile of change in demand due to FF55 relative to baseline	Third quartile of change in demand due to FF55 relative to baseline	Bottom quartile of change in demand due to FF55 relative to baseline (Skills for which Fit for 55 is projected to have the strongest negative effect on skills demand)
Information ordering	Fluency of ideas	Oral expression	Written comprehension
Mathematical reasoning	Economics and accounting	Originality	Language
Memorisation	Medicine and dentistry	Administrative	Building and construction
Sociology and anthropology	Food production	Mathematics	Production and processing
History and archaeology	Fine arts	Personnel and human resources	Transportation
Service orientation	Sales and marketing	Philosophy and theology	Engineering and technology
Management of personnel resources	Public safety and security	Computers and electronics	Design
Critical thinking	Psychology	Telecommunications	Physics
Active listening	Communications and media	Law and government	Mechanical
Systems evaluation	Biology	Chemistry	Quality control analysis
Offset printing presses	Education and training	Therapy and counselling	Complex problem solving
Network monitoring software	Geography	Management of material resources	Equipment maintenance
Geographic information system	Customer and personal service	Time management	Resource management skills (general)
Program testing software	Administration and management	Enterprise resource planning (ERP) software	Repairing
Video creation and editing software	Programming	Object-oriented database management software	Information retrieval or search software
Enterprise application integration software	Management of financial resources	Graphics or photo imaging software	Word processing software
Compliance software	Systems analysis	Computer-based training software	Spreadsheet software
Database management system software	Judgement and decision making	Automatic teller machines (ATMs)	Blow moulding machines
Business intelligence and data analysis software	Monitoring	Optical character reader (OCR) or scanning software	Internet browser software
Access servers	Web platform development software	Office suite software	Lasers
Transaction security and virus protection software	Object or component-oriented development software	Assisting and caring for others	Computer-aided design (CAD) software
Safety harnesses or belts	Customer relationship management (CRM) software	Judging the qualities of things, services, or people	Injection moulding machines
Presentation software	Milling machines	Thinking creatively	Computer-aided manufacturing (CAM) software
Desktop publishing software	Development environment software	Performing general physical activities	Inspecting equipment, structures, or material
Metadata management software	Web page creation and editing software	Establishing and maintaining interpersonal relationships	Repairing and maintaining electronic equipment
Configuration management software	Analytical or scientific software	Documenting/recording information	Monitor processes, materials, or surroundings
Music or sound editing software	Cloud-based data access and sharing software	Training and teaching others	Operating vehicles, mechanised devices, or equipment

Top quartile of change in demand due to FF55 relative to baseline (Skills for which Fit for 55 is projected to have the weakest negative effect on skills demand)	Second quartile of change in demand due to FF55 relative to baseline	Third quartile of change in demand due to FF55 relative to baseline	Bottom quartile of change in demand due to FF55 relative to baseline (Skills for which Fit for 55 is projected to have the strongest negative effect on skills demand)
Operating system software	Guiding, directing, and motivating subordinates	Interacting with computers	Developing and building teams
Application server software	Coaching and developing others	Monitoring and controlling resources	Getting information
Database user interface and query software	Provide consultation and advice to others	Interpreting the meaning of information for others	Processing information
co-ordinating the work and activities of others	Selling or influencing others	Organising, planning, and prioritising work	Estimating the quantifiable characteristics of products, events, or information
Identifying objects, actions, and events	Developing objectives and strategies	Evaluating information to determine compliance with standards	Repairing and maintaining mechanical equipment
Resolving conflicts and negotiating with others	Communicating with supervisors, peers or subordinates	Self-control	Repairing and maintaining mechanical equipment
Staffing organisational units	Scheduling work and activities	Attention to detail	Handling and moving objects
Performing administrative activities	Communicating with persons outside an organisation	Initiative	Controlling machines and processes
Performing for or working directly with the public	Making decisions and solving problems	Leadership	Dependability
Analysing data or information	Updating and using relevant knowledge	Achievement/effort	Integrity
Persistence	Analytical thinking	Concern for others	Stress tolerance
Innovation			Adaptability/flexibility
			Co-operation

Note: Individual skills are grouped into four groups depending on the size of the difference in projected skills demands in 2030 under the Fit for 55 scenario and the baseline scenario. Each skill is assigned a colour depending on the skill category to which the skill belongs. Estimates of changes in skills demands were computed by multiplying the calculated importance of a specific skill with the percentage change in employment numbers in 2030 under the Fit for 55 and the baseline scenario.

- Abilities
- Knowledge
- Skills
- Technology Skills and Tools
- Work Activities
- Work Styles

Source: Calculations based on OECD ENV-Linkages model, Lightcast (2023[14]), Lightcast™, https://lightcast.io/, (accessed April 2023), European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

3.3.1. Similarity in the skill set of workers employed in different sectors and occupations

In order to facilitate the successful transition of workers from sectors expected to contract in the next decade to sectors expected to grow, it is necessary to develop training opportunities. This requires identifying both the overall changes in skills demanded across the economy and the extent to which different jobs share similar skill requirements. Additionally, projected employment trends and the relative scale of various employment opportunities need to be considered. Jobs that are growing very rapidly in demand but are small in size might, in fact, offer fewer transition opportunities than jobs that are growing little in demand but represent a large share of the overall labour market.[16]

Even after having identified the skills that adults should acquire to successfully transition into occupations or sectors that will expand in the medium term, a major challenge is to ensure that education and training systems are designed in a flexible way to enable smooth transitions. This requires adult education and training systems to have a certain degree of flexibility with respect to several dimensions: time (when does learning occur and for how long), place (where does learning occur), mode (which learning style) and content (which skills to learn) (OECD, 2023[16]). However, many adult education and training systems are not yet developed to meet these challenges. Scope for improvement exists in many areas, such as the recognition of prior learning (OECD, 2019[17]), which is also closely linked to occupational entry regulations and, for example, has implications for labour mobility (von Rueden and Bambalaite, 2020[18]); ensuring inclusiveness of learning systems. To date, a large share of workers still does not participate in training (OECD, 2019[17]).

Blue-collar and farm work occupations are projected to shrink in overall demand (Figure 3.3) in the Fit for 55 and baseline scenarios. As a result, many existing blue-collar and farm workers will have to consider transitioning into non-blue-collar and farm work occupations and initial education and training. Therefore, young people should be made aware of shrinking/increasing labour market opportunities while they are in initial education and training, and such information should be reflected in orientation programmes to help them make educational and career decisions that are aligned with labour market needs. At the same time, blue-collar and farm work will not disappear, and there are sectors in which demand is projected to increase. Identifying the degree of similarity in the skills required in different sectors and occupations and their capacity to absorb new workers due to labour market trends can aid both individuals who consider transition opportunities and policy makers in organising effective upskilling and reskilling programmes.

For some blue-collar workers employed in shrinking sectors, transitioning into other blue-collar jobs in growing sectors would entail moving into a sector with relatively high levels of skills similarity (Figure 3.9).[17] For example, blue-collar workers employed in Sector 20 ("manufacture of chemicals and chemical products") and 21 ("manufacture of basic pharmaceutical products and pharmaceutical preparations") are projected to decrease between 2019 and 2030 in the Fit for 55 scenario (these sectors are shown in the second cluster from the left in Figure 3.9). However, the skill set demanded of blue-collar workers in these sectors is relatively similar to the skill set demanded in Sector 35 ("electricity, gas, steam and air conditioning supply"), Sector 41 ("construction of buildings") and 42 ("civil engineering"). These sectors are projected to increase between 2019 and 2030 under the Fit for 55 scenario, employ a relatively large share of blue-collar workers and therefore exemplify relatively viable transition opportunities.

Although Figure 3.9 suggests that some blue-collar workers would have opportunities to transition into sectors with similar skills profiles, for other workers, skills requirements in sectors projected to increase in demand and that account for a large number of the blue-collar workforce differ substantively from the skill set required in their current jobs. For example, the highest degree of similarity in demand of blue-collar workers employed in Sector 5 ("mining of coal and lignite") is the skill set demanded of blue-collar workers in Sector 33 ("repair and installation of machinery and equipment") (these sectors are shown in the fifth cluster from the left in Figure 3.9). However, both sectors are projected to decline between 2019 and 2030. There are no other sectors in the same cluster with a skill set that is relatively similar and that is projected to grow, thus providing more viable transition opportunities.

Blue-collar workers are the only category of workers that are projected to experience an absolute contraction in employment opportunities. Figure 3.9 sheds light on the overall share of employment of blue-collar and farm workers in different clusters of sectors with similar skills requirements in 2019 and indicates if employment is projected to increase or decrease between 2019 and 2030. However, it does not indicate the extent to which such an increase/decrease will result in an overall expansion of employment opportunities – a necessary condition of within-cluster transitions – or a net loss or gain of employment.

Dendrogram illustrating sectors based on skills similarity for blue-collar workers, employment shares in 2019 and projected growth/decline between 2019 and 2030 under the implementation of Fit for 55
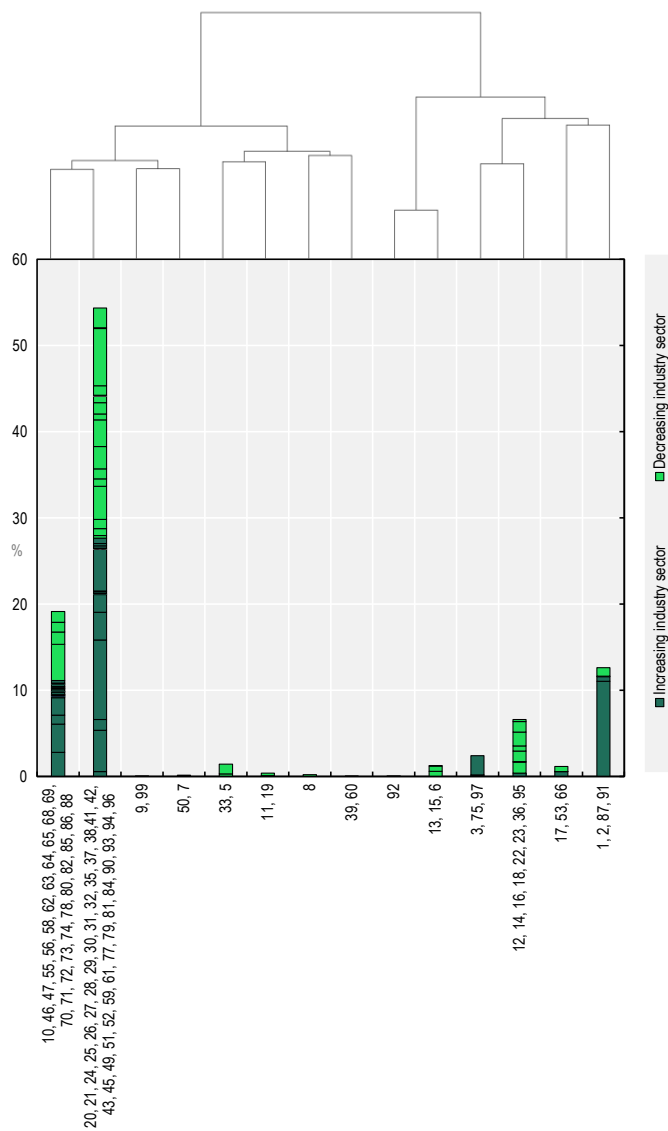
Note: The top part of the dendrogram illustrates the degree of similarity in the skill set needed in jobs performed by workers in different sectors. Sectors that share the same tree of the dendrogram are closest in terms of skills requirements, as estimated through cosine distance and hierarchical/agglomerative clustering using the Ward variance minimisation algorithm, followed by sectors belonging to the same level one branch, followed by those belonging to the same level two branch, etc. The bottom part identifies the share of blue-collar and farm workers employed in each sector in 2019 (vertical axis, with stacked bar reflecting the size of sectors in increasing NACE [Nomenclature of Economic Activities] code numbering). Each sector bar is colour-coded to reflect if the sector is projected to increase or decline in demand between 2019 and 2030 under the Fit for 55 scenario. Sectors represented in dark green are sectors for which the demand for blue-collar workers is projected to increase between 2019 and 2030, whereas sectors in light grey are sectors for which the demand for blue-collar workers is projected to decrease. Underlying data are available in the Statlink.

Source: Calculations based on OECD ENV-Linkages model, Lightcast (2023[14]), Lightcast™, https://lightcast.io/, (accessed April 2023), European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

StatLink 🔗 https://stat.link/qcuyok

Figure 3.10 illustrates absolute employment losses and gains for each of the sectors in the first cluster (from the left) presented in Figure 3.9, one of the largest clusters in terms of overall employment in 2019 for blue-collar workers. Within this cluster, a positive net employment gain across EU countries of around 315 000 people is projected between 2019 and 2030. This means that for blue-collar and farm workers in this cluster, transition opportunities are available that require a relatively small difference in skills requirements, because projected employment creation in this cluster exceeds projected employment destruction in their original sector.

Figure 3.10. Sectors with several within-cluster transition opportunities

Absolute employment gains and losses by sector
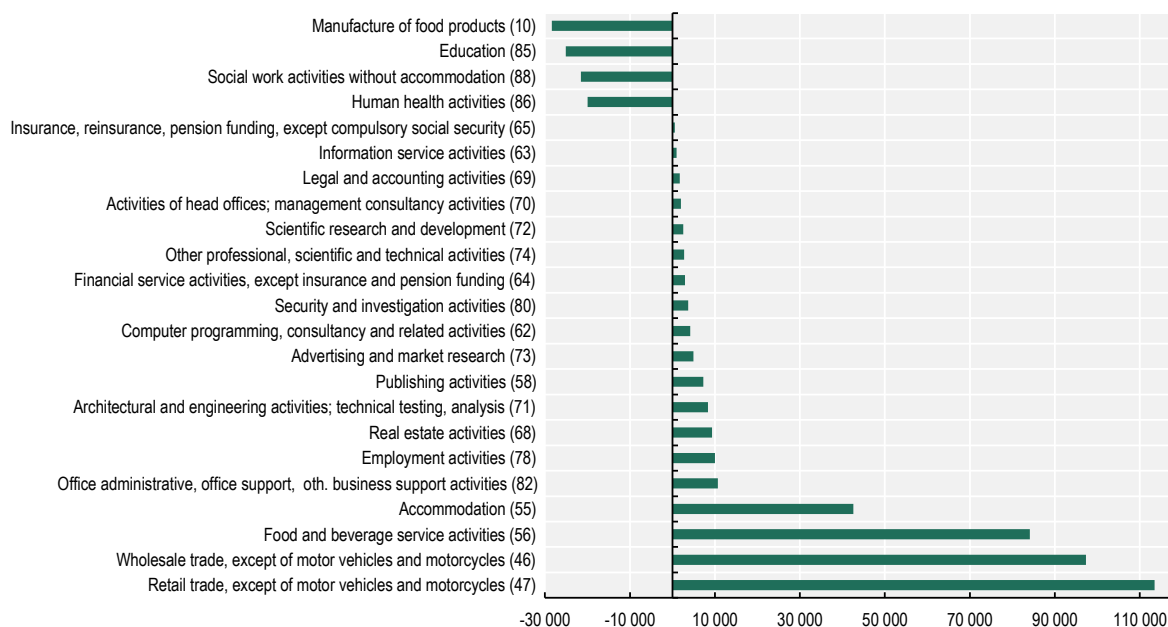
Note: The figure shows the absolute employment gains and losses for the cluster on the left in Figure 3.9, reflecting the difference between total employment gains and total employment losses within the sector. NACE sector numbers are provided behind sector names. Sectors are sorted in descending order from sectors with highest employment gains to sectors with highest employment losses. Borgonovi et al. (2023[2]) provides an overview of NACE sector numbers and sector names.
Source: Calculations based on OECD ENV-Linkages model, European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

StatLink 📊🖥 https://stat.link/mxzi70

By contrast, in Figure 3.10, which illustrates absolute employment losses and gains for the second cluster presented in Figure 3.9, total employment gains are smaller than total employment losses. Overall, approximately 1 300 000 jobs are projected to be lost within this cluster between 2019 and 2030. Therefore, blue-collar and farm workers in sectors in this cluster will not enjoy sufficient transition opportunities involving redeployment in jobs with similar skills requirements and will have to consider transitions into sectors with higher dissimilarity in skills requirements in other clusters, a likely indication of longer and more intense training requirements.

Figure 3.11. Sectors with limited within-cluster transition opportunities

Absolute employment gains and losses by sector
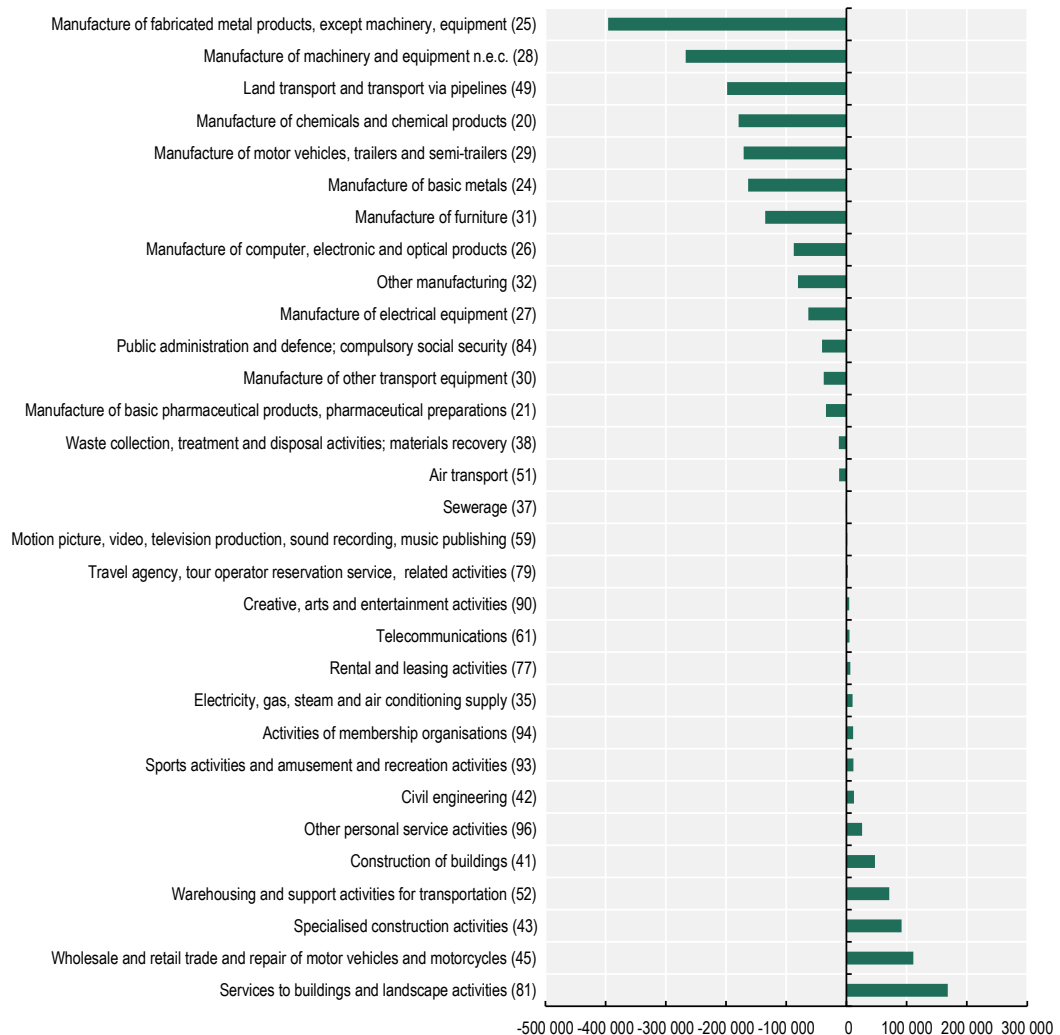
Note: The figure shows the absolute employment gains and losses for the second cluster from the left in Figure 3.9, reflecting the difference between total employment gains and total employment losses within the sector. NACE sector numbers are provided behind sector names. Sectors are sorted in descending order from sectors with highest employment gains to sectors with highest employment losses. Borgonovi et al. (2023[2]) provides an overview of NACE sector numbers and sector names The abbreviation "'n.e.c.'" in the cluster: "manufacture of machinery and equipment n.e.c," stands for "not elsewhere classified".
Source: Calculations based on OECD ENV-Linkages model, European Union (2019[15]), European Labour Force Survey, ad hoc data extraction (for the year 2019), https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey, in Borgonovi et al. (2023[2]), "The effects of the EU Fit for 55 package on labour markets and the demand for skills", https://doi.org/10.1787/6c16baac-en.

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However, workers in certain sectors that are projected to shrink in employment following the Fit for 55 will also need to transition into new roles. Borgonovi et al. (2023[2]) illustrate opportunities for managers and professionals, technicians and associate professionals, clerical workers and sales and service workers.

3.4. Conclusions

The COVID-19 pandemic gave new impetus to the implementation of climate change mitigation policies worldwide. In particular, in the aftermath of the pandemic, EU governments recognised the short-, medium- and long-term potential threat to public health posed by environmental degradation. Moreover, given the severity of the economic crisis induced by lockdowns, many countries adopted stimulus packages to promote economic growth. In many countries, such investments were tied to achieving reductions in GHG emissions and ambitious structural investments in digital infrastructures. Because past waves of structural transformation led to job losses and long-term vulnerability for some groups of workers, it is crucial to ensure that efforts to promote environmental sustainability will also aim to ensure that the green transition will be a just and inclusive transition, leading to improvements in working conditions and minimising widespread job losses and contractual instability. In order to enhance societal-level resilience and mitigate the risk of environmental disasters resulting from GHG emissions, it is crucial to complement efforts to reduce emissions in production with investments in resilient labour markets. This can be achieved through effective skills policies that facilitate environmentally-driven structural transformations.

Projected changes in employment illustrated in the chapter reflect the specific scenario implemented. However, there is no single pathway towards the green transition and towards meeting the Fit for 55 policy targets. For instance, the EU could rely more on the transition towards a circular economy, scaling up policies such as taxes on primary raw materials, extended producer responsibility, recycled content standards or subsidies for the use of secondary materials as well as R&D towards recycling and better product design for recyclability. A previous modelling analysis shows that the implementation of a material fiscal reform aimed at increasing the relative price of primary materials as compared to secondary materials, would substantially increase the circularity of the economy, while also reducing the environmental impacts of materials use, including greenhouse gas emissions (Bibas, Chateau and Lanzi, 2021[19]). Such a policy package would result in a reallocation of jobs with increases in sectors such as services and waste management and decreases in other sectors such as extraction and mining. Overall, the policy package would result in a small increase in employment (Mavroeidi and Chateau, 2020[20]).

Skills policies, which comprise education and training policies targeted at both young people and adults, can play an essential role in achieving the twin objectives of greening the economy and ensuring that the benefits of new investments do not lead to new forms of vulnerability and deprivation. Skills policies can facilitate the reallocation of workers away from sectors that will shrink because they are responsible for a large share of CO_2 emissions, such as mining of coal and lignite, into sectors that will expand because they can sustain the production of energy without emitting large quantities of CO_2, such as wind and solar energy production or in sectors that will expand because of the new demands induced by the demographic transition (to care for and support rapidly ageing populations) (OECD/ILO, 2022[21]) or the digital transition (to work alongside digital tools and applications performing tasks that will not be automatable) (Lassébie and Quintini, 2022[22]). They are therefore important both because they can facilitate the provision of an adequate supply of workers in sectors that need to develop if CO_2 emission reductions are to be met while maintaining current levels of overall consumption and because they can ensure workers who previously worked in sectors that will decline or disappear will be able to find employment in other parts of the economy. At the same time, skills policies are only part of a broader set of policies that can ensure that the transition is just and inclusive. These include social policies, active labour market policies, and local economic development policies. Achieving green objectives while maintaining strong labour markets and broader social well-being is possible but requires the participation of key actors, including governments as well as social partners.

Results presented in this chapter should be evaluated alongside results from other studies that map how the green transition will change the tasks workers will be required to perform in existing jobs to reduce GHG emissions or in new jobs that will emerge to promote the green transition. In particular, changes in the task content of occupations will change the bundle of skills individual workers and/or teams of workers

will need to possess to successfully carry out their jobs, with important implications for the development and implementation of education and training programmes.

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Notes

1. The Fit for 55 package is described in a series of legislations from the European Parliament and the Council (2009[26]; 2009[25]; 2018[27]; 2003[29]; 2008[28]). Following the Fit for 55 package (EU Commission, 2021[24]), EU member states need to reach more ambitious targets than those stated in the Nationally Determined Contributions (NDCs). Furthermore, in June 2022, the Fit for 55 package was revised to include more sectors and more stringent targets for 2030 (European Council and Council of the European Union, 2022[30]).

2. Net emissions include emissions and removals from land-use change and forestry (LULUCF).

3. A review of this literature is available in Borgonovi et al. (2023[2]).

4. In line with information provided in the context of the OECD Skills for Jobs database, the term "skills" is used both as a generic indicator for human capital as well as a term indicating a specific set of proficiencies in manipulating data and things (OECD, 2017[23]). As a generic indicator of human capital, the term skills refers to the broad set of cognitive abilities, physical abilities, socio-emotional abilities and metacognitive abilities (e.g. information-processing skills, dexterity, teamwork, self-organisation) as well as to abilities in performing specific jobs or tasks (e.g. accounting or hair colouring) (OECD, 2017[23]). At the same time, in the context of official classifications of the different sets of skills individuals possess, the term "Skills", capitalised, is used to refer to a particular category of competences.

5. A detailed description of the model is available in Borgonovi et al. (2023[2]).

6. The cut-off date for the baseline scenario policies derives from IEA's *World Energy Outlook 2021*.

[7] Some jurisdictions enacted climate policies after the publication of the *World Energy Outlook 2021*, such as the Inflation Reduction Act in the United States. These climate policies have not been included in the baseline.

[8] While this analysis focuses on emission reductions, the Fit for 55 package also includes other targets, such as achieving a 40% share of renewable energy in total energy consumption and an emission reduction of 55% for new cars and of 50% for new vans. Furthermore, this analysis applies the targets to CO_2 emissions.

[9] ETS sectors include: fossil-fuel-powered electricity, other energy-intensive industries (e.g. steel, cement, glass, paper), air transport, maritime transport (added in new Fit for 55 package). ESR sectors include: road transport, buildings, agriculture, waste, small industries.

[10] The resulting levels of the carbon prices needed to achieve the targets are provided in Borgonovi et al. (2023[2]).

[11] When interpreting the results, it is important to keep in mind that in a CGE model like ENV-Linkages the labour market is cleared so that labour demand equals labour supply. Therefore, while the policy simulations result in a reallocation of sectoral employment, the labour market will overall remain in equilibrium. In a CGE model, employment can increase or decrease following changes in production. However, the labour market will remain in equilibrium so that it is not possible to evaluate unemployment. While CGE models have the advantage of being able to assess the economy-wide impacts of policies, the fact that they cannot evaluate unemployment is a shortcoming.

[12] The new Fit for 55 package is more ambitious for EU-ETS sectors: -61% between 2005 and 2030 levels, vs -43% for the former target.

[13] In these sectors, a decrease in emission intensity implies that CO_2 emissions decrease more than production.

[14] A detailed description of the methodology is available in Borgonovi et al. (2023[2]).

[15] A detailed description of the different skills categories is available in Borgonovi et al. (2023[2]).

[16] A final consideration pertains to wages.

[17] A detailed description of the methodology used to develop skills similarity is available in Borgonovi et al. (2023[2]).

4 Preparing for a changing world: Promoting key skills to adapt to climate change through education and training

The COVID-19 pandemic provided important lessons on how education can be reorganised and learning supported in extreme conditions, highlighting the importance of physical infrastructures, such as indoor air quality, and the inadequacy of these in many countries. The chapter provides evidence on the effects of extreme temperatures and air pollution on skills acquisition, and on the effects of environmental conditions on individuals' willingness to prioritise environmental protection. The chapter also makes the case that adapting to climate change will require developing a wide range of skills, including physical skills. To ensure that individuals and societies are better equipped with the set of skills needed to adapt to environmental changes, the chapter suggests preparing learning environments for extreme weather events, investing in green infrastructure and sustainable practices, and considering the differential effects of environmental conditions on the acquisition of skills.

Key messages

Despite the most ambitious mitigation efforts, a certain degree of climate change is already inevitable due to past emissions. Therefore, it will be necessary to implement a variety of adaptation policies to reduce the vulnerability of individuals and societies to the impacts of climate change and environmental degradation. This chapter explores the mechanisms through which adverse environmental conditions – such as extreme temperatures and air pollution – can disrupt skills acquisition and effective skills use; how environmental conditions shape the formation of attitudes and dispositions towards climate change and environmental degradation; and the physical skills and knowledge individuals will need to adapt to climate change and promote the green transition.

Key findings include:

- Events such as wildfires, extreme temperatures and flooding can disrupt skills acquisition directly by forcing the closure of schools and increasing absenteeism, but also indirectly by reducing the potential of individuals to learn when they are in class and to achieve their full potential during high-stakes exams.

- Exposure to extreme temperatures and air pollution impairs cognitive acuity and attentional and behavioural processes. For example, complex cognitive skills and analytical problem solving that rely heavily on working memory, sustained attention or arithmetic efficiency are more impaired with increased temperatures.

- Socio-economically disadvantaged children and adults are more likely to suffer the negative consequences of adverse environmental conditions. This is because they are often more exposed to poor environmental conditions and lack the resources to invest in adaptation technologies or protective behaviours.

- Concern for climate change, and willingness to prioritise the environment over the economy, increase after the occurrence of natural disasters linked to human activity. A 1 standard-deviation difference in the number of people affected by a natural disaster is associated with around 1 percentage-point change in the likelihood that individuals will be willing to prioritise the environment over the economy if this were to be necessary.

- However, a 1 percentage-point increase in unemployment is associated with a 1.7 percentage-point decrease in the likelihood that individuals will be willing to prioritise the environment over the economy if this were to be necessary.

- Greater awareness of the natural world and physical skills (e.g. riding bicycles or swimming without assistance) will be important to adapt to new environmental conditions. However, many people around the world do not have such skills. Nor are these skills prioritised in formal education.

- Among countries with available data, 83% of adults in Poland reported being able to cycle, whereas less than 60% did in Australia, Italy and Great Britain. Similarly, in OECD countries such as Finland, Germany, the Netherlands, Norway and Sweden, over nine in ten adults report being able to swim without assistance. By contrast, less than one in two individuals report the same in Mexico.

4.1. Introduction

Estimates suggest that, compared to children born in the 1960s, children born at the onset of the coronavirus (COVID-19) pandemic in 2020 may experience twice as many wildfires and 6.8 times more heatwaves across their lifetimes (Global Commission on Adaptation, 2019[1]). Should countries be successful in limiting global warming to 1.5 degrees Celsius above pre-industrial levels, they will be able to reduce additional lifetime exposure to heatwaves by 45% and to wildfires by 10%.

On top of actions aimed at reducing global warming, it is important to consider an array of actions ranging from system-level policies to classroom-level adaptations to reduce the impact of temperatures and pollution on learning and cognitive development. An extensive review of the literature on the effects of environmental conditions on skills development, swimming skills around the world, and the role of environmental conditions and unemployment on public support for environmental policies, as well as detailed descriptions of the data used in the analyses presented in this chapter, are available in the following technical working papers: Asai, Borgonovi and Wildi (2022[2]); Borgonovi, Seitz and Vogel (2022[3]); and Horvath and Borgonovi (2022[4]).

Adaptation is a key stage of the resilience process, and in the context of policies aimed at promoting environmental sustainability, it refers to a set of actions that can reduce the vulnerability of individuals and societies to the impacts of climate change. Adaptation is critical to building resilience at the individual and societal level to climate change because even with the most ambitious mitigation efforts, some level of climate change is already locked in due to past emissions. Even assuming that the commitments countries have made in recent years to halt global warming by reducing greenhouse gas (GHG) emissions and reducing other forms of environmental degradation, such as air pollution, will be effective, adaptation and mitigation policies and behaviours will be crucial in the short and medium terms.

For example, communities world wide will have to find new ways to live in a world with more extreme weather events and higher average temperatures. Changing environmental conditions will require changes in the organisation of schooling and education systems so that learning will be as little disrupted as possible due to extreme weather events. Education and training systems will also be tasked with equipping all learners with the skills needed in a changing world.

In the context of education and skills policies, adaptation includes infrastructural measures directed at reducing the impact of environmental conditions on the ability of schools and training systems to promote learning; changes in how learning is organised to ensure learning occurs despite environmental changes; and changes in the set of skills that individuals should master to be able to thrive in an overall warmer environment and an environment characterised by an increased frequency of extreme weather events.

To this end, the chapter looks at a variety of adaptation policies to reduce the vulnerability of individuals and societies to the impacts of climate change and environmental degradation. It begins with a review of the evidence on the extent to which skill acquisition is promoted or inhibited by two key environmental conditions: temperatures and air pollution. The chapter then details some of the potential adaptation policies that could be implemented to reduce learning disruptions as a result of negative environmental conditions and ensure equitable learning outcomes. Second, the chapter reveals the extent to which experiencing an environmental disaster that is directly linked to human activity or experiencing adverse macroeconomic conditions, such as increases in unemployment shapes public support for adaptation policies aimed at halting environmental degradation. Third, the chapter considers what new sets of skills could become crucial to adapt to a changing climate and provides evidence on the distribution of one such skill – swimming – both across countries and within countries across different population groups. Finally, conclusions and implications for policy are discussed.

4.2. Environmental conditions shape skills and human capital accumulation

4.2.1. Exposure to extreme environmental conditions is increasing

Increases in global surface air temperatures have intensified population exposure to at least one extreme heat day per year with levels above thresholds set for human safety. Research has found that people are increasingly exposed to heatwaves, which are increasing in temperature and length, and that cities carrying more than half of the world's population are facing a severer threat of extreme heatwaves (Wang et al., 2023[5]; Chambers, 2020[6]). Given current population numbers, an increase of 1°C from pre-industrial levels has increased the number of people exposed from 97 million to 275 million. Should temperatures increase further, for example, to 3°C, this number is set to increase to 1.22 billion (Li, Yuan and Kopp, 2020[7]). Increases in global temperatures and heat extremes also threaten to offset the progress made in lowering pollution emissions in developed countries, as high temperatures incur chemical reactions with gaseous pollutants and can trap surface-level ozone.

The health burden of increasing temperatures and air pollution is considerable, as air pollution and high temperatures increase the incidence and severity of respiratory and cardiovascular diseases, including asthma, bronchitis, lung cancer and heart disease. But beyond their impact on health, environmental conditions also have an impact on the developing brain, affecting people's capacity to acquire information and use it to achieve their goals (see Horvath and Borgonovi (2022[4]) for a review of this literature).

Average temperatures have been rising consistently worldwide at an unprecedented rate since 1970 (Gutiérrez et al., 2021[8]). In 2020, global mean surface air temperature over land had risen 1.7°C above the climate normal, which references the period between 1951 and 1980, with the largest increases found in Europe (UNFAO, 2021[9]). In addition to higher average temperatures, hot temperature extremes have risen in frequency and intensity. In 2020, natural disasters classified as extreme temperature events averaged approximately 22 per year globally over the past 20 years, compared to an average of 7 per year recorded between 1980 and 1999 (Figure 4.1). Extreme temperature events are expected to continue increasing, with scientists estimating that very extreme heat events that occurred only once in 50 years will likely occur about 14 times more under a 2°C warming scenario (Gutiérrez et al., 2021[8]).[1]

Figure 4.1. Absolute number of natural disasters due to extreme temperature events per year in OECD countries and globally, 1980-2020
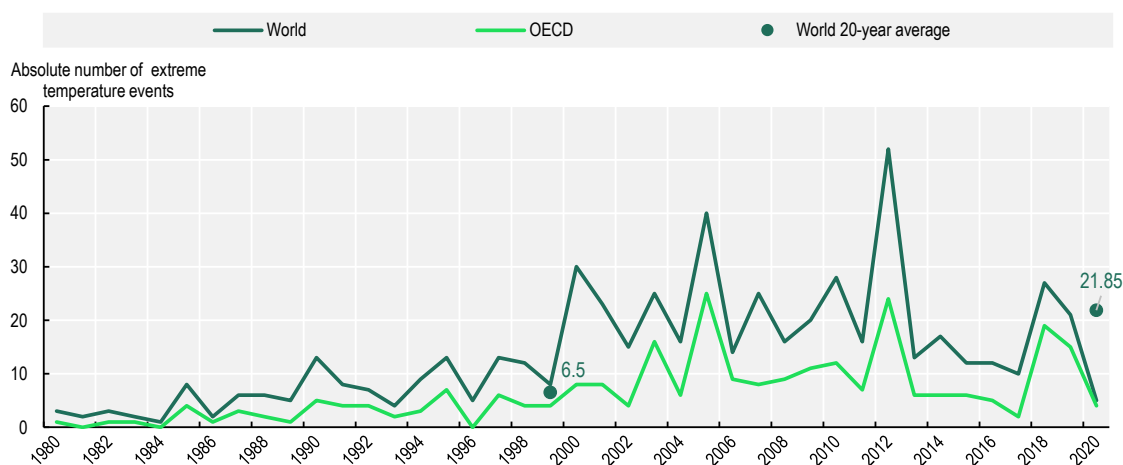
Note: A natural disaster event is included in this data if it fulfils at least one out of the following four criteria: 1) 10 or more people were reported killed; 2) 100 or more people were reported affected; 3) a declaration of a state of emergency was issued; or 4) a country called for international assistance. Extreme temperature events consist of either: 1) a cold wave; 2) a heat wave; or 3) severe winter conditions.
Countries included in the OECD country group are those that were OECD countries in 2021.
Source: EM-DAT (2021[10]), *International Disasters Database 2021*, www.emdat.be.

StatLink https://stat.link/qxgwn7

Not all countries are similarly exposed to climate-related hazards [see (Maes et al., 2022[11]) for an overview of key indicators regarding a range of climate-related hazards and country exposure]. For example, Figure 4.2 illustrates that whereas on average across OECD countries 11% of the population is exposed to days with daily maximum temperatures above 35°C for over two weeks per year, in the Republic of Türkiye (hereafter 'Türkiye') and Mexico, 10% of the population is exposed to such temperatures for over eight weeks per year.

Figure 4.2. Share of exposure to very hot days in OECD countries, 2017-21

Average percentage of a country's population exposed to days with a daily maximum temperature exceeding 35°C
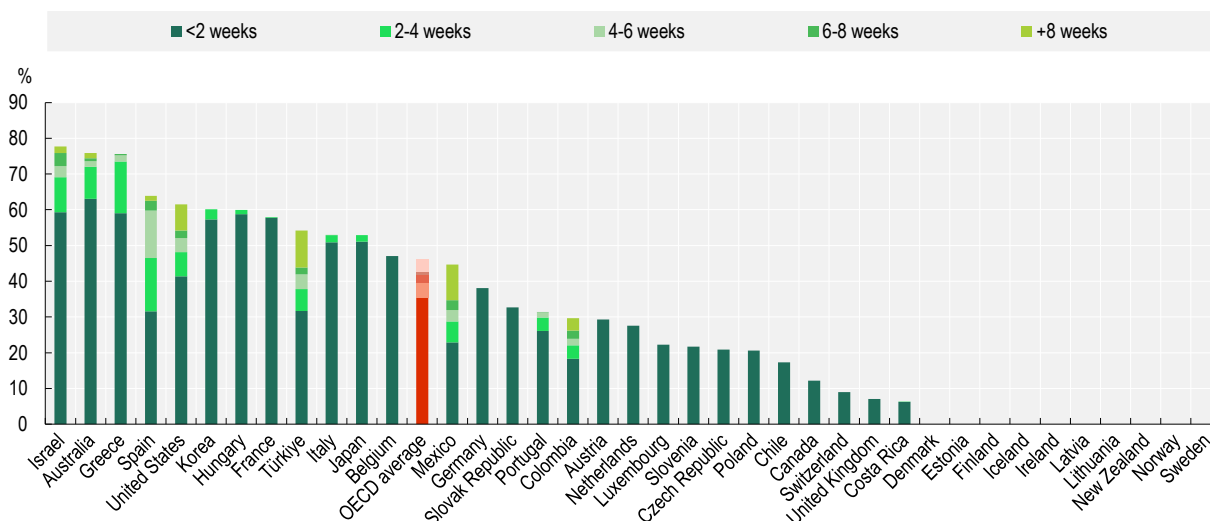
Note: The figure shows the percentage of a country's population exposed to "hot days", i.e. days exceeding 35°C for fewer than two weeks, between two to four weeks, between four to six weeks, between six to eight weeks and more than eight weeks averaged over the period 2017-21. Countries are sorted in descending order of the population being affected by hot days.
Source: IEA/OECD (2022[12]), "Climate-related hazards: Extreme temperature", https://oe.cd/dx/4TF.

StatLink https://stat.link/t69e8k

Exposure to climate-related hazards has increased as a result of human-induced climate change. For example, Figure 4.3 indicates that, on average, individuals in OECD countries had to endure 14 additional days with strong heat stress exposure, defined as Universal Thermal Climate Index (UTCI) exceeding 32°C, over the 2017-21 period compared to the reference period (1981-2010). In Israel and Costa Rica, populations had to endure almost an additional month per year of strong heat stress exposure (26 additional days). In Italy, populations had to endure 18, in Mexico 17, in the United States and in Türkiye 16, and in Hungary 15. In as many as 18 (out of 39) countries with available data, populations had to endure at least one additional week per year (i.e. seven extra days) with strong heat stress exposure in the 2017-21 period compared to the reference period.

Figure 4.3. Increase in heat stress exposure in OECD countries, 2017-21 compared to 1981-2010

Additional days per year of at least strong heat stress exposure (UTCI > 32°C) over 2017-21 compared to the reference period 1981-2010
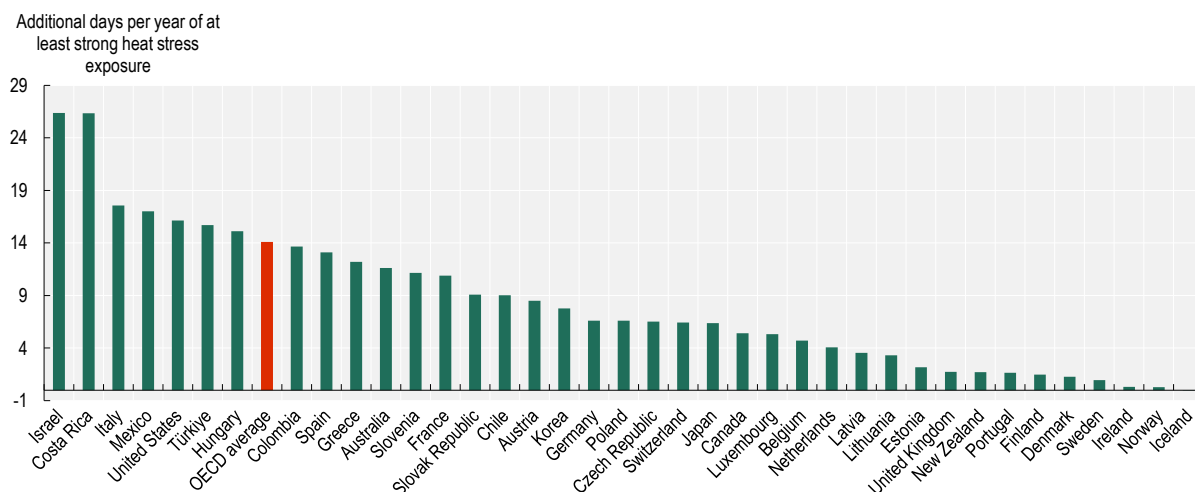
Note: The figure provides the additional days per year of at least strong heat stress exposure (UTCI > 32°C), which accounts for other meteorological effects besides air temperature, such as relative humidity, wind speed and solar radiation, over the period 2017-21 compared to the reference period 1981-2010. Heat stress is estimated using the Universal Thermal Climate Index (UTCI). A UTCI value between 32°C and 38°C is considered as strong heat stress, between 38°C and 46°C as very strong heat stress, and above 46°C as extreme heat stress. For more information, see Maes et al. (2022[11]).
Countries are sorted in descending order of the number of additional days with strong heat stress exposure.
Source: IEA/OECD (2022[12]), "Climate-related hazards: Extreme temperature", https://oe.cd/dx/4TF.

StatLink https://stat.link/qf7oz0

Recent evidence from the Intergovernmental Panel on Climate Change (IPCC) indicates that at least 50% of the rise in extreme temperature events is due to human-induced climate change, with carbon dioxide (CO_2) recognised as the main driver (Gutiérrez et al., 2021[8]). Other pollutants, such as black carbon, a product of particulate matter (PM) and the result of incomplete fossil fuel combustion and biomass burning, also play a significant role in accelerating warming by absorbing large amounts of solar radiation and turning it into heat (Bond et al., 2013[13]; Matthews and Paunu, 2019[14]). In addition, human activities, such as the burning of fossil fuels through vehicular transportation or electricity generation, release large quantities of CO_2, a GHG, as well as other compounds into the atmosphere (Gutiérrez et al., 2021[8]). Disasters alongside natural processes, such as forest fires and desert dust, can also contribute substantially to air pollution – a catch-all term that describes deterioration in air quality due to toxic compounds and gasses – burden in some regions (WHO, 2021[15]). National air quality guidelines typically consider six criteria based on pollutant concentrations to assess the potential harm to human health. These include: fine particulate matter (PM2.5), coarse particulate matter (PM10), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO), with additional standards for less ubiquitous pollutants. These pollutants interact chemically with each other as well as temperature, with resulting interactions determining their respective concentrations and air quality at ground level, where people breathe (Orru, Ebi and Forsberg, 2017[16]).

Unlike temperatures, Figure 4.4 shows that on average across OECD countries, mean population exposure to PM2.5 pollution decreased from 17.8 micrograms per cubic metre (µg/m³) in 2000 to 13.93 µg/m³ in 2019, a decrease of about 22%. Although this decline marks an important success for population health, exposure remained above recommended levels. For example, in 2019, all OECD

countries had levels of exposure to PM that exceeded the updated air quality guidelines by the World Health Organization (WHO) in 2021, which were based on an improved understanding of the adverse effects of PM on human health. Moreover, outside of OECD countries, particularly in Asia, the Middle East and Africa, PM2.5 levels remain critically high (OECD, 2021[17]).

Figure 4.4. Mean population exposure to PM2.5 in OECD countries, 2000 and 2019
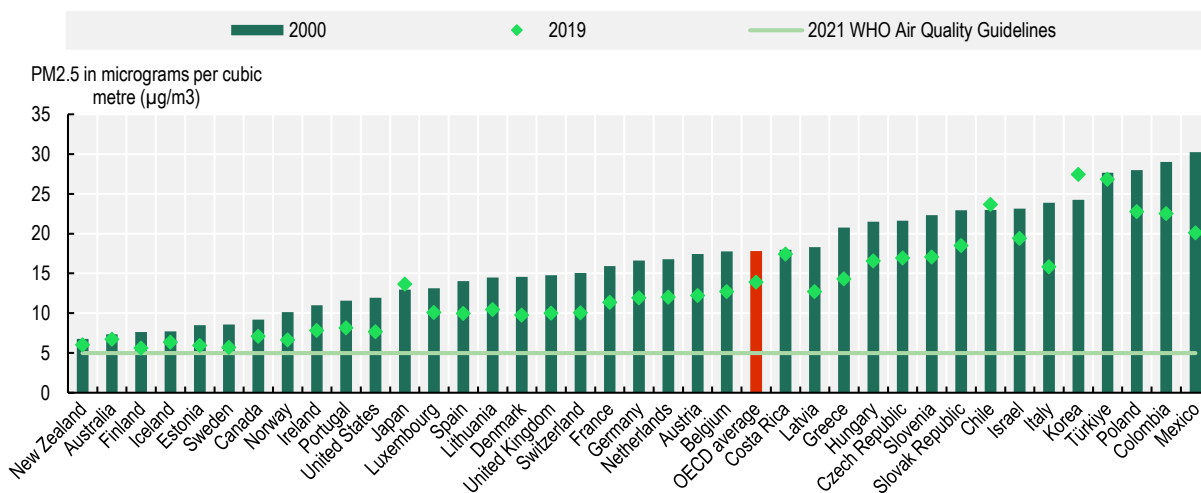
Note: Mean population exposure to particulate matter (PM2.5) is shown in units of micrograms per cubic metre (μg/m³). The horizontal green line indicates the WHO global air quality guidelines updated and published in 2021 for PM2.5 at 5 μg/m³.
Source: OECD (2021[18]), *Exposure to PM2.5 in countries*, https://stats.oecd.org/.

StatLink 🔗 https://stat.link/kgcfdr

4.2.2. Environmental conditions influence learning and skill development

With regard to education, climate change affects school infrastructure. As extreme weather events become more frequent and severe, schools are at increased risk of damage from floods, hurricanes and wildfires. This can lead to school closures and interruptions in learning, which can have a negative impact on student achievement. High temperatures and levels of pollution can also influence students' learning potential without forcing schools to close but reducing young people' ability to learn while in class.

The changes described will significantly affect societies' health and human capital. Figure 4.5 summarises the mechanisms through which adverse environmental conditions such as extreme temperatures and air pollution shape cognitive skills. Table 4.1 (further below) summarises the range of estimates effects sizes detailed in the empirical literature.

Figure 4.5. Mechanisms of the effects of adverse environmental conditions on cognition over the life course
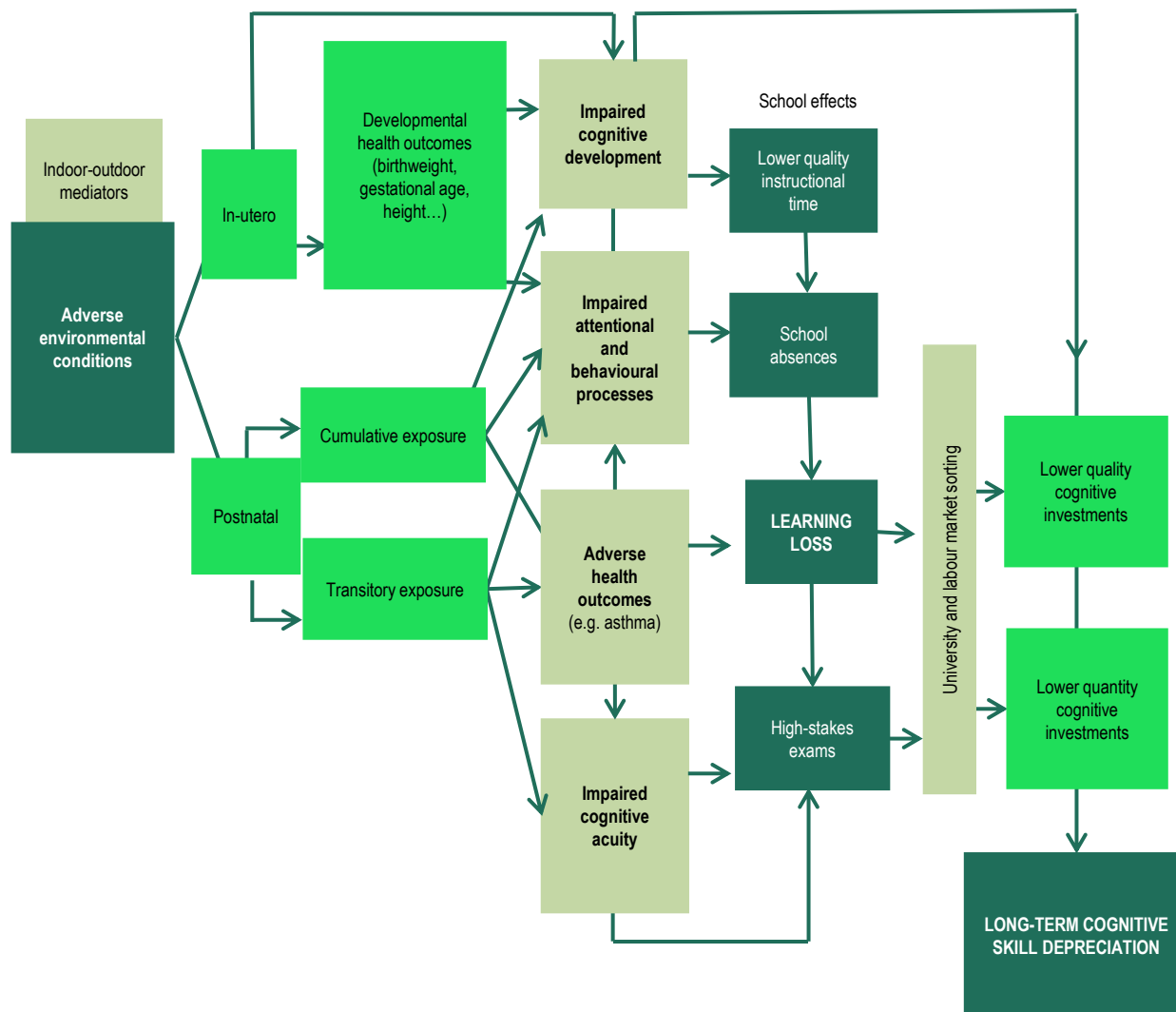
Note: This figure traces the mechanisms through which adverse environmental conditions can affect cognitive acuity and development. The focus is on indoor temperatures and increases in air-pollution/low air quality because these have been linked to worse cognitive functioning. Furthermore, these adverse environmental conditions tend to be sustained, with individuals experiencing higher temperatures and worse air quality for longer periods of time. Other disruptive events such as flooding can also negatively impact learning.

First, during gestation, exposure to air pollution and extreme temperatures can directly affect later life cognitive ability by impairing natural developmental processes that occur in the central nervous system throughout early childhood. Indirectly, children whose mothers experience adverse environmental conditions during pregnancy may also be born with low birthweight, grow up shorter than their peers, or experience impaired lung development. In turn, these development outcomes can affect academic performance when children reach school age.

Second, postnatal environmental conditions can also, directly and indirectly, affect short- and long-term cognition, amplifying any previous cognitive losses. In the short term, adverse exposure can impair cognitive acuity and attentional and behavioural processes, which can result in lower academic achievement in school. In addition, the exacerbation of respiratory and other illnesses may lead to increased school absences for students. These adverse effects on health, behavioural and attentional

processes may accumulate over time to decrease the overall quality of cognitive investments during childhood, such as instructional and study time.

Third, towards the end of secondary school, high levels of transitory pollution and extreme temperatures can lower students' performance on high-stakes exams used to select students for tertiary-level education, influencing the ability of those most affected by adverse environmental conditions to attend tertiary-level education as well as the quality of that education. Because levels of air pollution and temperatures vary geographically, individuals living in areas most exposed to negative conditions just before or during selective examinations may suffer a penalty and fail to gain entrance into tertiary educational institutions or fail to enter the most prestigious institutions. Similarly, socio-economic conditions could determine the possibility that individuals and families will mitigate the negative effects of environmental conditions and therefore acquire an edge during selection processes. The resulting sub-optimal educational and labour market sorting may alter long-term skill acquisition and earnings. Once in the labour market, transitory exposure to adverse environmental conditions may further affect the willingness and ability of adults to engage in cognitively demanding activities and effective lifelong learning.

Importantly, the effects of air pollution on cognitive development have been found to occur below current international air quality standards, in both indoor and outdoor settings and across various regions around the world. Similarly, these effects have been observed when the duration, intensity and spread of extreme temperature spells were well below current projections.

In many cases, the largest effects are felt by socio-economically disadvantaged children and adults, who often have higher exposure to pollution and limited resources to protect themselves.

Table 4.1. Summary of evidence in the literature on the effects of temperatures and air pollution on skills development

Effects are expressed in percentages of a standard deviation

	Negative effects of in-utero exposure to adverse environmental conditions on child and adult cognition, as a percentage of standard deviation		Negative effects of postnatal transitory and cumulative pollution and temperature exposures on cognition in school-aged children, as a percentage of standard deviation		Negative effects of transitory and cumulative temperature and pollution exposures on high-stakes examinations, as a percentage of standard deviation	
	Childhood and adolescence	Adulthood	Transitory	Cumulative	Transitory	Cumulative
Temperature	NA	4.8	12-13.5	2-3	5.5-5.83	4.2-6.4
Air pollution	3.4-11	NA	2-6	2.4-4	4-15	NA

Note: The effect of in-utero temperature exposure on adulthood is that due to ten additional days above 29.4°C and excludes the positive effects found on later-life literacy in sub-Saharan Africa. The effect of in-utero pollution exposure on childhood and adolescent cognition is that due to a standard deviation increase in pollution exposure during gestation or being conceived within two miles of a Superfund site. The effects depicted in this table are upper and lower bounds found in the literature based on several country estimates and are likely to differ between countries. The transitory effect of temperature is that due to experiencing a transitory temperature of 32°C or above. The transitory effect of pollution is that due to a one-unit standard deviation increase in transitory pollution exposure. The cumulative effect of temperature is the effect of ten additional hot days (or hot school days) with temperatures of 26.7°C or above in the past three to four years. The cumulative effect of pollution is the annual effect due to a 25% increase in pollution exposure or that due to attending a school within one mile of a TRI (Toxics Release Inventory) site. The transitory effect of temperature on high-stakes exams is that caused by a one-unit standard deviation increase in ambient temperature during exam taking. The cumulative effect of temperature is that caused by ten additional days with a maximum daily temperature above 34°C during the summer, relative to days with a maximum temperature between 28-30°C on maths and English tests. Effect sizes of effects of in-utero exposure to adverse environmental conditions aggregated from (Bharadwaj et al., 2017[19]; Molina, 2021[20]; Peet, 2020[21]; Persico, Figlio and Roth, 2020[22]; Sanders, 2012[23]). Effect sizes of postnatal transitory and cumulative pollution and temperature exposures aggregated from (Garg, Jagnani and Taraz, 2020[24]; Marcotte, 2017[25]; Park, Behrer and Goodman, 2020[26]; Park et al., 2020[27]; Rojas-Vallejos et al., 2021[28]; Zivin, Hsiang and Neidell, 2018[29]). Effect sizes of transitory and cumulative temperature and pollution exposures aggregated from (Cho, 2021[30]; Cho, 2017[31]; Ebenstein, Lavy and Roth, 2016[32]; Graff Zivin et al., 2020[33]; Graff Zivin et al., 2020[34]; Park, 2020[35]).

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Individuals and societies can take a range of adaptations and protective measures to reduce the impact of environmental conditions on cognitive development. These include installing air filtration and air conditioning units in schools, homes and the workplace, reorganising school curricula and pedagogical formats to avoid exposure, and ensuring equal access to environmental information, which can help induce protective behaviours. Given recent projections for increased global surface warming in the next several decades, it is worth examining the empirical literature on adverse environmental exposures and their consequences on cognitive skill development over the life course to better understand the magnitude of these effects, their underlying mechanisms and distributional consequences – and the potential for mitigating them.

4.2.3. The effects of environmental conditions differ depending on where and when they occur and often magnify underlying socio-economic disparities

The effects of pollution and extreme temperatures on cognitive development can differ significantly across regions due to cross-country environmental, socio-economic and institutional differences. Moreover, the relationship between pollution levels and temperatures and cognition can be non-linear, with stronger effects observed at higher temperatures and pollution levels. For example, decreases in cognitive acuity can occur when pollution levels are moderate, but additional effects on health symptoms at higher pollution levels can further compromise achievement. Additionally, the magnitude of the effects of environmental conditions may differ significantly across countries due to the mechanisms by which they occur. For example, an additional ten days with temperatures above 26.7°C lowers performance on test scores of the Programme for International Student Assessment (PISA) tests by 2.1% of a standard deviation in poorer countries, with insignificant effects found in more affluent countries (Park, Behrer and Goodman, 2020[26]).[2] These differences may exist due to several reasons.

For example, low-income and rural settings may suffer from an additional income effect due to high temperatures. Specifically, in rural parts of the People's Republic of China (hereafter, "China") and India, the effects of temperature on cognition are more pronounced in regions that have not undertaken heat-resistant crops, the lack of which results in lower crop yields during the growing season, reducing the demand for agricultural workers and lowering the family income of agricultural households. In turn, lower family income reduces overall family resources for investment in education, such as nutrition and school attendance, lowering cognitive development in the long term. Furthermore, a high prevalence of poverty and poor state support and information infrastructures may prevent many families from making protective investments, such as air conditioning and air filters, or contribute to higher costs for exercising avoidance behaviours, such as staying at home when temperatures and air pollution are high. Additionally, some countries may be burdened with weak regulatory infrastructures due to lack of funding and expertise, as well as dependence on foreign income in pollution-intensive industries, which has made pollution control difficult.

Within countries, colder cities and counties experience larger cognitive declines because of high temperatures, demonstrating that increases in temperature do indeed have an impact on cognitive ability. Such findings, provide evidence for the successful implementation of adaptation strategies, such as air conditioning, in order to lower temperatures and improve cognitive capacity in regions with historically high temperatures. However, even in affluent countries and regions with high rates of air conditioning penetration, such as the United States, estimates under median climate change projections of 2.8°C warming suggest 3% of a standard deviation lower academic achievement due to temperatures by 2050 (Park et al., 2020[27]). Therefore, although air conditioning is a good adaptation strategy it cannot mitigate all of the cognitive declines associated with increases in temperatures and is in itself a source of energy consumption.

Young people with a socio-economically disadvantaged and minority background experience worse environmental conditions and worse outcomes

The negative effects of environmental conditions can affect some groups more than others, with important distributional consequences. First, the air and temperatures individuals are exposed to from birth onwards result from various inter-related social and economic processes. For example, in North America, disadvantaged and minority households and students are more likely to live, work, attend schools and be born in areas with higher pollution levels. Similar patterns of unequal pollution exposure have been found in Asia, Africa and the WHO European region, but may differ based on the pollutant considered. In addition to higher exposures, poor households may be less able to make protective and compensatory investments, such as additional tutoring, in response to any cognitive losses experienced due to environmental conditions.

In fact, adverse environmental conditions can have larger impacts on the test scores of students from lower socio-economic backgrounds from the day they are born, with inequalities increasing as individuals age. In Chile, the effects of exposure to CO_2 during pregnancy on cognitive ability are more than twice as large for children of mothers without a secondary school diploma. In China and India, cognitive losses due to environmental exposures operate in part via an income effect that overwhelmingly affects poor agricultural households, as mentioned above. In Israel, the impact of contemporaneous PM2.5 exposures on high-stakes exams is larger for low socio-economic status (SES) students. Each point is even "higher stakes" for low SES students due to the latter's reduced ability to rely on social capital and financial advantages during the transition to the labour market compared to their high SES counterparts. These inequalities continue to widen as people age, as exposure to high pollution levels more significantly impacts the verbal abilities of less-educated older adults.

In addition, recent evidence suggests that environmental conditions play a non-negligible role in the racial achievement gap in the United States because of their effect on, for example, asthma and the residential locations of minorities in areas with high levels of air pollution. Additionally, it has been suggested that between 3% and 7% of the gap on standardised tests between white and Black and Hispanic students can be explained by the effects of heat on learning during compulsory school years (Park et al., 2020[27]). These effects are driven by lower school-level investments such as air conditioning and the geographical distribution of minorities in hotter regions across the United States. Estimates from Florida suggest that pollution from Superfund sites *alone* could account for at least 2% of the Black-white test score gap in the state (Persico, Figlio and Roth, 2020[22]). In fact, recent evidence suggests that the effects of pollution on reduced attainment of tertiary-level education may be intergenerational, indicating that the environment may present an additional and under-explored avenue from which intergenerational racial inequalities persist.

Gender differences in exposure and outcomes differ depending on the context

The effects of adverse environmental conditions on cognitive ability may also differ by gender. Males are thought to be more susceptible to detrimental intra-uterine environments and may therefore experience larger cognitive deficits due to high temperatures and air pollution exposure during gestation. A review of the health effects of pollution over the life course suggests that while during gestation and early childhood, boys are more susceptible to the adverse health effects of pollution, women may be more vulnerable in adulthood, potentially due to greater exposure in socially derived roles (e.g. pollutants present in cleaning products or cooking fumes). This is supported by recent findings that women experience higher rates of and more severe asthma symptoms than males after puberty but not before.

However, the distributional impacts on cognitive ability by gender are likely to differ based on the underlying mechanisms by which they exert their effects, as well as country-specific social and institutional differences. For example, school-aged girls experience larger cognitive declines in India due to contemporaneous pollution conditions. In Israel, the effects of pollution on performance on high-stakes

exams are between two and four times larger for boys than girls, consistent with a significantly higher incidence of asthma in male Israeli adolescents. However, pollution-related performance losses have a greater detrimental impact on the likelihood of matriculation, enrolment and completion of post-secondary education among girls than boys. Similarly, while estimates from the Philippines and Mexico suggest that pollution in-utero and early childhood affects the cognitive ability of boys and girls equally, the effects on women in terms of reduced schooling and income are more salient during the transition to the labour market.

Effects are larger for skills that rely on working memory, sustained attention and arithmetic efficiency

Complex cognitive skills that rely heavily on working memory, sustained attention or arithmetic efficiency are more impaired during heat stress than tasks such as visual orientation, reaction time and simple arithmetic. In fact, the short-term effects of high temperatures on cognition in school children and adults tend to be most pronounced when performance in math is considered and are weakest for verbal performance. These findings provide further support for a neurological mechanism that suggests the brain regions responsible for solving math and analytical problems are more sensitive to heat.

School absence rates are also driven by respiratory illnesses, suggesting low avoidance behaviour. Reduced attendance due to environmental conditions can affect learning and academic achievement by decreasing class time and teacher-student interactions, causing students to fall behind and perform worse on tests. Chronic absenteeism, defined as missing 10% or more of the school year, is associated with approximately 10% and 8% standard deviation decreases in math and reading scores, respectively, among elementary school-aged children in the United States (Gottfried, 2015[36]). Absenteeism also leads to negative externalities: the classmates of children who are chronically absent can experience a reduction in test scores approximately half the size of the reduction experienced by the absent children themselves.

4.2.4. Indoor air quality matters too

Most of the evidence on ambient environmental conditions considers the aggregate impact of ambient conditions on learning activities that occur primarily indoors (i.e. schools and training centres) and thus estimates the net effects of such conditions, including any adaptation strategies adopted by different populations to respond to such conditions. Estimates indicate that individuals in developed economies spend approximately 90% of their time in work buildings, school classrooms or at home (EPA, 2021[37]). However, the indoor environment in itself can have an additional impact on learning and cognitive skill development depending on indoor air quality (IAQ). Although indoor-outdoor pollution levels are correlated, factors such as ventilation, air conditioning, air filters and building characteristics can mediate the interaction and effects of ambient temperature and pollution levels that are found indoors. Thus, this interaction is a mediating channel by which ambient environmental conditions can affect cognitive development.

Few studies have estimated the effects of IAQ on skills development and effective skills use, largely because before the COVID-19 pandemic, IAQ was rarely monitored. In the United Kingdom, a one-unit standard deviation increase in indoor PM10 levels of university classrooms can lower exam scores by as much as 6.4% of a standard deviation. Evidence from German chess players also suggests a one-unit standard deviation (13.19 µg/m^3) increase in indoor PM2.5 during competitive tournaments is associated with approximately a 10% standard deviation increase in meaningful errors (Künn, Palacios and Pestel, 2019[38]).

By contrast, a wider set of studies have considered the effects of indoor temperatures on cognition in school and office environments. Meta-analytic evidence from such studies indicates that lowering the temperature from 30°C to 20°C is associated with a 20% improvement in school tasks involving earning and cognitive exertion (Wargocki, Porras-Salazar and Contreras-Espinoza, 2019[39]). For adults, the

performance of office workers is estimated to increase by about 9% following similar decreases in temperature (Wargocki and Wyon, 2017[40]). Additionally, decreasing humidity levels when temperatures are high has been found to mediate the impact on cognitive impairment (Tian, Fang and Liu, 2020[41]).

Indoor air quality refers to "the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants" (EPA, 2021[37]). It is the combination of: 1) indoor pollution from indoor sources (e.g. chemical and biological contaminations from furnishing, building materials and appliances); 2) indoor pollution that originated from ambient pollutants; and 3) their interactions with a variety of processes, such as ventilation, temperature, building characteristics and occupant activity and density. The indoor air in schools world wide has been found to be unsatisfactory and linked to asthma and other health issues. For example, in 2014, around 65% of classrooms in the WHO European region were estimated to have PM2.5 concentrations higher than the daily maximum recommended by the WHO guidelines at the time (25 µg/m^3) (Annesi-Maesano et al., 2014[42]).

A primary mediating factor in the relationship between ambient temperature and pollution levels and their indoor counterparts is ventilation: the flow of air into and out of a space. Adequate ventilation improves IAQ by diffusing the concentrations of indoor pollutants and introducing fresh air. Higher ventilation rates are associated with increased student attendance and improved cognitive performance on school tests based on cross-section and intervention studies. Empirical estimates from the United States suggest that the average school construction project aimed at improving IAQ through ventilation leads to 7% and 11% standard deviations improvements in math and reading scores, respectively (Stafford, 2015[43]). Outside of school environments, a one-unit standard deviation increase in indoor CO_2 levels (~300 ppm) is associated with a 1.8 percentage-point increase in the probability of advanced chess players making a meaningful error during competitive tournaments (Künn, Palacios and Pestel, 2019[38]), indicating impaired decision making of adults during highly cognitive activities. Additionally, increasing ventilation by 10 L/s improves the performance of office work by 6% as long as new air filters are installed (Wargocki, Wyon and Fanger, 2004[44]).

However, the effects on health and IAQ and performance are also partially dependent on the mode of ventilation and other factors, such as occupancy rate and occupant activity (Toftum et al., 2015[45]). Mechanical ventilation refers to either systems that extract indoor pollutants (i.e. mechanical exhaust ventilation) or systems that both remove indoor pollutants and concurrently supply fresh indoor air (i.e. mechanical supply and exhaust ventilation or balanced ventilation) (Toyinbo et al., 2016[46]). Natural ventilation, typically achieved by opening windows and doors of classrooms, refers to "the introduction of outdoor air into a building driven by natural produced pressure differentials" (Owen, 2009[47]). While outdoor air supply to buildings is an essential component of ventilation, it must be balanced with the evidence that allowing outdoor air into buildings can add to the burden of indoor air pollution (Leung, 2015[48]). Estimates suggest that in the United States, the net annual costs per person of improving ventilation to adequate levels would be less than 0.1% of current public spending on elementary and secondary education (Fisk, 2017[49]).

4.2.5. Education systems can adapt to changing environmental conditions

The potential of online learning to reduce the harmful effects of wildfires and particulate matter

Destructive wildfires have become increasingly common, with countries in the Mediterranean and others such as Australia, Chile and the United States experiencing record-breaking wildfire disasters in recent years (OECD, 2021[50]). In the United States alone, 7.4 million children annually are exposed to unhealthy levels of PM2.5 due to fires (Rappold et al., 2017[51]).[3] In addition, wildfires affect the respiratory health of surrounding populations, partly due to the large amounts of PM they release. The projected increase in wildfire risk and severity is so significant that increase in burning could offset the decrease in PM emissions achieved by a country such as the United States by 2050 (Ford et al., 2018[52]; McClure and Jaffe, 2018[53]).

Early evidence suggests that PM2.5 from wildfires could have as much as ten times larger negative impacts on the respiratory health of children and adults than PM2.5 from alternatives sources, as well as larger effects on high-stakes exams (Aguilera et al., 2021[54]; 2021[55]; Graff Zivin et al., 2020[34]).[4] Given that children spend much of their early lives in the classroom, schools and educational systems must implement mitigation and adaptation measures to protect the health and learning of students and vulnerable adults.

For one, building schools away from wildfire- and pollution-prone areas may be an important method of reducing exposure. Additionally, improving air filtration systems, adopting the use of portable air cleaners and providing surgical masks and N95 respirators in schools can protect against inhaling fire-related particles, although more evidence is needed to understand the full effects of face coverings for young children. Furthermore, allowing for flexibility concerning when and how classes occur can ensure that children are protected during long wildfire seasons without losing instructional time due to school closures.

For example, switching to online provision of course material and digital learning as an alternative to classroom-based learning during significantly polluted weeks or months also could help reduce ambient exposures (Box 4.1).

Box 4.1. Impacts of the shift to online learning during the COVID-19 crisis and lessons learned

The pandemic has improved understanding of the technological, pedagogical and other factors that can contribute to making online learning successful, such as improving teacher preparedness to use digital tools (Dhawan, 2020[56]; OECD, 2021[57]) and the effects of school closures on learning outcomes of different groups. Ensuring that interventions aimed at limiting the effects of school closures due to environmental conditions on learning require an awareness of the conditions that are needed to make them a success but also disparities that may arise. For example, the lower technological infrastructure in the homes of disadvantaged children and the need to provide additional guidance and support to vulnerable students (Bacher-Hicks, Goodman and Mulhern, 2021[58]; OECD, 2021[57]) may negatively impact equity in learning outcomes.

Analyses of national or subnational assessments and studies that are either census-based (i.e. cover all pupils in the target grade(s) or age group(s) in a jurisdiction or school system) or assess a representative sample of the target grade(s) or age group(s) that were standardised in order to allow comparisons of learning outcomes of cohorts of students assessed in 2021-22 and those of cohorts assessed before the pandemic.

Results presented in Figure 4.6 reveal that declines in performance are observed more frequently than increases between the immediate pre-pandemic and 2022, both in reading and in mathematics, in primary and secondary education. Among the group of States of the United States, observations of declines are far more frequent than those of increases in both domains. No clear evidence emerges of differential impacts of pandemic-related disruptions by grade level.

The scale of changes in performance, whether negative or positive, is generally less than 10% of a standard deviation, except in the United States, where falls in performance are generally above 10% of a standard deviation and in India. Declines in performance are generally larger in mathematics than in reading and the scale of falls in performance is generally greater in mathematics too.

In jurisdictions in which there were large initial falls in performance in 2020-21 compared to the immediate pre-pandemic period, there were often large increases in performance in the following school year. This is particularly true of States of the United States where, performance generally increased between 2020-21 and 2021-22, often significantly, in both English and mathematics. The small number of jurisdictions for which these data are available and the lack of diversity in terms of geographic region and income level mean that they cannot be considered representative of any broader groupings.

Figure 4.6. Evolution of learning outcomes between pre-COVID and 2021-22 assessments

Effect sizes by country or jurisdiction, all grades assessed
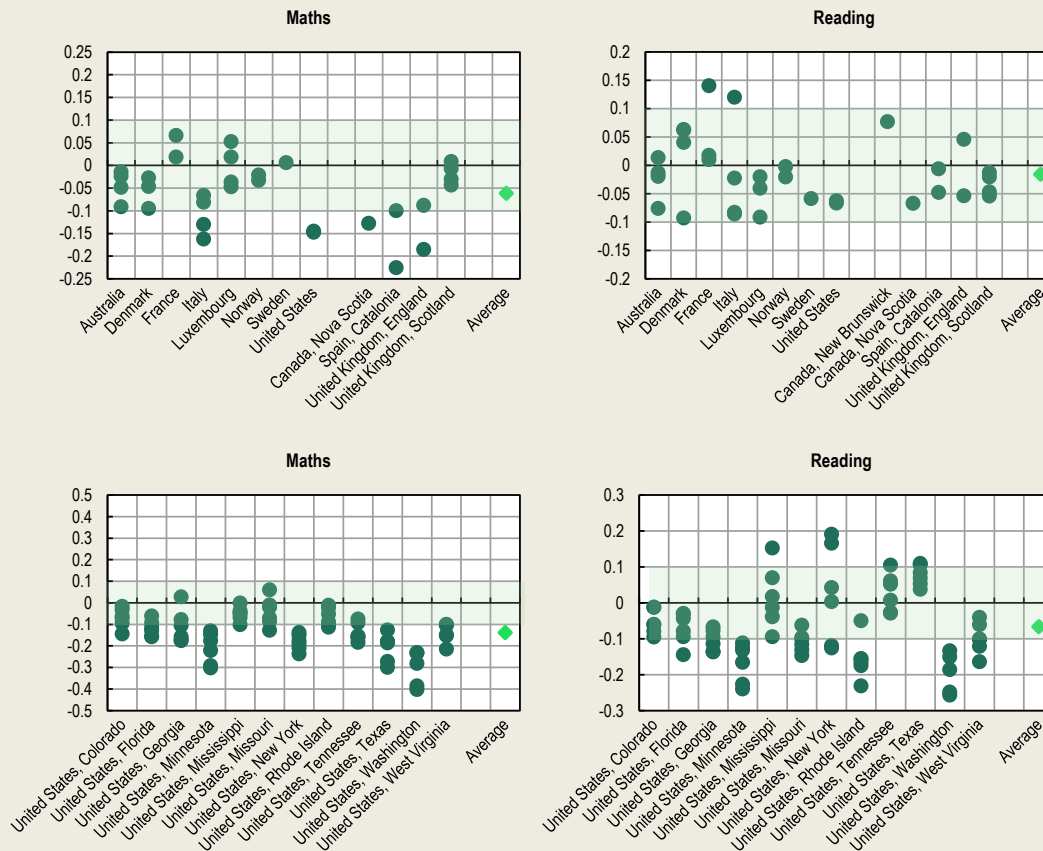
Note: A positive effect size means that performance has increased between the latest pre-pandemic assessment and 2021, while a negative effect size denotes a fall in performance. The different points represent the results of the effects for each grade that has been assessed within a jurisdiction in both primary and secondary education. The average is the average of the average effect size for all grades within a jurisdiction. The shaded area represents effects sizes (changes in outcomes) that are small or negligible, whether on the positive or negative side.

Source: Thorn and Vincent-Lancrin (forthcoming[59]), "Learning continues: effects of the pandemic on schooling and achievement".

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Finally, data collection and dissemination of air quality conditions during wildfire episodes using low-cost sensors should be made widely accessible to teachers, administrators, students and parents, and particularly pregnant mothers, to help guide decision making and induce avoidance behaviours, such as staying indoors, whenever possible.

Adaptive technologies can reduce the cognitive burden of high pollution levels and extreme temperatures

Children and adolescents spend a significant portion of their lives in classrooms. Thus, ensuring that schools and education systems are adequately prepared and supplied with the technology to deal with the burden of air pollution and high temperatures may be one way policy makers can mitigate against the early

environmental impact on cognition. Air conditioning and air filters are two main technologies that may confer significant health and cognitive benefits.

Air filters trap small particulates that may easily pass indoors. In the United States, replacing filters with high-efficiency air filters (minimum efficiency reporting value > 12) in schools is estimated to reduce the asthma burden due to PM2.5 by 13% per year (Martenies and Batterman, 2018[60]). These health effects are likely to confer additional cognitive benefits. In fact, early estimates suggest that the installation of air filters in schools can raise math scores by 20% of a standard deviation over four months at an annual cost of only USD 1 000 per class (Gilraine, 2020[61]). However, filters must be frequently replaced in heat, ventilation and air conditioning systems to avoid accumulated particles diffusing from filters attached to air conditioning units.

Additionally, air conditioning can offset a majority of the cognitive losses due to heat. In the United States, home and school air conditioning offset 41% and 57%, respectively, of the learning losses encountered on hot school days, with similar effects found in China (Park et al., 2020[27]; Zhang, Chen and Zhang, 2021[62]). For example, construction projects installing air conditioning units in schools that did not previously have them were found to increase reading scores by 15% standard deviations in Connecticut (Neilson and Zimmerman, 2014[63]). Although such school renovations present high upfront costs, they may be more cost-effective in improving test scores than class-size reductions and are highly scalable compared to other educational interventions as they require straightforward technical solutions. Although using technologies such as air filters and air conditioning can significantly reduce the negative effects of pollution and high temperatures on cognition, they use energy and, by doing so, potentially contribute to global warming. When new school buildings are planned, locations should be identified so as to minimise exposure to pollutants, and design solutions should be implemented to reduce exposure to high temperatures.

In addition to air filters and air conditioning, retrofitting school bus engines of an entire district, which may decrease PM emissions by as much as 60-90%, is associated with improvements in reading of 9% standard deviations (Austin, Heutel and Kreisman, 2019[64]). Additionally, night-time cooling through ventilation, which refers to opening windows or using low-energy cooling devices during the night, has been found to be a cost-effective way of improving the productivity of office workers. Cool roofs, which can be achieved by retrofitting rooftops with cooling materials or white paint, have also been shown to improve thermal comfort and reduce energy load by lowering air conditioning use in European office and school buildings. Passive measures such as installing low-energy windows and removing classroom and office furniture or devices that trap heat, such as printers, can additionally lower energy generation.

Importantly, any policy design that aims to improve children's and adults' health and performance outcomes should consider personal exposure to environmental conditions rather than aggregate indoor or outdoor levels. In European cities, for example, more than 90% of the variation in air pollution exposure of individuals is determined by individual characteristics, such as employment status and occupation, rather than pollution differences between cities (Schweizer et al., 2006[65]). Additionally, a study from Portugal found that rather than classrooms, cafeteria rooms had the highest levels of ultrafine particles while being outdoors during the school day sometimes contributed up to 70% of the total daily dose of pollution (Slezakova, de Oliveira Fernandes and Pereira, 2019[66]). Thus, improving learning outcomes depends on consideration of the outdoor-indoor environmental relationship, the activities of the targeted population, and the micro-environments within which they occur.

Reorganising high-stakes exams can help reduce inequalities arising from worsening environmental conditions

High-stakes exams at the end of secondary school are used worldwide as a signal of student cognitive ability, and in some countries, as the primary admissions criteria for admission into higher education. However, random disturbances on the day or week of high-stakes exams, including higher levels of transitory air pollution and temperatures, can affect students' performance on such exams, with long-term

economically significant consequences. As socio-economically disadvantaged students are more likely to attend schools with lower adaptive technologies and live in areas with worse environmental conditions, high-stakes exams can exacerbate existing inequalities by lowering tertiary educational attainment and the quality of that education.

Schools and education systems could take several measures to attenuate the impact of adverse environmental conditions on the high-stakes performance of disadvantaged students to ensure that all students have an equal chance to perform to their potential. For one, limiting the pollution around testing sites and requiring that all testing sites have adequate indoor protections, such as air conditioning and air filters, can reduce unequal exposure during test taking. Furthermore, in addition to evidence that students perform better early in the day, scheduling high-stakes exams early in the morning when temperatures are lower could help avoid the impacts of heat and cognitive fatigue, although the positive effects of lower temperatures early in the day should be weighted against the negative effects on the cognitive capacity of teenagers early in the morning due to sleep disturbances (Van Someren, 2000[67]). Additionally, because rescheduling and retaking exams can be costly in terms of time and money, reducing barriers to retaking exams can ensure that disadvantaged students have the same opportunities to retake and prepare for exams as their advantaged counterparts.

Finally, as the academic year typically finishes when historically the agricultural harvest was organised, at the start of summer (May to July in the northern hemisphere and December to February in the southern hemisphere), high-stakes exams are typically taken in the early summer months, when temperatures tend to reach high levels. Adjusting the general schedule of the academic year and the timing of high-stakes exams according to local climate may help reduce students' exposure to adverse environmental conditions. Allowing further flexibility of such policies to take into account when temperatures and pollution levels are high can reduce the overall health and cognitive burden on students. As the COVID-19 pandemic saw dozens of highly selective tertiary institutions waving standardised testing requirements, shifting reliance from high-stakes exams to other signals of student quality may become increasingly necessary.

4.3. Environmental and macroeconomic conditions shape human attitudes and dispositions

4.3.1. Experiencing environmental disasters due to human activity increases the extent to which individuals report being willing to prioritise environmental protection

Although there is mounting evidence on the severity of the climate crisis and growing awareness of climate change among the general population (Lorenzoni and Pidgeon, 2006[68]; Poortinga et al., 2011[69]), there has not been a significant increase in the willingness to prioritise the environment over the economy (Figure 4.7). The fact that within each country, individuals' reported intention to prioritise environmental protection varies over time suggests that people's perception of their priorities depends on the environmental, social and economic context they face. In particular, the fact that in many of the countries with available data, individuals' willingness to prioritise the environment over the economy was lowest between 2010 and 2014, the period just after the financial crisis, suggests that both environmental conditions and economic conditions may shape individuals' attitudes towards environmental protection.

Figure 4.7. Trends in stated prioritisation of the environment over the economy, selected countries, 1994-2020

Percentage of individuals aged 16 or older who reported that the environment has priority over the economy
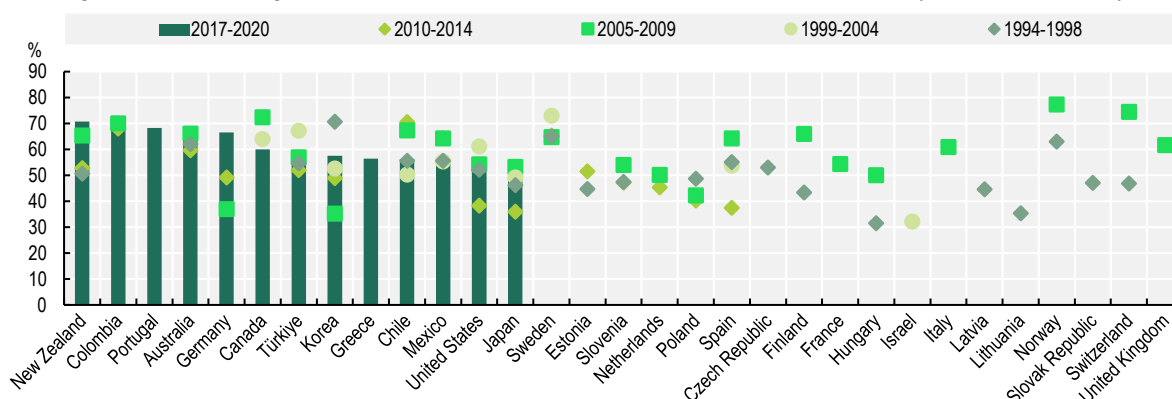
Note: The figure shows the percentage of individuals aged 16 years or older who prioritise the environment over economic growth and job creation by country and wave. The missing value indicates either the country did not participate in the survey or the question was not asked. Countries are ranked in descending order of the mean value for the latest available wave.
Source: Calculations based on World Values Survey (2014[70]), *World Values Survey: All Rounds - Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7).

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The occurrence of natural disasters can affect how people perceive the environmental and economic trade-off. For example, if individuals experience a natural disaster that is potentially due to climate change or environmental degradation, their perception of the environmental and economic benefits associated with enacting climate change mitigation policies can increase, thereby pushing them to prioritise the environment over short-term economic benefits. In fact, research indicates that natural disasters raise the endorsement of pro-environmental attitudes: when individuals experience bad environmental conditions, they are more willing to take environmental action, irrespective of their attitudes towards environmental protection (see also Chapter 2 on this topic). For example, individuals who have been negatively affected by air pollution are more likely to take environmentally-friendly action and believe that additional measures are needed by the government to tackle climate change. Equally, those who have experienced flooding express more concern about climate change and are more willing to take climate-mitigating action.

Risk perceptions increase as a result of experiential factors, such as natural disasters. When one personally experiences a natural disaster, the psychological distance of climate change decreases: climate change stops being something that will affect people and places far away and becomes more personal and tangible. Risk perception and concern for climate change have been found to increase right after a recent natural disaster; however, the increased risk perception caused by extreme weather appears to fade with time.

Table 4.2 reveals the association between the likelihood that individuals will be willing to prioritise the environment over the economy and their experience in the preceding 12 months of natural disasters related to climate change, such as droughts, extreme temperatures, floods, landslides, storms and wildfires. The following measures of natural disaster intensity were constructed: the number of disasters; the number of affected persons per 1 000 people in a country; the number of deaths per 1 000 people in a country; the number of injured people per 1 000 people in a country. The last three measures are population-standardised (i.e. per 1 000) to take into account the differences in population size, providing the likelihood of exposure to and damages from natural disasters.

Table 4.2. Effect of natural disasters on the likelihood that individuals will prioritise the environment over the economy

Regression coefficients of natural disaster measures

	(1)	(2)	(3)	(4)
Number of disasters	0.0020 (0.0015)			
Number of affected persons per 1 000		0.0015** (0.00078)		
Number of deaths per 1 000			0.79** (0.39)	
Number of injured persons per 1 000				15.3*** (2.39)
Individual controls	Yes	Yes	Yes	Yes
Fixed effects	Country, year	Country, year	Country, year	Country, year
Observations	79 145	79 145	79 145	79 145

Note: The table summarises the estimated effects of natural disasters on the probability of prioritising the environment over economic growth and job creation. All regressions control for individual characteristics (age, gender, educational attainment, employment status and income deciles) and include fixed effects in the country and year in which the survey took place. Natural disaster measures were constructed based on all the disasters recorded in the International Disaster Database (EM-DAT) that occurred within 12 months before the survey month. Each column differs in the natural disaster measures used, as indicated in the table. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01. The full regression table is available in Asai, Borgonovi and Wildi (2022[2]).
Source: Calculations based on World Values Survey (2014[70]), *World Values Survey: All Rounds – Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7) and EM-DAT (2021[10]), *International Disasters Database*, www.emdat.be.

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All coefficients are positive, suggesting that an increased prevalence of higher natural disasters is associated with a higher share of individuals reporting that they prioritise the environment over the economy. However, the estimated effect of the number of natural disasters is not significant. This may be because the occurrence of natural disasters alone may not alter the perceived cost and damage of environmental destruction. However, results indicate that when the number of affected persons per 1 000 in the year before the survey took place increased by 1 (that is, when the probability of being affected by natural disasters increased from 0.001 (=1/1000) to 0.002 (=2/1000)), the probability that respondents reported being willing to prioritise the environment over the economy increased by 0.15 percentage point. Since one standard deviation (s.d.) for the number of affected persons per 1 000 is 3.6 in the sample, a 1-s.d. effect will be 0.83 percentage point. The results, therefore, suggest that individuals are more willing to prioritise the environment over the economy when they perceive a higher risk of being affected by climate-change-related natural disasters.

The effect of experiencing a natural disaster and the subsequent change in the likelihood of being willing to prioritise the environment over the economy could be temporary. In other words, the impact of natural disaster shocks could be transitory and have little long-term effects on environmental attitudes and beliefs. Yet, effects could be permanent or long-term if individuals regularly experience natural disasters and their risk perceptions are permanently updated or if affected individuals experience scarring effects and long-term economic costs due to the disasters. To examine these questions, Asai, Borgonovi and Wildi (2022[2]) considered relations including measures of exposure to natural disasters in the year prior to the survey being conducted as well as exposure in the two years prior to the survey. Results indicated that experiencing natural disasters may have a relatively persistent effect on the likelihood that individuals will be willing to prioritise the environment over the economy. However, the effect is not permanent, as it is inconsistent with the fact that despite a long-term increase in the occurrence of natural disasters, there

does not appear to be a corresponding long-term increase in the likelihood that individuals reporting being willing to prioritise the environment over the economy (as shown in Figure 4.7).

4.3.2. When unemployment increases, individuals are less likely to prioritise the environment over the economy

Supporting a just transition that guarantees the employment opportunities of all is not just important for equity considerations but may be a precondition of policies to promote the green transition in the first place. Prior evidence, in fact, suggests that during periods of economic contraction and rising unemployment, public support for the environment decreases. During economic recessions and/or increases in unemployment, individuals may expect policy makers to focus on economic recovery rather than on the environment, since immediate economic costs may be more salient than future benefits arising from environmental protection. On average, when the unemployment rate increases by 1%, the probability that individuals will prioritise the environment falls by around 1.7 percentage points (Asai, Borgonovi and Wildi, 2022[2]). The relatively high responsiveness of individuals' willingness to prioritise the environment over the economy as a function of the contemporaneous unemployment rate suggests that public support for green growth policies is likely to be very sensitive to the economic conditions individuals experience.

Individuals with higher educational qualifications and incomes are more likely to prioritise the environment over the economy. For example, less than half (46%) of those with only primary education prioritise the environment, whereas 59% of tertiary graduates do (see also Chapter 2). The difference is similar in magnitude to the difference observed between the first (lowest) and the fifth (highest) income quintiles.[5] The effect of unemployment on the probability that individuals will prioritise the environment over the economy could be higher among social groups that are more vulnerable to economic shocks and fluctuations. Conversely, those with higher education and stable, full-time jobs may be less sensitive to economic situations because they may be less likely to lose their jobs and be personally affected by negative economic conditions.

Figure 4.8 indicates that the effects of unemployment are negative and statistically significantly different from the null hypothesis of no effects among all socio-economic groups. The effect of unemployment over the likelihood that individuals will prioritise the environment over the economy is similar among men and women and individuals who completed different levels of education. Self-employed individuals appear more sensitive to the unemployment rate than others. Finally, Figure 4.8 reveals an inverse U-shape: individuals in the lowest and highest income groups appear to be the most sensitive to the unemployment rate.

Figure 4.8. Heterogeneity of the effect of unemployment on environment prioritisation, by socio-demographic group, 1995-2020

Impact of a 1% increase in the unemployment rate
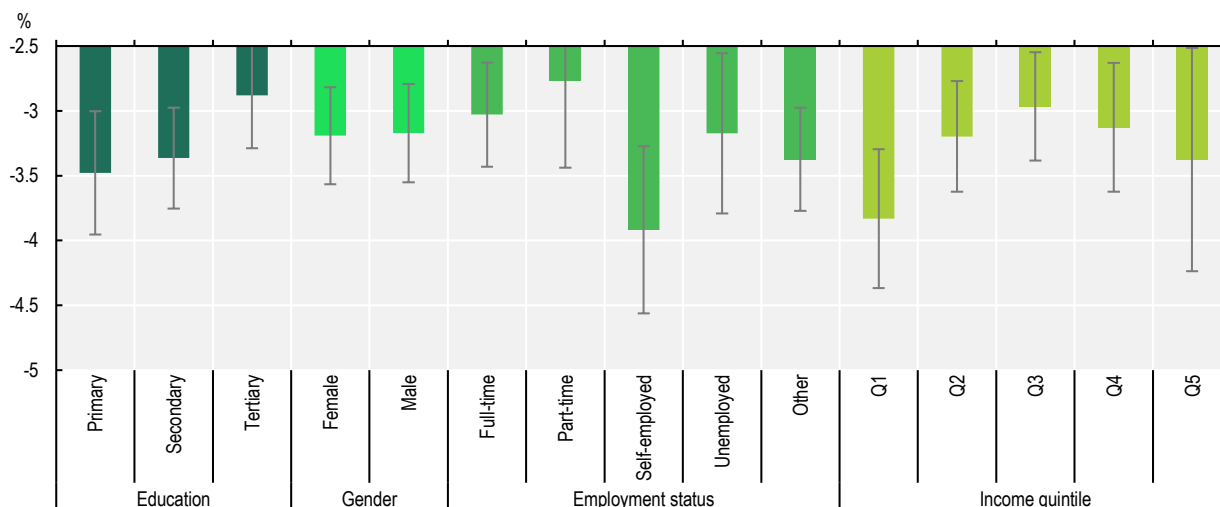
Note: Each bar represents the impact of the unemployment rate on environmental prioritisation by socio-demographic group (educational, attainment, gender, employment status and income quantile). The coefficients were obtained by interacting unemployment rate with dummy variables associated with each socio-demographic group from separate regressions. Grey spikes in the figure indicate the 95% confidence interval.

Source: Calculations based on World Values Survey (2014[70]), *World Values Survey: All Rounds - Country-Pooled Datafile Version* (database), www.worldvaluessurvey.org/WVSDocumentationWVL.jsp (used waves 3-7).

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4.4. Physical skills needed to adapt to a changing climate

As climate change continues to result in more frequent and extreme weather events, individuals will need to acquire new skills and knowledge to adapt. Physical education programmes in areas prone to flooding, for example, will need to prioritise teaching individuals how to swim to prevent drowning in the aftermath of destructive events. Furthermore, as extreme heat becomes more prevalent, it is important for individuals to be able to undertake medium-length trips without walking, which can be dangerous due to prolonged exposure to intense heat. This is particularly important for socio-economically challenged individuals who may not have access to a car. Therefore, cycling education programmes might be incorporated into physical education curricula, along with road safety for cyclists. By learning these skills, individuals can reduce the use of cars, which emit CO_2, and avoid the dangers of walking in extreme heat. Additionally, planting vegetation in urban settings will be necessary to provide shade, absorb CO_2 emissions and reduce the urban heat island effect. Science courses can also integrate modules on water requirements for different plants and their resistance to extreme weather conditions. Understanding the effects of extreme heat and humidity on human physiology, especially among different genders and age groups, can also help individuals and organisations avoid risk behaviour and undertake protective practices to reduce the negative impacts of climate change on human health and productivity.

4.4.1. Many people do not know how to ride a bicycle

To develop effective policies for climate change adaptation, it is essential to comprehend human mobility patterns and identify the skill sets required for populations to respond effectively to natural disasters and changing environmental conditions. Research suggests that accessibility to urban centres, where

economic opportunities are concentrated, varies significantly worldwide (Wu et al., 2021[71]) and is a crucial limitation to the opportunities for personal realisation and economic empowerment, particularly for individuals living in low-income settings (Weiss et al., 2018[72]).

However, physical infrastructure (or lack thereof) is only one of the factors shaping the use of different modes of transportation by different groups of individuals, the degree of accessibility and the types of connections existing between the places in which different individuals reside, work, shop, socialise and learn – see also Box 4.2 on improving the quality of active travel in cities. The affordability of, access to, and skills can limit the ability of different socio-economic and demographic groups to use a range of modes of transportation. For example, cost can limit the accessibility to cars among low-income groups and, in many countries, gender norms, cultural barriers and fear of sexual harassment and assault can deter women from using certain modes of transport or travel at certain times (Goel et al., 2022[73]).

The use of bicycles is being promoted in cities around the world as a way to reduce GHG emissions and reduce traffic. Cycling allows individuals to engage in medium-length travel in a way that is fast, limiting prolonged exposure to intense heat and extreme weather conditions. At the same time, many individuals world wide do not have the skills necessary to use bicycles. Cycling can also reduce the risk of non-communicable diseases like obesity and diabetes.

Between 25 March and 8 April 2022, Ipsos conducted the online Cycling Across the World survey in 28 countries world wide. In total, 20 057 adults participated. In most countries, participation involved people aged 16-74, except for Norway (where 16-99 year-olds participated) and the United States, Canada, Malaysia, South Africa and Türkiye (where 18-74 year-olds participated). Samples in Argentina, Australia, Belgium, Canada, France, Germany, Great Britain, Hungary, Italy, Japan, Korea, the Netherlands, Norway, Poland, Spain, Sweden and the United States represented these countries' general adult populations under the age of 75. Samples in Brazil, Chile, People's Republic of China, Colombia, India, Malaysia, Mexico, Peru, Saudi Arabia, South Africa and Türkiye were more urban, more educated, and/or more affluent than the general population in the respective countries.

Box 4.2. Improving the quality of active travel in cities

Walking, cycling and other active mobility solutions can benefit cities and urban environments and add resiliency to urban transportation systems. In addition to the potential positive health benefits of active travel, these modes and the facilitation of their use can be valuable levers for improving cities' livability and environmental quality.

Encouraging people to walk and cycle, and ensuring they can do so safely and enjoyably, goes beyond the simple provision of infrastructure and must include components beyond the transport system. There is ample evidence of people walking and cycling despite poor or non-existent infrastructure and underused infrastructure in other contexts. Understanding how, when, where and why people actively travel is complex. To answer these questions, it is necessary to:

1. consider the underlying policy and legal frameworks currently in place that disadvantage other forms of mobility in many cities
2. reduce the inherent systemic violence that reinforces car-centric mobility systems
3. understand the local population's wants and needs.

More specifically, it is necessary to change the context of city transport environments, the attitudes of policy makers and planners, and the general perceptions associated with different modes. Changes in context can induce changes in attitudes and behaviour by changing the provision of conditions that reward and encourage some mobility behaviours and penalise and discourage others. At the same time, attitudinal shifts are a catalyst for new or increased changes to an existing transport system.

The encouragement of more active mobility in cities should follow sound safety principles like those which form the basis of the "Safe System" approach. The Safe System builds on the fundamental proposition that there is no acceptable level of fatalities or serious injuries due to road crashes. This approach means that rather than making road users responsible for their safety in a sometimes inherently unsafe traffic system, all actors – especially those designing and maintaining the road environment and establishing rules for its use – bear a fundamental responsibility to ensure safety (ITF, 2022[74]).

All road users, including children, teenagers, young adults and elderly adults, each having varying capacities and skills, must understand how city road space functions for all types of users and not just drivers. As such, a fundamental change is needed in how transport networks are designed so that they can account for a greater variety of uses without prioritising large and fast vehicles above all else.

More specifically for children, following the lead of countries like Denmark and the Netherlands, it is essential to look ahead and focus on future generations and teach school children how to navigate urban streetscapes independently. In the Netherlands, it is a common rite of passage to go through bicycle training. It allows children to learn traffic rules and desired behaviours while still young and is an important milestone in their development. Expanding these training efforts to other transport modes at different stages can be conducive to sustained changes in the societal perceptions of what is feasible and acceptable as a mode of transport.

Finally, building capacity and training planners and decision makers is also key. These stakeholders make decisions that define the context of how cities' transport systems are designed and function. There needs to be a shift from a mobility paradigm centred on motorised hypermobility and vehicular throughput to one prioritising accessibility and safety.

Source: ITF (2023[75]), "Towards the light: Effective light mobility policies in cities", www.itf-oecd.org/sites/default/files/docs/towards-the-light-effective-light-mobility-policies-cities.pdf; ITF, (forthcoming[76]), "Beyond infrastructure: Improving the quality of walking and cycling in cities".

Results indicate that, except for Saudi Arabia, most adults in participating countries reported being able to ride a bicycle, but significant minorities in virtually all countries did not (Figure 4.9). For example, 83% of respondents reported being able to ride a bicycle in Poland, and in Hungary and Sweden, 77% of respondents did. By contrast, only 36% of respondents in Saudi Arabia reported being able to ride a bicycle. Furthermore, in Australia, Brazil, Belgium, Great Britain, India, Italy, Malaysia and Peru, less than 60% of the adult population reported being able to ride a bicycle. Moreover, Figure 4.10 suggests that across the 28 countries considered, the ability to ride a bicycle was higher among males and individuals with higher educational qualifications.

Figure 4.9. Cycling skills in selected countries around the world, 2022

Percentage of the population who report being able to ride a bicycle
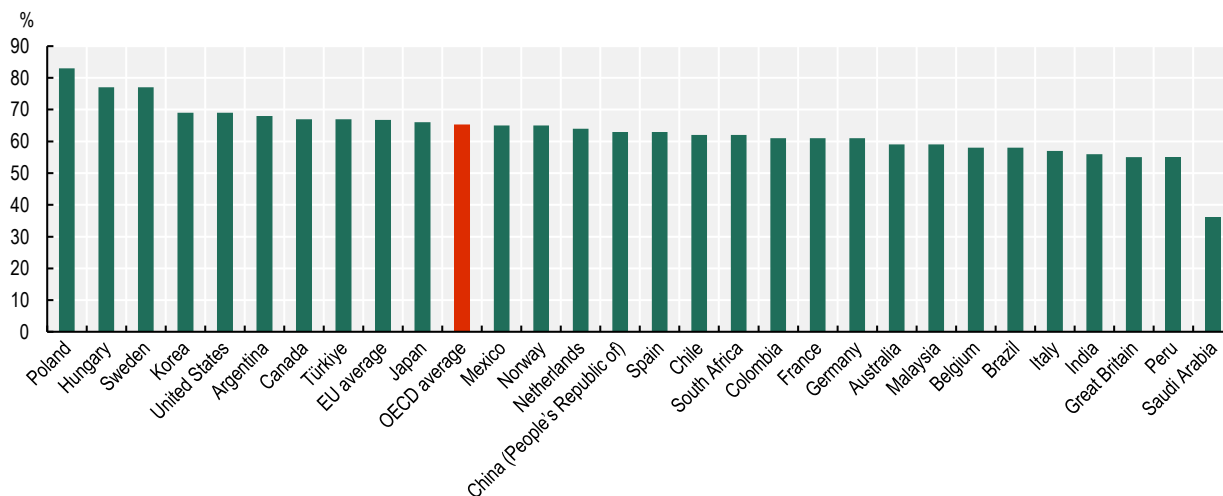
Note: The figure shows the percentage of a country's population who report being able to ride a bicycle. Respondents are aged 16-99 in Norway, 18-74 in Canada, Malaysia, South Africa, Republic of Türkiye, and the United States, and 16-74 in the remaining countries.
Countries are sorted in descending order of the percentage of the population who reported being able to ride a bicycle.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

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Figure 4.10. Cycling skills in selected countries around the world, by education and gender, 2022

Percentage of the population who report being able to ride a bicycle
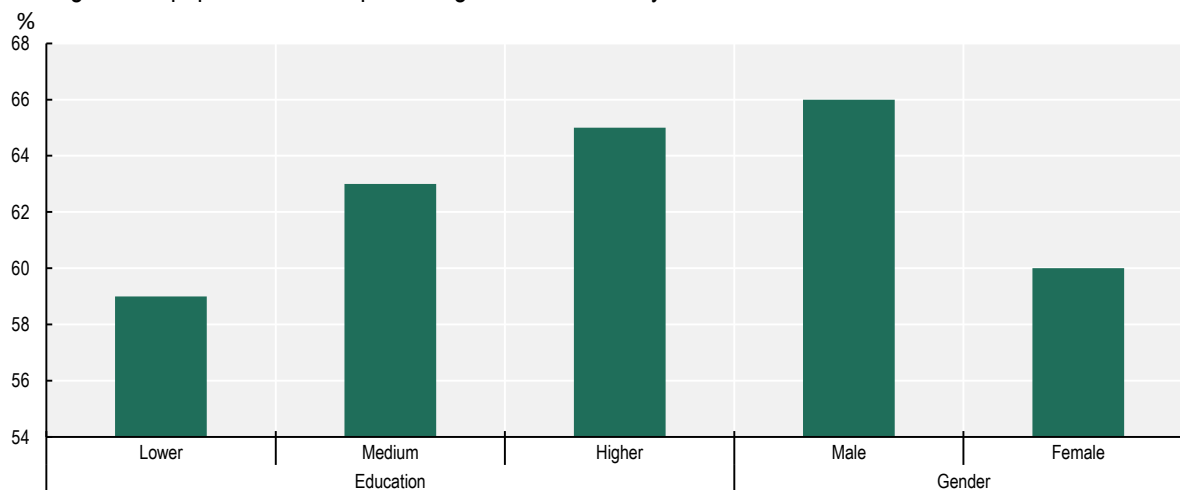
Note: The figure shows the percentage of the population who reported being able to ride a bicycle by education and gender. Respondents were aged 16-99 in Norway, 18-74 in the United States, Canada, Malaysia, South Africa, and Republic of Türkiye and 16-74 in the remaining countries.
Country specific educational categories used to define educational attainment are available via the Statlink.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

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In most countries, over one in two individuals interviewed in 2022 indicated that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects. However, Figure 4.11 indicates that supporters of bicycle prioritisation projects were a minority in Great Britain, where 48% of respondents said that new road and traffic infrastructure projects should prioritise bicycles over automobiles, Japan and Australia (where 45% of respondents did), the United States (44%) and Canada (41%). By contrast, in Peru, as many as 86% of respondents noted that new road and traffic infrastructure projects should prioritise bicycles over automobiles. Within countries, individuals' willingness to prioritise bicycles over automobiles in new road and traffic infrastructure projects did not differ by level of educational attainment. However, it was higher among young people than among older age groups and was higher among individuals living in large cities than in rural areas (Figure 4.12). These differences most likely reflect differences in health – with younger individuals being more willing to use active modes of transportation than the elderly – as well as differences in existing infrastructures and the length of the average travel – with communities living in rural areas being less likely to be able to use bicycles for a large share of their travel needs.

Figure 4.11. Willingness to prioritise bicycles over automobiles in new road and traffic infrastructure projects in selected countries around the world, 2022

Percentage of the population reporting that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects
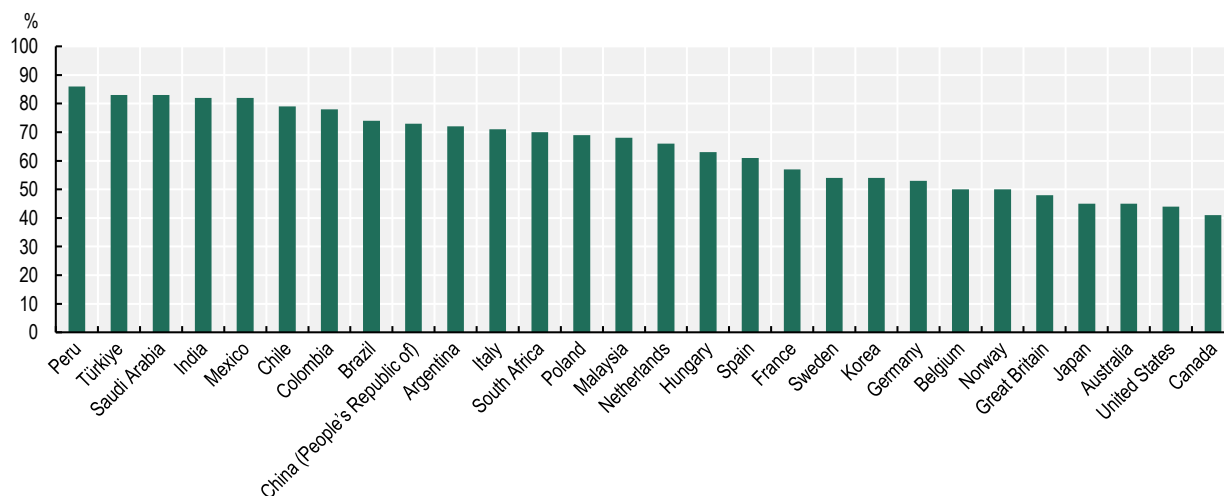
Note: The figure shows the percentage of the population who report that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects. Respondents are aged 16-99 in Norway, 18-74 in Canada, Malaysia, South Africa, Republic of Türkiye and the United States, and 16-74 in the remaining countries. Countries are sorted in descending order of the percentage of the population prioritising bicycles over automobiles.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

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Figure 4.12. Willingness to prioritise bicycles over automobiles in new road and traffic infrastructure projects, by age, degree of urbanisation and education in selected countries around the world, 2022

Percentage of the population reporting that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects, by age, degree of urbanisation and education.
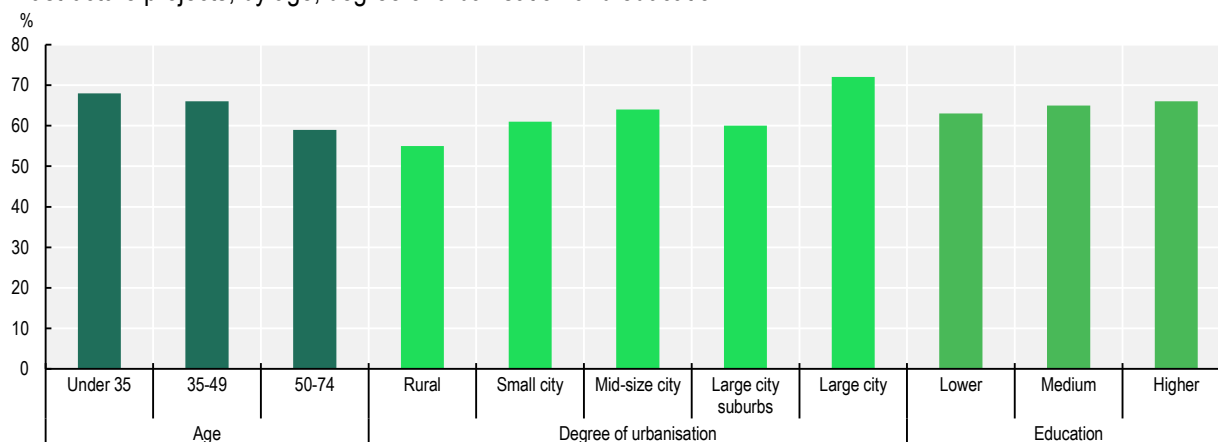
Note: The figure shows the percentage of the population who report that bicycles should be prioritised over automobiles in new road and traffic infrastructure projects, by age, degree of urbanisation and education. Respondents are aged 16-99 in Norway, 18-74 in Canada, Malaysia, South Africa, Republic of Türkiye and the United States, and 16-74 in the remaining countries. Country specific educational categories used to define educational attainment are available via the Statlink.
Source: Adapted from Ipsos (2022[77]), *Cycling Across the World*, www.ipsos.com/en/global-advisor-cycling-across-the-world-2022.

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4.4.2. Many people do not know how to swim without assistance

Disparities in life skills, such as the ability to swim, can disproportionally reduce the welfare of certain groups in society. This is in part because some groups may be especially likely to face situations in which these skills are valuable and in part because some groups lack skills that would provide alternative opportunities for personal realisation and economic empowerment. For example, socio-economically disadvantaged groups may be especially vulnerable to extreme weather events because they tend to live in areas susceptible to floods or extreme heat (Sam et al., 2017[78]). They may also have less access to mitigation technologies and may therefore be more likely to try to cool off in water during extreme temperatures. There is also evidence that the vulnerability to extreme weather events is gendered (Salvati et al., 2018[79]). Similarly, in many situations, women's opportunities related to the use of physical skills, how they move and what such movement would entail in terms of clothing are determined by a range of explicit and implicit cultural and legal restrictions, as well as lack of skills and capabilities to use their bodies.

Many life skills, such as swimming, are acquired during childhood when children in most countries have the right and duty to devote their time to learning. When certain skills are not taught (and learnt) in formal educational settings, opportunities for skills development depend on the resources and willingness to impart instruction at the household and community levels. While it is reasonable to expect that, as adults, individuals may vary in their preferences for engaging in activities that require swimming, the acquisition of swimming skills among children is mostly a function of the provision of instruction at school or organised by families and the extent to which such instruction is prioritised. Therefore, large and pervasive differences in levels of swimming ability between socio-demographic groups can be taken to reflect disparities in opportunity rather than underlying differences in preferences between members of such groups.

Swimming is essential to reduce the risk of drowning when individuals are in or near water. In many developing countries, labour market opportunities are often geographically concentrated near lakes, rivers and other water sources. Being able to swim may be a precondition if individuals are to benefit from such opportunities. Furthermore, the sea, rivers and other waterways constitute important trade routes, so individuals who know how to swim are more likely to be able to safely travel and engage in trade and commerce between different villages or areas. In many countries, waterways also interrupt roads seasonally or permanently, and boats or other vessels are the only way to travel across. The ability to swim is also necessary to work in professions such as marine biology and naval engineering, as technicians in offshore wind farms, and in conservation projects to remove plastics from the ocean. Many of the occupations involved in the development of sustainable exploitation of renewables for energy production and conservation of natural habitats require being able to swim.

Over the past years, weather and climate extremes, such as flooding, have increased (IPCC, 2021[80]). Recent global shocks, such as the COVID-19 pandemic and the Russian Federation's war of aggression against Ukraine, with its effect on energy costs, have highlighted the fragility of education systems, not only in maintaining academic skills (Hanushek and Woessmann, 2020[81]), but also in teaching essential life skills such as swimming, which may be associated with decreasing drowning deaths in high-income countries.

The ability to swim without assistance is a key component of swimming skills, alongside water competencies about how to be safe in water, such as risk awareness or knowledge of hazards (Stallman et al., 2017[82]). The ability to swim without assistance is unevenly distributed among countries with different economic development levels (Figure 4.13). Among OECD countries, for example, in Finland, Germany, the Netherlands, Norway and Sweden, over nine in ten adults report being able to swim without assistance. By contrast, less than one in two individuals report the same in Mexico. Among OECD countries, differences in swimming ability amount to up to almost 50 percentage points between Sweden, with the highest share of swimmers, and Mexico, with the lowest share of swimmers. Differences are even more pronounced when considering the full set of 138 countries with available data. In Sweden, 95% of adults report being able to swim without assistance, whereas in Rwanda, Pakistan and Ethiopia, 15%, 17%, and 19%, respectively, do. The between-country variation in swimming ability maps closely between-country differences in levels of economic development.

Embedding swimming classes in schools is one way in which countries ensure that young children have swimming skills. Doing so can also reduce inequalities in who knows how to swim and who does not. In some countries, swimming lessons are mandatory in the elementary school curriculum, such as in Austria, France, Germany, and Sweden.

On the contrary, the Netherlands has removed mandatory swimming lessons from its curriculum. The country introduced compulsory swimming lessons in the late 1960s, early 1970s, but this changed in 1985 (Floor, 2016[83]; Isgeschiedenis, 2022[84]). Over the years, the number of schools in the Netherlands that offered swimming as part of the curriculum dropped considerably, from about 90% of schools in the early 1990s to less than 50% in the early 2010s. A reason for the decision of schools not to voluntarily continue to offer swimming classes was that many children reported already being able to swim. Some municipalities consequently felt swimming classes did not provide sufficient added value to justify the investment in school swimming programmes, particularly at a time of tight budgets for local authorities (van der Werff and Breedveld, 2013[85]). In order to reduce adverse effects arising from discontinuing compulsory swimming programmes in schools, a series of safety net schemes were introduced at the local level to support young people with disadvantaged backgrounds (Borgonovi, Seitz and Vogel, 2022[3]).

Another essential element of swimming competence is knowledge of water safety (Stallman et al., 2017[82]; WHO, 2022[86]). Providing people with the ability to swim and water safety knowledge gives them the agency to engage in water-related activities and reflect on their behaviour and actions. For children,

however, restricting access to water and supervision by parents or caretakers is essential to drowning prevention.

Figure 4.13. Swimming ability around the world, 2019

Percentage of the population aged 15 and older who report being able to swim without assistance
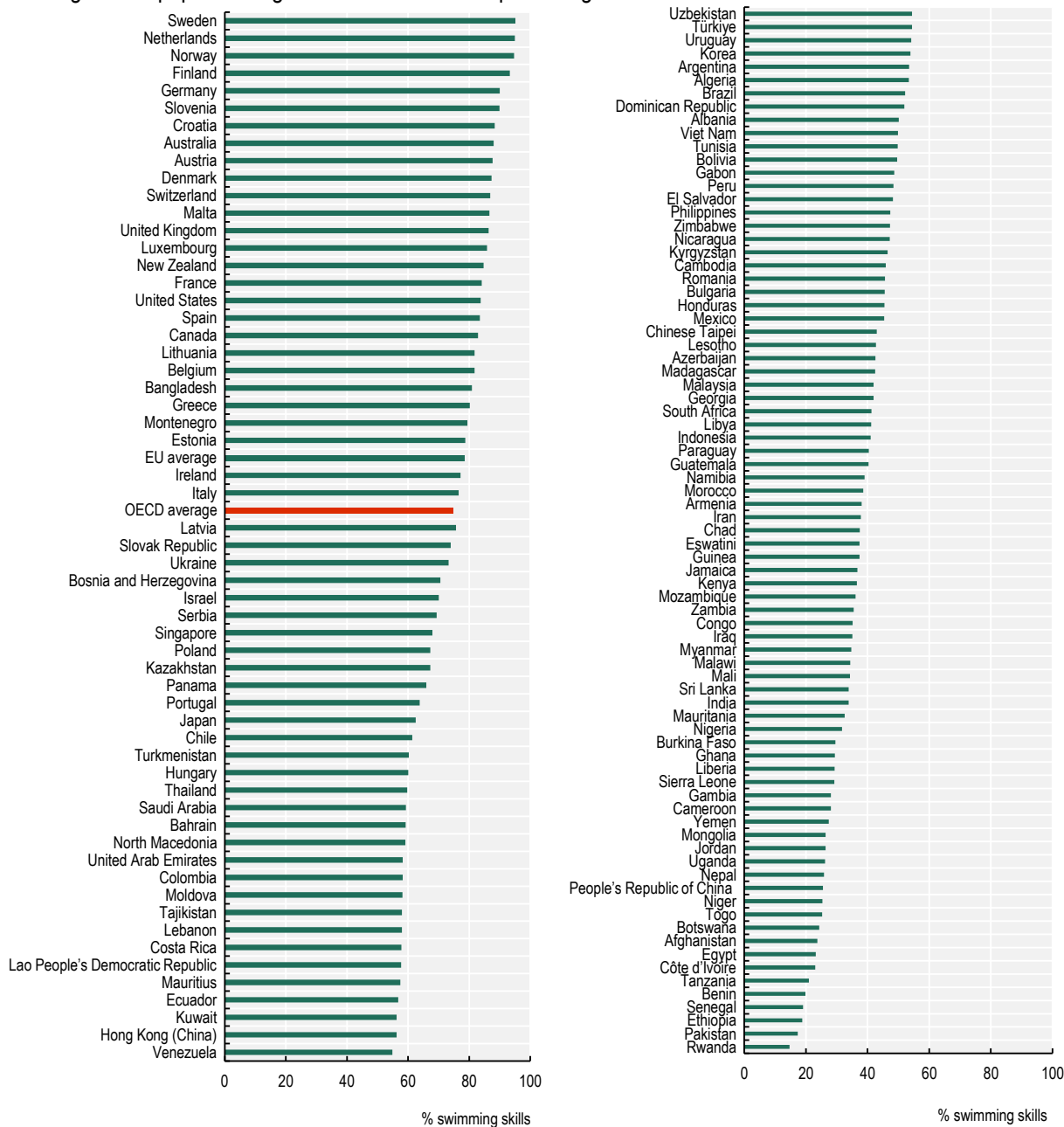
Note: Countries are sorted in descending order of individuals who are 15 or older who reported being able to swim without assistance.
Source: Adapted from World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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Disparities in swimming ability

Individuals who attended school longer are more likely to report being able to swim

The ability to swim without assistance and the risk of drowning differ by level of educational attainment. Figure 4.14 shows that irrespective of the level of economic development, individuals who attended school longer are more likely to report being able to swim without assistance than individuals who attended school for fewer years. In low-income countries, for example, among people with a maximum of eight years of education, on average, 21% report being able to swim. However, this share is 34% among those who attended between 9 and 15 years of education, while among those with more than 16 years of education, 46% report being able to swim without assistance. In contrast, in high-income countries, among people with a maximum of 8 years of education, on average, 59% report being able to swim, while this share is 76% and 84% among those who attend between 9 and 15 years of education and those with more than 16 years of education, respectively.

The positive individual-level association between years of education completed and swimming ability illustrated in Figure 4.14 is also mirrored by a country-level correlation between the share of individuals in a country who completed, at most, primary school and the percentage of individuals who report being able to swim without assistance. Figure 4.15 shows a strong negative association between the percentage of individuals in a country who obtained, at most, primary education and the percentage of people who can swim without assistance. In other words, the higher the share of people with only basic educational qualifications, the lower the average swimming ability in a given country.

Figure 4.14. Swimming ability, by education and country income group, 2019

Percentage of the population aged 25 and older who report being able to swim without assistance, by country income group and by years of education
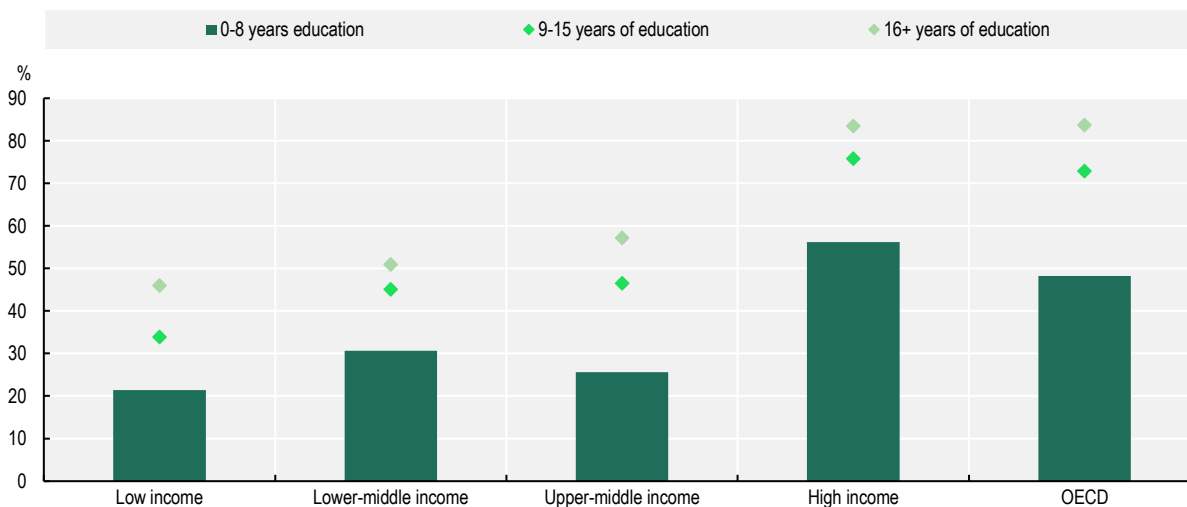
Note: The figure shows the swimming ability by country income group and by educational level of the population aged 25 and older.
Source: Adapted from World Bank (2022[88]), *World Bank Current Classification by Income* (database), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups; World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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Figure 4.15. Country-level association between educational level and swimming ability, 2019

Correlation between the percentage of the adult population who obtained at most primary school and the percentage of the population who reports being able to swim without assistance
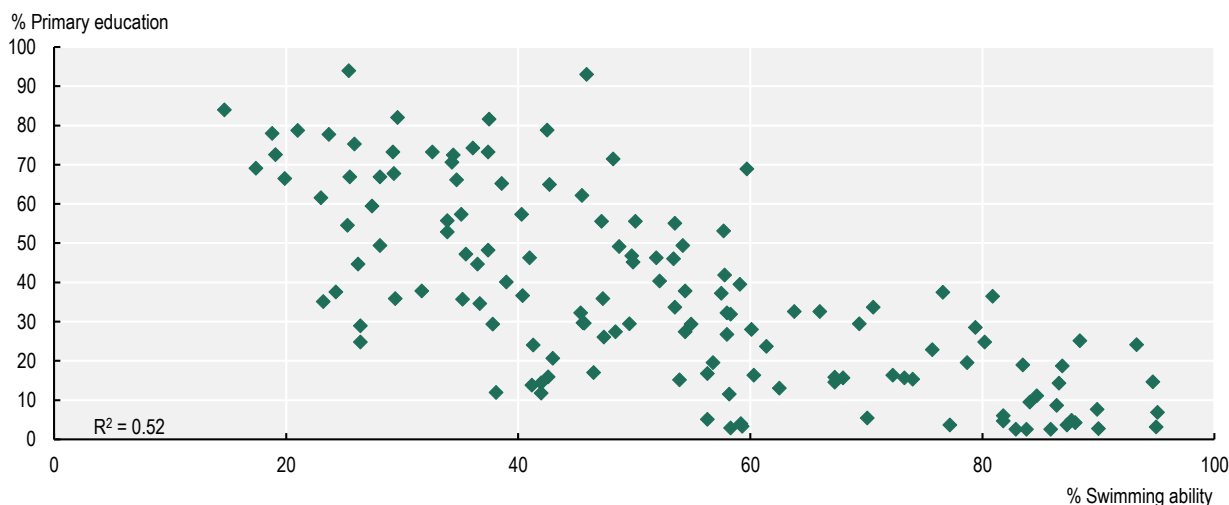
Note: The figure shows the correlation between the share of completed primary educated (y-axis) and the percentage of people who are able to swim without assistance (x-axis). While Belarus and the Russian Federation are not among the data points shown in this figure, their data are included in the R^2 calculation.

Source: Adapted from World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/; World Bank (2022[88]), *World Bank Current Classification by Income* (database), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

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Men are more likely than women to report being able to swim

Men are more likely to report being able to swim than women in countries of different levels of economic development (Figure 4.16). For example, in low-income countries, 15% of women report being able to swim without assistance. This figure is 24% in lower-middle- and upper-middle-income countries, 70% in high-income countries, and 67% in OECD countries. Among men, 39% report being able to swim without assistance in low-income countries, 52% and 53% in lower-middle- and upper-middle-income countries, and 85% in high-income and OECD countries.

Several explicit and implicit barriers could explain why women are less likely to report being able to swim than men (Borgonovi, Seitz and Vogel, 2022[3]). These include, among others, cultural and religious norms, lower levels of engagement in physical activity in general, fear of judgement and struggles with one's body image. Because lack of engagement is potentially due to a variety of factors, the relative importance of which could vary depending on the context, tackling the gender gap in swimming requires action at multiple levels and needs to be adapted to local contexts and circumstances. For example, it is important to normalise the use of a diverse range of swimwear so that girls and women feel comfortable going in water regardless of their body shapes and willingness to show their bodies in social situations. It is equally important to educate girls and women about swimming while menstruating, so that they feel comfortable going in water at any stage of their cycles. Around the world, there have been numerous initiatives, some at the national and others at a local level, to draw attention to the fact that many women do not learn how to swim or do not feel comfortable in water, and so lose confidence in their swimming ability or lose proficiency over time.

Figure 4.16. Swimming ability, by gender and country income group, 2019

Percentage of male and female respondents aged 15 and older who reported being able to swim without assistance
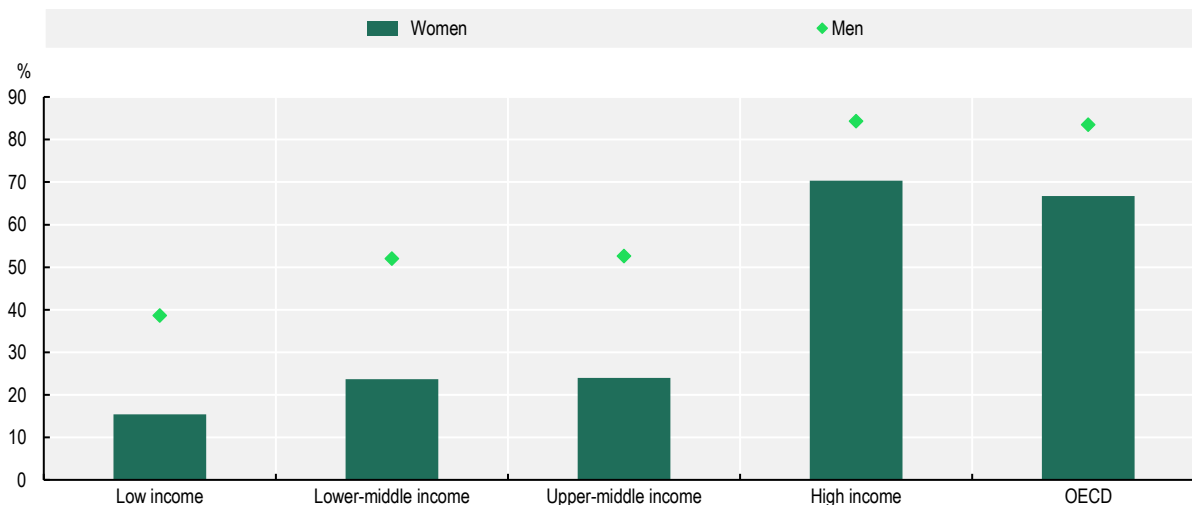
Note: The figure shows the percentage of women (bars) and men (markers) within one country income group who reported being able to swim without assistance.
Source: Adapted from World Bank (2022[88]), *World Bank Current Classification by Income* (database), https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups; World Risk Poll (2019[87]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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4.5. Conclusions

Climate change is one of the greatest threats facing humanity, with far-reaching and devastating impacts on people, the environment and the economy. Lessons from the past suggest that while technological innovations and human progress created many environmental problems that plague the planet, they also have the potential to solve these problems. The capacity to solve highly complex problems, process vast amounts of information and engage in interpersonal communication and social co-operation are some of the distinct human abilities that have led to human progress over millennia. This chapter clarifies that climate change and persistent levels of environmental pollution require education and training systems to adapt in multiple ways. Although it is important for children and young adults to learn higher-order cognitive skills, it is also essential for them to acquire life skills, such as learning how to safely engage in physical exercise and use their bodies to go about work and everyday life.

First, they need to consider the effects environmental conditions have on the capacity of individuals to develop their skills to their potential and use them effectively. This requires considering infrastructural, pedagogical and organisational investments to ensure learning environments are redesigned and aligned to facilitate learning.

Second, adapting to environmental conditions requires populations to acquire new skills, especially in those contexts that will be most severely affected by environmental changes and disasters. Greater awareness of the natural world and physical skills, such as the ability to ride bicycles or swim without assistance, will also need to be considered as skills that education and training systems should provide more systematically to promote effective adaptation to a changing natural environment and reduce inequalities in the distribution of risk associated with new environmental challenges.

Third, education and training systems should recognise the extent to which public support for public policies aimed at halting climate change and promoting environmental sustainability can fluctuate depending on the context individuals experience. In particular, whereas public support for efforts prioritising the environment over the economy is generally stronger after individuals experience natural disasters that are linked to human activity, memories of such disasters tend to fade over time and are thus not sufficient to sustain long-term investments to promote environmental sustainability. Moreover, individuals appear less willing to prioritise the environment over the economy – when these two objectives are not aligned – in periods characterised by higher unemployment.

Notwithstanding the relevance of efforts to map how well or poorly education systems worldwide are equipping individuals with key information processing skills, such as literacy and numeracy, this chapter makes clear that major inequalities persist even in physical skills needed to adapt to changing environmental conditions, such as the ability to swim without assistance or to ride a bicycle. Such inequalities make it clear that the substantive freedom many groups have to engage in activities that can enhance their subjective well-being, economic prospects, and safety is restricted and curtailed. For example, when individuals do not know how to swim, their choice set is restricted. Climate change and environmental degradation may lead to higher welfare losses due to the lack of life skills such as swimming and cycling.

The outbreak of the COVID-19 pandemic in early 2020, which was followed by containment measures in most parts of the world, provides important lessons about how schooling can be reorganised and learning supported in extreme conditions requiring the physical closure of schools and training institutions. It also drew attention to the importance of IAQ as a pre-condition of students' learning (and safety) and the inadequacy of the physical infrastructures of schools and training institutions in many countries. The pandemic led to pervasive limitations to movement and the closure of sporting facilities as well as schools and, as such, impacted not only the extent to which individuals learnt academic skills but also the extent to which they learnt valuable physical skills and how to keep safe in their surroundings. Such closures weighed most heavily on socio-economically disadvantaged children who primarily depended on schools to learn these key competencies.

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Notes

[1] Relative to the base period of between 1850 and 1900.

[2] In this study, poor countries are defined as countries whose per capita income was less than USD 14 000 in 1995, while rich countries are defined as countries whose per capita income was greater than USD 14 000 in 1995.

[3] This statistic is based on data from 2008 to 2012. The threshold for high exposure to fire-PM2.5 was annual levels of 1.5 μg/m^3 or above.

[4] In the People's Republic of China, the effects of wildfire-induced PM2.5 on reduced performance on high-stakes examinations are significantly larger than those found due to PM2.5 in other countries from other sources (Graff Zivin et al., 2020[34]). However, this difference may be attributable to other country-specific mechanisms, such as lower protective investments in classrooms.

[5] In each wave, income deciles are defined in each country/region.

5 Skills and attitudes for new information landscapes

This chapter considers the extent to which adults and young people in OECD countries reach baseline levels of proficiency across key information-processing skills – namely text comprehension, numeracy and scientific literacy – to be able to validate complex information sources. The chapter also suggests that alongside proficiency in information-processing skills, the complex digital information landscapes of the 21st century require that individuals have high levels of metacognitive skills. These include an awareness of their own ability and the level of difficulty of the information challenges they face; a willingness to recognise their lack of familiarity with the information they are exposed to; and a solid understanding of the scientific process as a way to gather evidence. Equipping people with solid cognitive and metacognitive skills is critical to solving the "trust challenge" of modern information landscapes.

Key messages

With the rise of social media, the decline of traditional news outlets and the rise of artificial intelligence (AI) technologies, there has been a proliferation of information available to individuals around the world. However, quantitative increases in the amount of information available have yet to be accompanied by increases in the quality of such information. Instead, there has been an increase in the amount of false or misleading information individuals are routinely exposed to. This chapter considers the extent to which individuals in OECD countries have developed the wide set of skills – including information-processing and metacognitive skills – and attitudes needed to reduce their vulnerability to false and misleading information and actively contribute to better the information landscape. The chapter also makes it clear that cognitive limitations – such as cognitive fatigue while engaging in prolonged cognitive tasks on line – shape how vulnerable individuals can be to low-quality information landscapes.

Key findings include:

- On average, across OECD countries in 2019, 59% of adults worried about receiving false information on line and 56% worried about online fraud.

- On average, 34% of 15-year-old students did not reach baseline proficiency levels in one or more key information-processing skills – reading, mathematics and science.

- One in four students is overconfident in their ability to locate and infer written information, given their low levels of reading ability. Girls are almost 40% less likely than boys to be overconfident in their ability to understand difficult texts.

- Levels of accuracy in performing a long series of cognitive tasks decline over time. On average, across countries with available data that took part in the Survey of Adult Skills (a product of the OECD Programme for the International Assessment of Adult Competencies, PIAAC), individuals who were administered the test on line correctly answered 60% of the test items when these were placed in the first part of the test. However, individuals who were administered the same set of items had an accuracy of 57% when the items were placed in the second part of the test. Similarly, among 15-year-old students participating in the Programme for International Student Assessment (PISA), accuracy was over 2 percentage points lower in the second compared to the first part of the assessment.

- On average, across OECD countries, 69% of 15-year-old students report having been taught strategies on "how to decide whether to trust information from the Internet"; 76% were taught strategies on how "to understand the consequences of making information publicly available on line on Facebook, Instagram etc."; 54% were taught strategies on "how to detect whether the information is subjective or biased"; and 41% were taught strategies on "how to detect phishing or spam emails".

- On average, 43% of respondents across OECD countries indicated trusting scientists "a lot" to find accurate information about the world. Levels of trust in science and scientists were higher in countries where young people had a better understanding of scientific methods of enquiry.

5.1. Introduction

The Internet and social media have dramatically increased the amount of information that is accessible and exchanged around the world. However, quantitative increases in the amount of information available have not been accompanied by increases in the quality of such information. The information landscape is complex and difficult to navigate. Modern information systems create opportunities as they allow instantaneous access to high-quality information once only available to the few (for example, in dedicated

libraries). At the same time, new information systems create new threats as they rely on technologies that allow easy and rapid access to false information or true information taken out of context. The fact that it is easy to produce and share information can also lead to information overload.

The decline of traditional news sites, such as newspapers and magazines, the increase of social media as a medium for disseminating information, the use of new generative AI models, such as ChatGPT, and the rise of deep-fake technologies all contribute to creating an information landscape that is larger, more diverse, and more complicated for individuals to filter and navigate. A study by the European Union (EU) found that deep-fake technology can have serious "malicious, deceitful and even destructive potential at an individual, organisational and societal level" either directly by spreading false information or indirectly by eroding trust in news and information on line (Huijstee et al., 2022[1]). In fact, the mere existence of deep fakes can increase distrust in information, regardless of whether it is true or false (Ternovski, Kalla and Aronow, 2021[2]), and individuals may struggle to trust any evidence because they might worry that it is a falsification (Chesney and Citron, 2018[3]). The erosion of trust in information can be observed in the results from the 2023 Edelman Trust Barometer, according to which more respondents answered that their government is "a source of false or misleading information" (46%) than answered that it is "a reliable source of trustworthy information" (39%) (Edelman, 2023[4]). Similarly, in the 2022 Edelman Trust Barometer report, 67% of respondents worried that journalists purposefully mislead by writing false, misleading, and exaggerated information, and 76% of respondents worried about the potential use of false information as a weapon (Edelman, 2022[5]). Citizen trust in the information available to them may only worsen as deep fakes and generative AI become more widely adopted and improve in the extent to which they can mimic human communication and behaviours.

A large number of adults in OECD countries worry about receiving false information on line (59% on average) or being the subject of online fraud (56% on average) (Figure 5.1). The share of adults worrying about receiving false information was highest in Italy (78%), the Republic of Türkiye (hereafter "Türkiye") (75%) and France (74%) and lowest in Poland (36%), Latvia (35%) and Lithuania (30%). Worries about fraud, i.e. stealing bank account information, were highest among adults in Portugal (78%), Türkiye (78%) and France (75%).

Figure 5.1. Percentage of adults worrying about false online information and online fraud in OECD countries, 2019
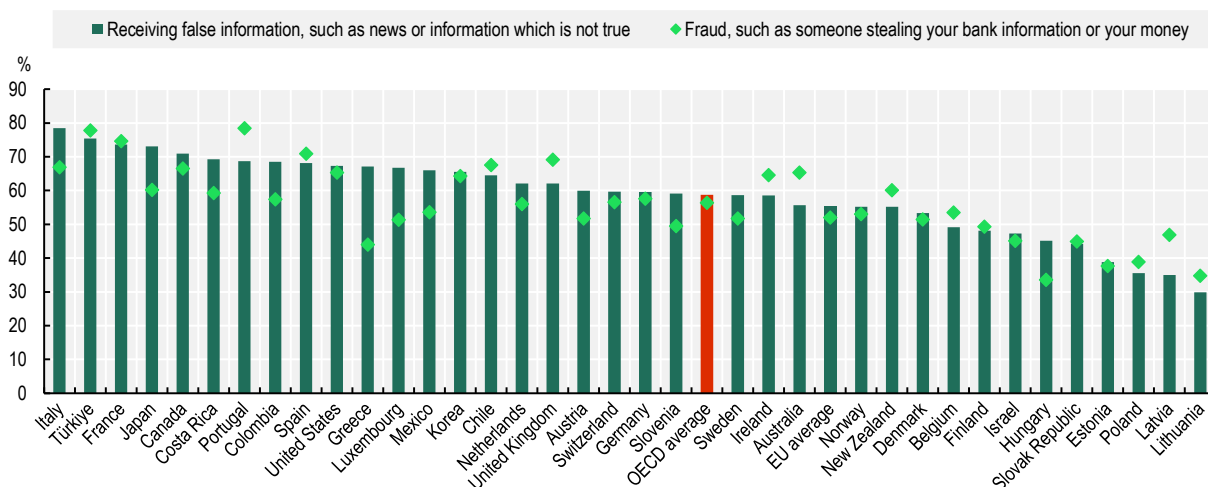
Note: Percentage of adults (aged 15 and older) worrying about risks related to "False information, such as you believing some news or information which is not true" and "Fraud, such as someone stealing your bank information or your money". Countries are sorted in descending order of the share of people who worry about receiving false information.

Source: World Risk Poll (2019[6]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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The emergence of generative AI systems has the potential to increase even further the complexity of the information landscape, shaping how easily individuals can use and exchange information and how businesses and societies build economic models based on information and data exchange. Generative AI models are statistical algorithms that create new content in response to prompts. In the case of written text, generative AI models can mimic humans by predicting the most likely sequence of words given a specific stimulus (prompt) and the corpus of content used to train them (training data). Generative AI systems can produce information content – text, video or images – instantaneously and cheaply. New generative AI systems are starting to be deployed in "content farms", i.e. websites containing AI-generated articles containing summaries of content published in traditional news outlets or false and misleading content created by the AI systems. For example, in April 2023, NewsGuard identified 49 websites in 7 languages – Chinese, Czech, English, French, Portuguese, Tagalog and Thai – were entirely or mostly generated by generative AI systems mimicking the content available in news websites, without indicating the sources of the material being published or specifying the ownership or control of the site (Sadeghi and Arvanitis, 2023[7]).

Generative AI models have the potential to significantly increase the volume of information in the information landscape, which can make it challenging for individuals to distinguish between relevant and irrelevant information. Generative AI models can also be used to create and spread false information intentionally, cheaply and quickly. Furthermore, AI systems can unintentionally produce false content in response to a specific stimulus – referred to as "hallucinating" – for example, because the quality of the training stimulus is poor, because the amount of training data is insufficient to provide an accurate output, because there are inconsistencies in the training data or because of misclassification and errors in encoding and decoding text. In both cases, generative AI systems can become powerful agents of disinformation. Moreover, because AI systems do not have an understanding of the meaning of the word sequences they produce, their output can be placed in the wrong context, thereby leading to the proliferation of misinformation.

Individuals and technologies powered by AI can lower the quality of the information landscape by:

- deliberately propagating false information to cause harm (**disinformation**)
- disseminating false information that is not intended to cause harm, often as a result of unknowing individuals sharing rumours or misleading content (**misinformation**)
- sharing genuine information with the intent to cause harm, for example, leaking private information or deliberately using true information in the wrong context (**malinformation**) (Wardle and Derakhshan, 2017[8]).

Although technologies play an essential role in shaping the quality of the information landscape, individuals also play an important role in the quality of such a landscape. Individuals are, in fact, not only passive consumers of information – including false or misleading information – that is available on line, but they are also active agents who shape the information landscape by creating content and/or by contributing to the spread of information. Whether willingly or unwillingly, through their actions, individuals can contribute to improving or worsening the quality of the information landscape. Social media tools have made it easier than ever for citizens to share information rapidly to large numbers of "friends" and followers, to the point where disinformation has been found to spread more rapidly and widely today than actual news (Pennycook and Rand, 2019[9]; Vosoughi, Roy and Aral, 2018[10]).

Some individuals may disseminate disinformation as part of an individual identity-building process (Papapicco, Lamanna and D'Errico, 2022[11]). Others may wish to share accurate information but may not have the skills needed to evaluate the quality of such information. Others may not verify the accuracy of information content due to lack of time or cognitive fatigue arising from information overload (Pennycook et al., 2021[12]). Moreover, individuals may over-rate their abilities to distinguish false news from true information and view themselves as better than others at discerning false and true information (Corbu et al., 2020[13]). For example, a study found that 84% of individuals in the United States felt at least

somewhat confident in their ability to detect fake news (Barthel, Mitchell and Holcomb, 2016[14]). However, another study found that only 17% of participants scored better than chance when trying to discern false headlines from real ones (Moravec, Minas and Dennis, 2018[15]). Similarly, Lyons and colleagues (2021[16]) found that three in four Americans overestimate their abilities to detect false headlines, and they ranked themselves on average 22 percentiles higher than their real ranking. The overconfidence in distinguishing false information from real information may, therefore, lead to individuals not only basing their actions and decisions on false or inadequate information content but inadvertently contributing to creating a low-quality information landscape by sharing false information or not putting information in the proper context. Behaviourally informed interventions can be an effective tool to reduce the spread of disinformation, as exemplified in Box 5.1.

Box 5.1. An international effort using behavioural science to tackle the spread of misinformation

Mis- and dis-information puts the legitimacy of democratically elected governments at risk by undermining citizen trust in public institutions. Driven by a joint objective to better understand and reduce the spread of misinformation with insights and tools from behavioural science, the OECD, Impact Canada (IIU)[1] and the French Direction interministérielle de la transformation publique (DITP)[2] partnered to test the impact of two behaviourally informed interventions on intentions to share true and false news headlines about COVID-19 on social media. The effects of these interventions – an attention accuracy prompt and a set of digital media literacy tips – were tested in a study conducted in Canada using a randomised controlled trial embedded within the longitudinal COVID-19 Snapshot Monitoring Study (COSMO Canada).[3]

The results from this experiment suggest that behavioural interventions can significantly reduce intentions to share false news headlines in online settings. The digital media literacy tips had the greatest impact on reducing intentions to share false headlines on line, reducing intentions to share by 21% compared to the control group. These findings are an important step in improving our understanding of the impact of mis- and dis-information and testing feasible, effective and collaborative solutions. The key insights from this report are the following:

- A comprehensive policy response to mis- and dis-information should include an expanded understanding of human behaviour.
- By empowering users, behavioural science offers effective and scalable policy tools that can complement system-level policy to better respond to misinformation.
- International experimentation across governments is vital for tackling global policy challenges and generating sustainable responses to the spread of mis- and dis-information.

1. For more information, see https://impact.canada.ca/en/behavioural-science/timeline.
2. For more information, see www.transformation.gouv.fr/.
3. For more information, see https://impact.canada.ca/en/cosmo-canada.
Source: OECD (2022[17]), "Misinformation and disinformation: An international effort using behavioural science to tackle the spread of misinformation", https://doi.org/10.1787/b7709d4f-en.

The worsening of the information landscape may have a detrimental impact on individuals' cognitive and behavioural processes. The overabundance of information of varying accuracy might obscure important facts and make it challenging for individuals to distinguish between credible and non-credible sources. This cognitive burden requires a heightened effort to critically evaluate and process information, which can be demanding on an individual's finite attentional resources. Additionally, constant exposure to conflicting information can lead to confusion and mistrust, hindering the formation of informed opinions and decision-making abilities (Bawden and Robinson, 2020[18]).

Individuals' exposure to false information could also pose a threat to society more broadly. In 2022, the World Health Organization conducted a systematic review of infodemics (an overabundance of both fake and correct information obscuring the information landscape) and health misinformation. It found that misinformation on social media had negative repercussions, leading to a rise in inaccurate interpretations of scientific information, polarisation of opinion, an increase in fear and panic, and/or a reduction in access to healthcare (Borges do Nascimento et al., 2022[19]). It also found that during times of crisis, such as the coronavirus (COVID-19) pandemic and humanitarian emergencies, social media had increasingly spread low-quality health-related information. For example, during the pandemic, there was a conspiracy that new 5G infrastructure was the cause of the COVID-19 virus. This conspiracy led to the damage and destruction of telecommunications masts in Australia, Europe, and North America, and there were several cases of verbal and/or physical abuse of engineers working with the new 5G network (Ankel, 2020[20]; Cerulus, 2020[21]; Pasley, 2020[22]).

Furthermore, scholars believe that misinformation is hindering action towards bettering the environment and fighting climate change (Benegal and Scruggs, 2018[23]). Scientists argue that "fake news" increases political polarisation and makes political action towards issues such as climate change more challenging (Tucker et al., 2018[24]).

The ability to evaluate the quality of information and the ability to seek and retrieve relevant information rest on a range of cognitive and metacognitive skills, knowledge, as well as attitudes and dispositions. Alongside the ability to process information – for example, text comprehension skills and numeracy skills, which have been extensively examined in other OECD-led reports and publications (OECD, 2019[25]; 2021[26]) – effectively operating in complex information landscapes requires: having the knowledge of how information is generated and the limitations inherent to different information generation processes and having an awareness of one's own and other people's cognitive limitations, i.e. having metacognitive skills.

As societies enter what some scholars have labelled the "post-truth" era (d'Ancona, 2017[27]) and a time when generative AI could have an unprecedented impact on information exchange, it is crucial to consider the skills individuals may need to navigate and make the most of an increasingly complex information landscape. At the same time, it is crucial to recognise how human cognition can shape how individuals perceive and process information and that upskilling and reskilling efforts are insufficient to ensure individuals' safety and well-being as they navigate complex information landscapes. Understanding the type of skills and competences people need to be more resistant to the increasing amount of false information circulating on line rests on an understanding of how people create, internalise and change their belief in information.

Media literacy is widely considered a key skill to help individuals assess the quality of information they are presented with (Valverde-Berrocoso, González-Fernández and Acevedo-Borrega, 2022[28]). Individuals with higher levels of media literacy have been found to be more adept at handling misleading information in a critical manner (Jones-Jang, Mortensen and Liu, 2019[29]). The concept of "media literacy" centres around the understanding that all forms of media are created with a specific purpose, and this purpose influences how information is conveyed (Huguet et al., 2019[30]). Media literacy encompasses the skills needed to engage with media at multiple levels and includes the ability to access, analyse, evaluate and create content in various contexts (Cortesi et al., 2020[31]; Livingstone, 2003[32]; Potter, 2010[33]). In Finland, for example, media literacy is seen as a "civic competence" and is therefore embedded in the education system and policies to promote media literacy in schools have been increasingly implemented in the United States and Japan (Box 5.2).

Box 5.2. Media literacy in Finland, the United States and Japan

Finland has long been at the forefront of media literacy. Media literacy education has been a part of the curriculum in Finnish schools since 1970 under the umbrella term of mass media education. Since 2017, the Media Literacy Index has worked to measure resilience to fake news in 35 European countries (expanding to 41 in 2022), and Finland has topped the list every time (Lessenski, 2022[34]). The focus on media literacy in the Finnish education system is considered one of the reasons for this success. According to the Media Literacy Index 2022, "Finland's government considers the strong public education system as a main tool to resist information warfare against the country" (Lessenski, 2022[34]). Similarly, Jed Willard, former Director of the Franklin Delano Roosevelt Center for Global Engagement at Harvard, said the "widespread critical thinking skills among the Finnish population and a coherent government response is thought to be a key element for resisting fake news campaigns" (Standish, 2017[35]).

Kansallinen audiovisuaalinen instituutti (KAVI), Finland's National Audiovisual Institute (the governmental authority promoting media education), argues that media literacy is seen as a civic competence in Finland (Kansallinen audiovisuaalinen instituutti, 2021[36]). KAVI emphasises that bodies across the government widely support media literacy skills. For example, the Ministry of Education and Culture supports media literacy education; the Ministry of Justice discusses media literacy from an angle of inclusion and as part of a democratic education; and the Finnish Competition and Consumer Agency supports focusing on media-related content in the context of consumer awareness information and education. In addition, with almost 100 different public, private and non-governmental organisations (NGOs) promoting media literacy in Finland (Kansallinen audiovisuaalinen instituutti, 2021[36]), the Finnish government is not alone in its efforts to promote resilience to false information.

Furthermore, in Finland, media literacy is seen as a core competency, and it is taught from a very early age. Jussi Toivanen, former Chief Communications Officer for the Finnish Prime Minister's Office, named kindergarten teachers the first line of defence against fake news (Mackintosh, 2019[37]). The national core curriculum for early childhood education and care includes an emphasis on teaching multiliteracies (several different literacies, including media literacy) as well as digital competence (Finnish National Agency for Education, 2022[38]). Students obtain media literacy training and education throughout their primary school years. In addition, media literacy is included in vocational education, and there are also media programmes in higher education. The University of Lapland offers a master's programme in media education.

In 2013, Finland published its first national media literacy policy. In 2019, Finland's Ministry of Education and Culture published a revised national media literacy policy, which aims to clarify the field of media education and describe the strengths, values and principles of media education in Finland (Salomaa and Palsa, 2019[39]). The national media literacy policy names three overarching goals for Finnish media literacy education: achieve a comprehensive, high-quality and systematic media education.

As evaluated by the Finnish Ministry of Education and Culture (Salomaa and Palsa, 2019[39]), the Finnish system for media literacy education had at the time the following strengths:

- Media education is diverse, and it is widely available.
- Media education has strong traditions.
- The position of media education is recognised in national strategies, and it receives financing.
- There is a lot of expertise in media education available.
- The significance of media education is recognised, and society provides a good platform for it.

Some of the many efforts to promote media literacy in Finland include: Media Literacy Week (MLW) and the Media Education Forum for Professionals (Kansallinen audiovisuaalinen instituutti, 2021[36]). The MLW is an annual initiative to promote awareness of media literacy and media education, as well as to support professionals working with media skills in developing their work. MLW creates around 30 different campaigns each year in collaboration with over 50 partner organisations, including private companies, public institutions and NGOs (mediataitoviikko, 2023[40]). The annual Media Education Forum is a national seminar day organised by KAVI for professionals working with media education. The forum aims to promote media education in Finland and foster partnerships and co-operation between the professionals and organisations working in the field.

Media literacy has been promoted in schools in **the United States**. Between 2015 and 2020, at least 14 bills on media literacy were enacted in 10 states (Education Commission of the States, 2021[41]). By the end of 2022, 18 states mandated media literacy to be taught in public schools in order to tackle growing online disinformation (Media Literacy Now, 2023[42]; Biron, 2023[43]).

For example, in 2022, New Jersey passed legislation that requires all students from kindergarten all the way to the end of secondary school to learn information/media literacy (Media Literacy Now, 2023[42]; Sitrin, 2023[44]). In particular, the legislation stipulates that at a minimum, curricula throughout public schools in the state will have to include instruction on: how information is produced and spread on the Internet; critical thinking skills; the difference between facts and opinions; research methods, including the difference between primary and secondary sources; the economic, legal and social issues surrounding the use of information; as well as the ethics of creating and sharing information both on line and in print (Sitrin, 2023[44]; LegiScan, 2023[45]). When commenting on the bill, Republican Senator Mike Testa emphasised that the key to media and information literacy is critical thinking skills, noting that the "law isn't about teaching kids that any specific idea is true or false. Rather, it's about helping them learn how to research, evaluate, and understand the information they are presented for themselves" (State of New Jersey, 2023[46]).

Illinois and Texas also added new standards for teaching media literacy (Pirlo and Novak, 2023[47]). More specifically, in 2021, the state of Illinois passed legislation amending the Illinois School Code. This amendment requires all public schools in the state, starting in the 2022-2023 school year, to teach a unit on media literacy (Illinois State Board of Education, 2022[48]). In particular, curricula will now include instruction on: "how to access information, analyse and evaluate media messages, create media, reflect on media consumption, as well as the social responsibility of engaging with media of all forms" (Illinois State Board of Education, 2022[48]). Teachers across the state have noted that the legislation "is already prompting a rise in the resources available to teachers on the subject" (Biron, 2023[43]).

In 2019, the Texas legislature passed a law requiring each school district to incorporate instruction in digital citizenship. In addition, in 2021, the state passed another law related to media literacy – one that requires teachers' and administrators' training programmes to include guidance on teaching media literacy (Media Literacy Now, 2023[42]).

In **Japan**, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Internal Affairs and Communication (MIC) are the two governmental ministries that are actively promoting media literacy education. For instance, in 2017, MEXT – the ministry that sets the national curriculum guidelines that are followed by all primary and secondary-level schools – revised the guidelines for textbooks starting from 2020 onwards. In 2017, there were at least 124 Japanese language textbooks used across many schools and grades (ranging from elementary to high school) that incorporated some elements of media literacy (UNESCO, 2020[49]; Nakahashi, 2015[50]). These textbooks were written not only by academics and government agencies but also by organisations and individuals working in the field of media, like media outlets and journalists (UNESCO, 2020[49]).The new guidelines introduced by MEXT in 2017 place even more emphasis on information and communication

technologies (ICT) and media literacy, with the specific aim of fostering students' abilities to use ICT, ranging from computer programming to media literacy skills (UNESCO, 2020[49]; Ministry of Education, Culture, Sports, Science, and Technology, 2020[51]). Meanwhile, MIC – the ministry charged with developing Japan's information and communication technology as well as the policies to govern the usage of digital technologies – has been actively producing media literacy materials designed for both formal and informal settings, for example, in the context of extracurricular activities, public workshops or self-learning (UNESCO, 2020[49]).

The Japanese government also introduced new elements in the curriculum in order to foster media literacy skills, such as the "period of integrated study". During the "period of integrated study", textbooks are not used, and classes are conducted in a way that allows students to develop the ability to think and learn for themselves while also teaching them how to learn and do research (Suzuki, 2008[52]). This period allows schools to provide creative learning while simultaneously developing students' critical thinking skills that transcend all subjects and are necessary for a more complex informational landscape. Another addition to the curriculum is that students are taught how to associate with the media. The goal is to: 1) learn the characteristics of different media and to appropriately choose between them; 2) understand the effects of the media on our lives; and 3) learn how to act safely in the media society (Suzuki, 2008[52]). Students are taught this through various practical activities. For instance, they are asked to develop a web page in order to convey information of their choosing to a target audience, which they then present to their fellow classmates. During these presentations, the classmates are expected to understand the position of the media (the person who created the webpage) and the receiver (those who will consume the information content). Similarly, students are asked to read newspapers and, in particular, interviews that are published in newspapers and understand the interviewer's and interviewee's positions (Suzuki, 2008[52]).

The media industry itself is also working to develop the Japanese population's media literacy skills. The public broadcaster Japan Broadcasting Corporation, for example, has been offering media literacy content for teachers and students, from lesson plans to video clips. Most notably, the outlet developed a show called 'The Media Times,' which first aired in June 2017. The show includes 20 ten-minute episodes. It showcases four protagonists who look into media production from different angles, including from the viewpoints of practitioners and the audience. The episodes cover various topics such as online reviews, opinion polls, disinformation and copyrights (UNESCO, 2020[49]).

Although Japan has implemented policies in order to promote media literacy, there are nevertheless challenges that remain, such as the lack of teacher training and the (at times) lack of consensus among different stakeholders engaged in media literacy education as to what should be taught and in what way (UNESCO, 2020[49]).

At the same time, it has been argued that media literacy alone is not sufficient for making people resilient to false and misleading information and that a combination of several literacies, including information literacy, digital literacy, science literacy and news literacy, are needed for individuals to reliably navigate the current information environment (Jones-Jang, Mortensen and Liu, 2019[29]). In the context of discussing the skills necessary for effectively handling information in the 21st century, it is important to consider that there is an overlap among such constructs.

A predominant trend in the research on media literacy is the adoption of a functional approach, which emphasises the identification of specific competencies necessary for effective media literacy, such as the ability to evaluate and verify sources, search for information and critically analyse media messages (Edwards et al., 2021[53]). Among the competencies associated with media literacy, as well as information literacy, digital literacy, science literacy, and news literacy, is critical thinking. Critical thinking is frequently recognised as a core component and is commonly cited in literature reviews of the field (Chapman, 2016[54]; Potter, 2010[33]). For example, one systematic literature review found critical thinking skills crucial for

identifying fake news (Machete and Turpin, 2020[55]). Definitions of critical thinking often emphasise logical or rational thinking, which encompasses the ability to reason, evaluate arguments and evidence and argue in a sound and cogent manner to arrive at a relevant and appropriate solution to a problem. While the concept of critical thinking encompasses multiple meanings in the literature, its essential components are widely recognised as abilities that help people analyse media messages, examine their underlying meanings and identify the motives of the sender, as well as abilities that help to evaluate media messages for accuracy, credibility, completeness and usefulness. Suspending judgement and not going with one's immediate intuition as a part of critical thinking to deal with misinformation has been shown in research to influence truth discernment.

The critical thinking process is contingent upon several key dispositions. Vardi (2015[56]) identified three dispositions involved in critical thinking: 1) self-regulation, characterised by self-discipline and self-management; 2) an open, fair and reasonable mindset, and a readiness to confront and recognise one's own biases and to revise one's views as necessary; and 3) being committed to ongoing self-improvement and the acquisition of knowledge. Thomas and Lok (2015[57]) also conducted research on dispositions or personal attitudes that support the development and application of critical thinking skills and found similar results. These include being open-minded and fair-minded, truth-seeking and curious, and avoiding cultural- or trait-induced bias and dichotomous black-and-white thinking.

As young people spend more of their time on line and are engaged on social media platforms, they might be increasingly exposed to false and misleading information (Twenge, Martin and Spitzberg, 2019[58]). Survey data from the United Kingdom indicates that 10% of young people aged 8-17 view false information more than 6 times per day, and over half of young people are exposed to it daily (Cawthorne, 2021[59]). Since young people are still developing executive functions, they are generally less capable of self-regulating interactive media use (Burns and Gottschalk, 2020[60]). They might, therefore, be at particular risk when exposed to misleading content.

It is worth noting that caregivers significantly influence children's media and digital technology exposure. They are typically the ones who introduce these technologies into children's lives and teach them how to use them. Consequently, children often imitate their caregivers' digital technology usage patterns as they initially engage with these technologies (Terras and Ramsay, 2016[61]). Evidence suggests that children of parents with lower levels of digital literacy have fewer resources available to develop their own digital/information/media literacy (Burns and Gottschalk, 2020[60]). Furthermore, data from the Programme for International Student Assessment (PISA) 2018 found that less advantaged pupils are more unclear on how to identify misinformation (OECD, 2021[26]; Suarez-Alvarez, 2021[62]). Even younger parents struggle with the nature of the digital world while being (mis)labelled as "digital natives". Furthermore, teachers also play an important role in developing critical thinking skills in students. Successfully teaching critical thinking hinges on teachers' attitudes and ability to create learning environments where students feel safe to take risks in their thinking and expressions.

This chapter discusses several important aspects related to information-processing skills and digital landscapes. First, it highlights the importance of achieving baseline proficiency in essential information-processing skills such as literacy, numeracy and science literacy for individuals to navigate complex information environments effectively. Next, it explores the dynamic nature of individuals' proficiency levels in information processing and how extended engagement in digital cognitive tasks can lead to declines in these skills. The chapter also addresses key metacognitive skills, including self-awareness of one's problem-solving abilities, the ability to evaluate the credibility of information sources and an understanding of the scientific process. The importance of trust in the scientific process is emphasised, particularly in situations where scientific advice may change, or disagreements among experts may arise. Furthermore, the chapter examines the current state of teaching strategies aimed at helping young people effectively navigate complex digital information landscapes. It considers existing guidelines and policy approaches as illustrative examples. Finally, the chapter concludes by discussing the implications of these findings for policy and practice.

5.2. How many people lack key information-processing skills?

5.2.1. Adult proficiency in literacy and numeracy

In the digital information landscape, individuals must construct and validate knowledge from multiple sources, including scientific information and numerical data, which may vary in quality and have unknown origins. As such, individuals must possess a wide range of skills and be able to deploy them concomitantly to extract meaning and use from information. For example, text comprehension skills (reading literacy) are not sufficient to be able to evaluate digital text but should be accompanied by strong numeracy (mathematics) and scientific literacy. Unfortunately, many adults and young people fail to reach baseline proficiency levels in these skills. Thus, they are at a heightened risk of being unable to meaningfully process information in the form often presented to them. Although in practice, individuals are required to possess high levels of proficiency, the analyses presented here illustrate the share of adults and young people in OECD countries who fail to meet minimum baseline levels of proficiency in key information-processing skills. As such, these individuals are particularly vulnerable to making wrong assessments on the basis of information presented on and offline.

Proficiency in accessing, comprehending, and evaluating texts, as well as critical reasoning with mathematical content, and the effective use of digital technology for information acquisition, communication and practical tasks, are vital skills for navigating information-rich environments in the labour market and everyday life (OECD, 2013[63]). Figure 5.2 shows that across OECD and EU countries, Japan has the lowest share of adults with the lowest levels of literacy and numeracy proficiency (at or below Level 1) (4%), followed by the Czech Republic and Finland (8%). In contrast, in Peru, almost seven in ten adults score at the lowest level of proficiency in literacy and numeracy, and in Chile and Mexico, around five in ten adults do so.

Figure 5.2. Percentage of adults with the lowest levels of literacy and numeracy in selected OECD countries, 2012, 2015 and 2019
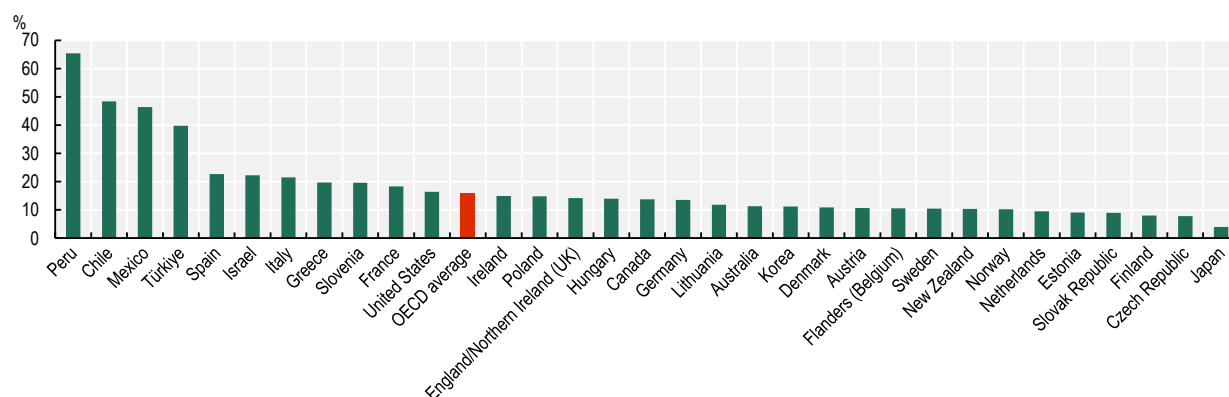
Note: The figure shows the percentage of adults aged 16-65 who achieved Level 1 or below in both numeracy and literacy in the Survey of Adult Skills (PIAAC). Countries are sorted in descending order of percentages.
Source: Calculations based on OECD (2012[64]), (2015[65]), (2019[66]), *Survey of Adult Skills (PIAAC) databases*, www.oecd.org/skills/piaac/publicdataandanalysis/.

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5.2.2. Young people's reading, mathematics and science proficiency

Young people who fail to reach baseline levels of proficiency in reading, mathematics or science can, at most, solve tasks involving familiar contexts where all relevant information is present, and the tasks are clearly defined, performing actions that are almost always obvious and follow immediately from a given stimulus (OECD, 2019[25]). On average, 34% of 15-year-old students across OECD countries did not reach baseline proficiency levels in one or more key information-processing skills – reading, mathematics or science (Figure 5.3). Estonia (83%) and Japan (79%) have the highest share of 15-year-old students who are baseline all-rounders, meaning they reached baseline proficiency levels in all three domains. By contrast, in Colombia, only 29% of 15-year-old students were baseline all-rounders.

Figure 5.3. Young people's reading, mathematics, and science proficiency in selected countries, 2018

Share of 15-year-old students who are baseline all-rounders (scoring Level 2 and above in all three domains)
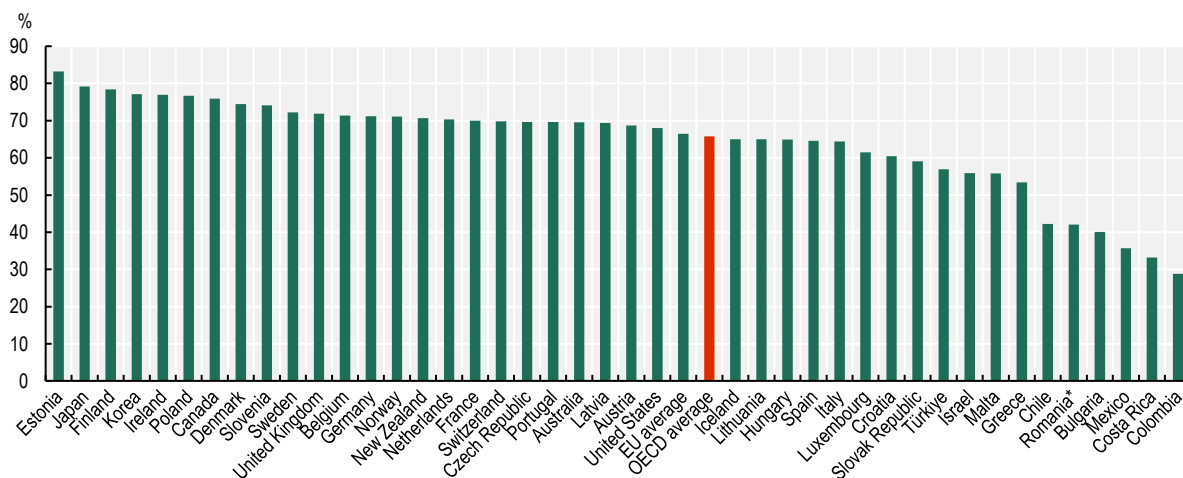
Note: The figure shows the share of students who are baseline all-rounders (scoring Level 2 and above in all three domains) for each country. Countries are sorted in descending order of the percentage of students who are baseline all-rounders.
The asterisk (*) indicates participation in the paper-based assessment mode.
Source: Calculations based on OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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5.2.3. Individuals' information-processing abilities decline with prolonged task completion

Individuals' ability to process information, including tasks like understanding, using and interpreting written texts or accessing, using, interpreting and communicating mathematical information and ideas, is not static. It varies based on contextual factors, such as fatigue or motivation to solve a particular task. In information-rich societies, a key skill that allows individuals to engage in effective information processing is task persistence, defined as the capacity to maintain high levels of accuracy and willingness to engage in demanding cognitive tasks (Ryan and Deci, 2000[68]). Greater fatigue and tiredness lead to lower levels of persistence. Moreover, individuals with greater skills relevant to completing a task are more likely to persist in solving such a task. Similarly, it is crucial for individuals to be able to monitor and recognise their own level of cognitive fatigue and how this affects their information-processing skills. Information-processing abilities may in fact decline after engagement in prolonged cognitive effort and individuals, recognising the

potential harmful effects of such decline, may act in ways that reduce their vulnerability to make suboptimal decisions (for example taking a break, postponing decisions or actions, and/or seeking the counsel of others).

In digital settings, task persistence is highly prized. Both children and adults spend an increasing amount of time using digital technologies performing long cognitive tasks (Fraillon et al., 2019[69]; Li et al., 2021[70]). Their day-to-day outcomes, i.e. how much they learn, how productive they are, and how well they are able to decipher the information they find on line, depend on their ability to maintain levels of accuracy over long periods or to recognise their cognitive limitations and take actions to address these. This could entail, for example, taking breaks or acknowledging that there is variability in how well they can deploy their information-processing skills, thereby organising their activities in ways that ensure that their peak levels of ability are devoted to the most challenging and consequential tasks.

Figure 5.4 indicates that, on average, across countries with available data that took part in the Survey of Adult Skills, individuals who took the online test correctly answered 60% of the test items when they were positioned in the first part of the test. However, when the same set of items was placed in the second part of the test, individuals' accuracy dropped to 57%, indicating a difference of 3 percentage points. At the same time, countries differed with respect to the decline in accuracy experienced by individuals between items placed in the first and second halves of the assessment. In particular, in Ireland, accuracy declined from 58% of correct responses to 53%. Similarly, in England/Northern Ireland (United Kingdom), it declined from 59% to 55%; in France, it declined from 56% to 52%. By contrast, in the Slovak Republic, accuracy remained almost stable – at 60% correct responses – and in the Netherlands, it declined by less than 2 percentage points from 65% to 63%.

Figure 5.4. Decline in accuracy among adult populations completing a long series of information-processing tasks in selected countries

Average percentage point decline in accuracy (% correct responses) in literacy and numeracy tasks placed in the first and second halves of the PIAAC assessment
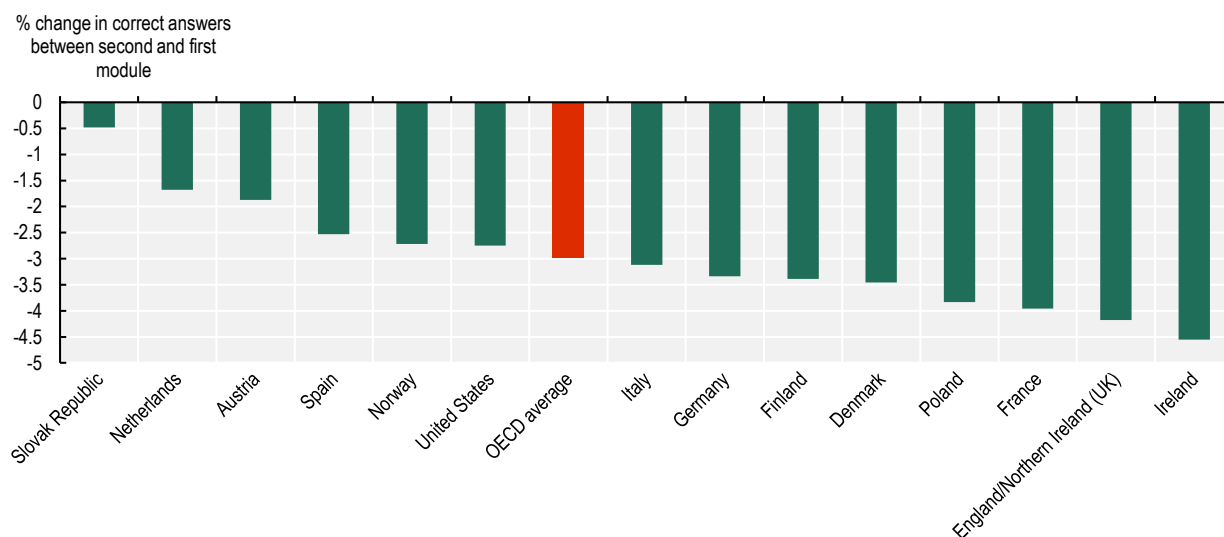
Note: The figure shows the difference in the percentage of correct answers between the second and the first module. Negative percentage differences indicate that items in the second module are less likely to be answered correctly.
Source: OECD (2017[71]), *Programme for the International Assessment of Adult Competencies (PIAAC), log files*, http://dx.doi.org/10.4232/1.12955.

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Differences in accuracy among adult populations appear to vary across socio-economic characteristics. For example, Figure 5.6 indicates that, on average, across the adult population surveyed, women experienced a larger decline in accuracy as a text progressed compared to men. Individuals with less than an upper secondary degree experienced significant declines in accuracy over the course of the PIAAC assessment, as did individuals who completed a tertiary degree. Interestingly, those who obtained an upper secondary degree saw, on average, less of a decrease in the percentage of correct responses between the first and second hour of the PIAAC assessment. Figure 5.5 also indicates that individuals coming from households in which neither parent had obtained a tertiary-level degree (a measure of socio-economic status) saw less of a decline in accuracy than individuals coming from households in which either one or both parents had obtained a tertiary-level degree.

Figure 5.5. Decline in accuracy among adult populations, by socio-economic characteristic

Average percentage point decline in accuracy (% correct responses) in mathematics and science tasks placed in the first and second hours of the PIAAC assessment
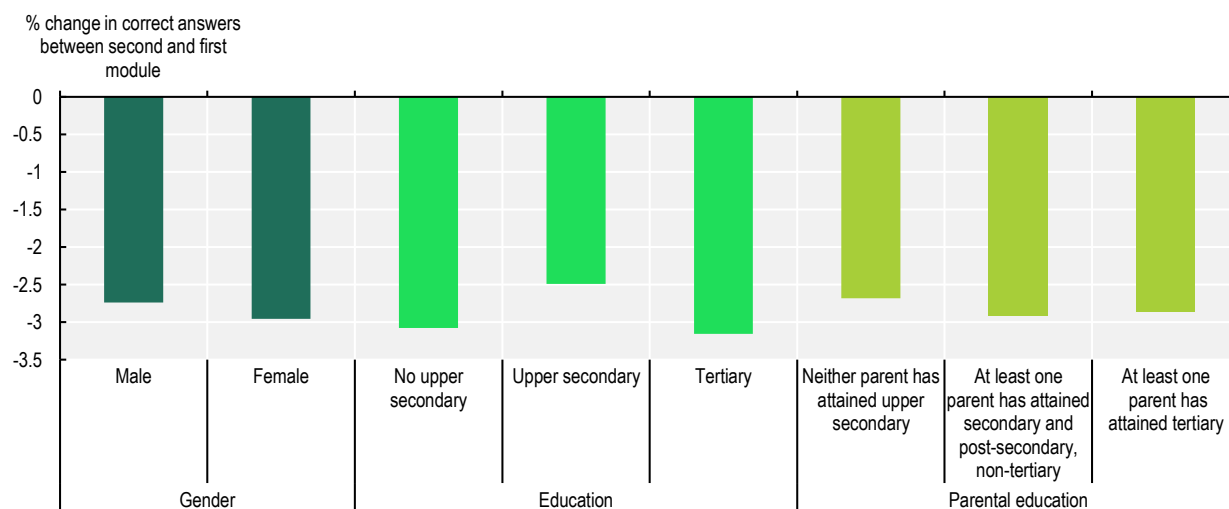
Note: The figure shows the difference in the percentage of correct answers between the second and the first module by gender, education and parental education. Negative percentage differences indicate that items in the second module are less likely to be answered correctly.
Source: OECD (2017[71]), *Programme for the International Assessment of Adult Competencies (PIAAC), log files*, http://dx.doi.org/10.4232/1.12955.

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Declines in levels of accuracy, when individuals are required to complete a long series of information-processing tasks, can also be identified among young people. Figure 5.6 reveals that when comparing the achievement of 15-year-old students who took part in the PISA 2018 assessment of science and mathematics, accuracy declined by 2.2 percentage points on average across OECD countries between the first and second hours of the assessment.[1] Declines in accuracy were especially pronounced in Colombia, Australia and Norway, where declines were larger than 3 percentage points and smallest in Greece, Lithuania, Hungary and Finland, where declines were smaller than 1 percentage point.

Figure 5.6. Decline in accuracy among adolescent populations completing a long series of information-processing tasks in selected countries, 2018

Average percentage point decline in accuracy (% correct responses) in mathematics and science tasks placed in the first and second hours of the PISA 2018 assessment
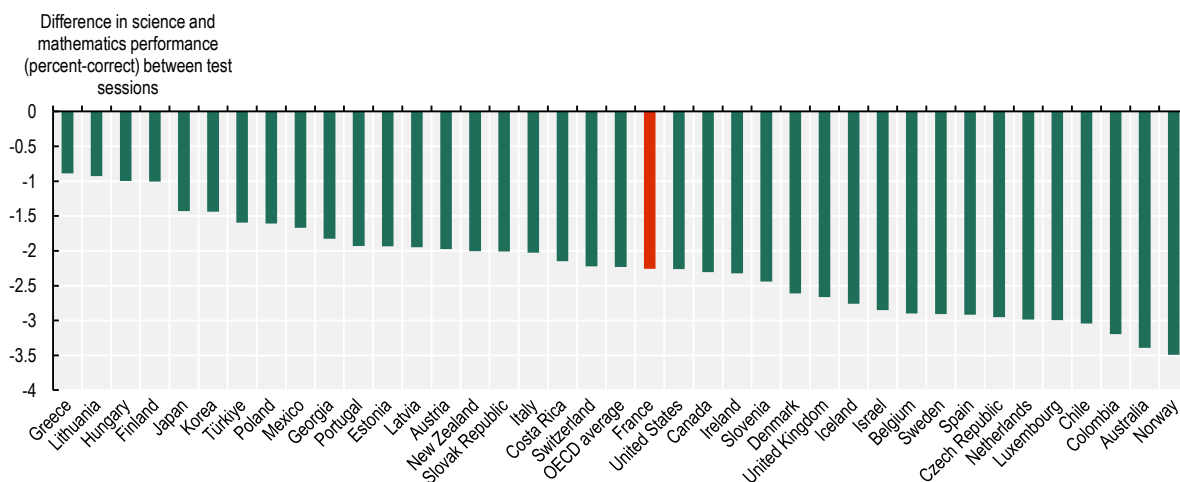
Note: Countries are ranked in descending order of the difference in the percentage of correct responses 15-year-old students participating in the PISA 2018 assessment gave to science and mathematics questions placed in the first hour of the assessment and the same questions placed in the second hour.
Source: OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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5.3. The role of metacognitive skills

5.3.1. Do young people know that they do not know when they do not know?

A key skill to be able to navigate complex information landscapes is to be aware of the complexity of information-processing tasks, given one's ability to process information. In 2018, 15-year-old students participating in the PISA assessment were asked to report if they felt they were able to understand difficult texts they had just been presented with in the context of the PISA reading assessment. Figure 5.7 reveals that, on average, across OECD countries, 67% of 15-year-old students reported being able to understand difficult texts. Among the top performers in reading – those with reading proficiency of Level 5 and above – 88% of students on average across OECD countries reported being able to understand difficult texts, while only 51% of students who, at most, had baseline levels of reading proficiency reported the same. Interestingly, the two countries where young people doubted their understanding the most were Japan and Korea, two countries with the highest reading achievement levels internationally. For example, in Japan, 28% of students reported being able to understand difficult texts; in Korea, 55% did.

Figure 5.7. Students' ability to understand difficult texts in selected countries, by reading proficiency level, 2018

Percentage of 15-year-old students who are able to understand difficult texts
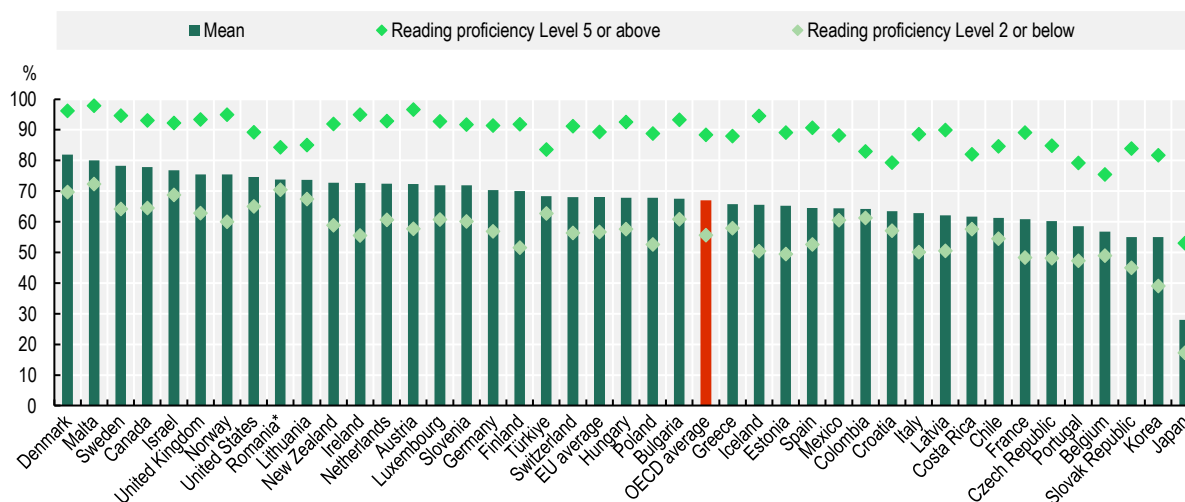
Note: The figure provides the average share of 15-year-old students who are able to understand difficult texts and by reading proficiency level (5 or above and below Level 2). The share is based on students who agree or strongly agree with the statement, "I am able to understand difficult texts". Countries are ordered in descending order according to mean share.
The asterisk (*) indicates participation in the paper-based assessment mode.
Source: Calculations based on OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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Although fewer low achievers than high achievers reported being able to understand difficult texts, Figure 5.8 reveals that a large number of students have low levels of understanding of digital texts (i.e. they performed poorly in PISA reading tasks) and believe they have high levels of understanding of digital texts (i.e. they reported being able to understand difficult texts in the PISA reading assessment). In fact, on average, across OECD countries, 25% of 15-year-old students believe they can comprehend difficult texts even though their measured reading proficiency suggests the opposite. Overconfidence, i.e. the overestimation of one's actual ability to perform a task successfully, is a well-established cognitive bias in psychological research (Kahneman and Tversky, 1996[72]). In the context of information processing, overconfident individuals could make suboptimal decisions for themselves, believing wrong information or misinterpreting correct information. At the same time, they could also potentially contribute to sharing wrong information with confidence or unwillingly creating and disseminating wrong information due to misinterpretation rather than malicious intent.

Figure 5.8. Students' ability to understand difficult texts who also have reading proficiency Level 2 or below, in selected countries, 2018

Percentage of 15-year-old students who report being able to understand difficult texts and who have reading proficiency Level 2 or below

Note: The figure provides the share of 15-year-old students who report being able to understand difficult texts and who have reading proficiency Level 2 or below. Countries are ordered in descending order according to the percentage of 15-year-old students who can understand difficult texts and have reading proficiency Level 2 or below.
The asterisk (*) indicates participation in the paper-based assessment mode.
Source: Calculations based on OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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The share of young people who reported being able to understand difficult texts even though they performed, at most, at PISA proficiency Level 2 in the reading assessment was highest in Romania, where 48% of young people were overconfident in their reading skills and the lowest in Japan, where 7% of young people were. In Romania, Colombia, Mexico, Bulgaria, Malta and Costa Rica (listed in descending order), four or more 15-year-old students in ten reported being able to understand difficult texts even though they had low levels of achievement in reading. By contrast, in Portugal, Germany, Belgium, Canada, Poland, Ireland, Finland, Estonia, Korea and Japan, fewer than two in ten 15-year-old students reported being able to understand difficult texts even though they had low levels of achievement in reading.

In most countries, boys are more likely than girls to report being able to understand difficult texts, though they performed poorly on tasks involving understanding those texts (i.e. they achieved at most proficiency Level 2 in the PISA reading assessment). On average, across OECD countries, girls are almost 40% less likely than boys to be overconfident in their ability to understand difficult texts (Figure 5.9) and in Finland, they are almost 65% less likely. Only in Colombia, Italy, Mexico and Bulgaria (listed in descending order) are boys and girls equally likely to be overconfident in their ability to understand difficult texts.

Figure 5.9. Students' ability to understand difficult texts who also have reading proficiency Level 2 or below, by country and gender, in selected countries, 2018

Odds ratio of girls' ability to understand difficult texts with reading proficiency Level 2 or below, relative to boys' ability to understand difficult texts with reading proficiency Level 2 or below
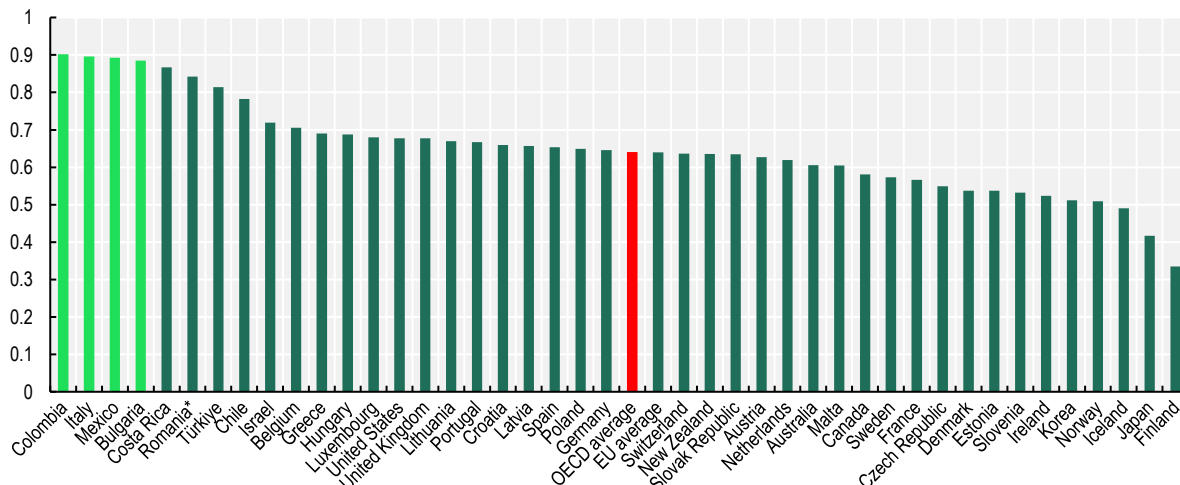
Note: This figure provides the odds ratio of girls' self-reported ability to understand difficult texts relative to boys' self-reported ability to do the same. Odds ratios are from logistic regressions. Students are able to understand difficult texts if they agree or strongly agree with the statement, "I am able to understand difficult texts". Countries are ordered in descending order according to estimates of odds ratios. Lighter bars denote that differences between girls and boys are not statistically significant.
The asterisk (*) indicates participation in the paper-based assessment mode.
Source: Calculations based on OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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5.3.2. Do young people know what to do when exposed to online fraud?

Alongside exposure to information of variable quality, individuals are increasingly targeted by online fraud, malware and schemes designed to extract their personal data through phishing messages. Taking inappropriate action when being the subject of phishing attempts can put one's own data at risk, as well as the data of others in one's social network.

In the context of PISA testing, students were proposed a scenario in which they had to imagine receiving an email from a well-known mobile phone operator telling them they had won a smartphone. They were asked to click on a link to fill out a form with their data so that the smartphone could be sent to them. Next, they were asked how appropriate a series of actions would be, including: 1) answer the email and ask for more information about the smartphone; 2) check the sender's email address; 3) delete the email without clicking on the link; 4) check the website of the mobile phone operator to see whether the smartphone offer was mentioned; and 5) click on the link to fill out the form as soon as possible. Clicking on the link to fill in the form as soon as possible was clearly inappropriate in the scenario. Yet, on average, across OECD countries, only around one in two 15-year-old students (49%) indicated that clicking on the link would not be appropriate when receiving a potential phishing email (Figure 5.10). The share of students who reported that it would not be at all appropriate to click on the link was highest in Denmark (82%) and lowest in Spain (27%).

Figure 5.10. Students' reactions to potentially phishing email content in selected countries, 2018

Percentage of students who reported that clicking on a link and giving their personal data after receiving a potentially phishing email would not be at all appropriate
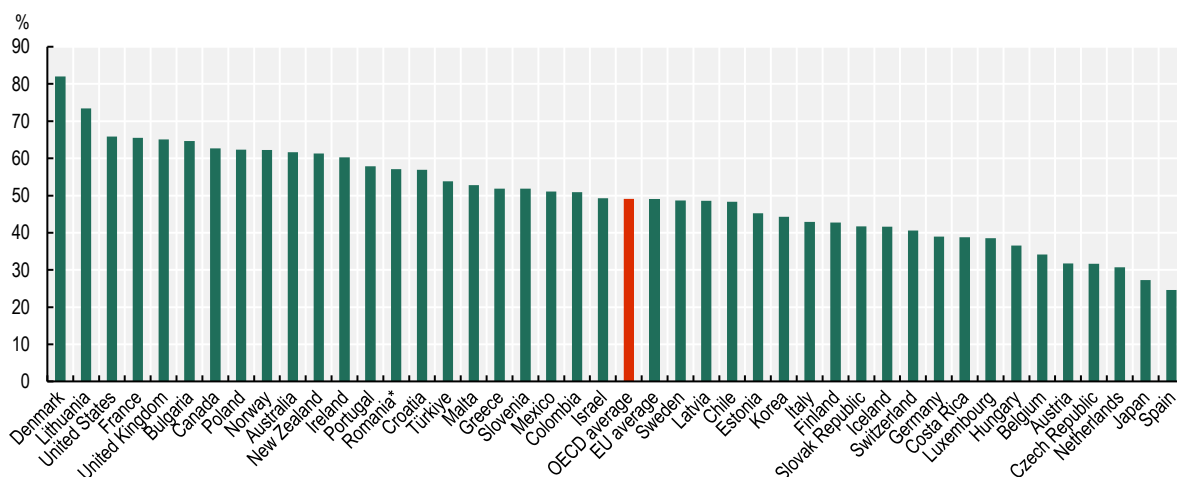
Note: The survey question asked students about the extent to which they would perceive as appropriate (1 = not appropriate at all to 6 = very appropriate) a series of strategies following receiving a potentially phishing email, including "Click on the link to fill out the form as soon as possible". The figure shows the share of students who chose "1 (not appropriate at all)". Countries are in descending order of the percentage of 15-year-old students who indicated that it would not be at all appropriate to click on the link to fill out the form as soon as possible.
The asterisk (*) indicates participation in the paper-based assessment mode.
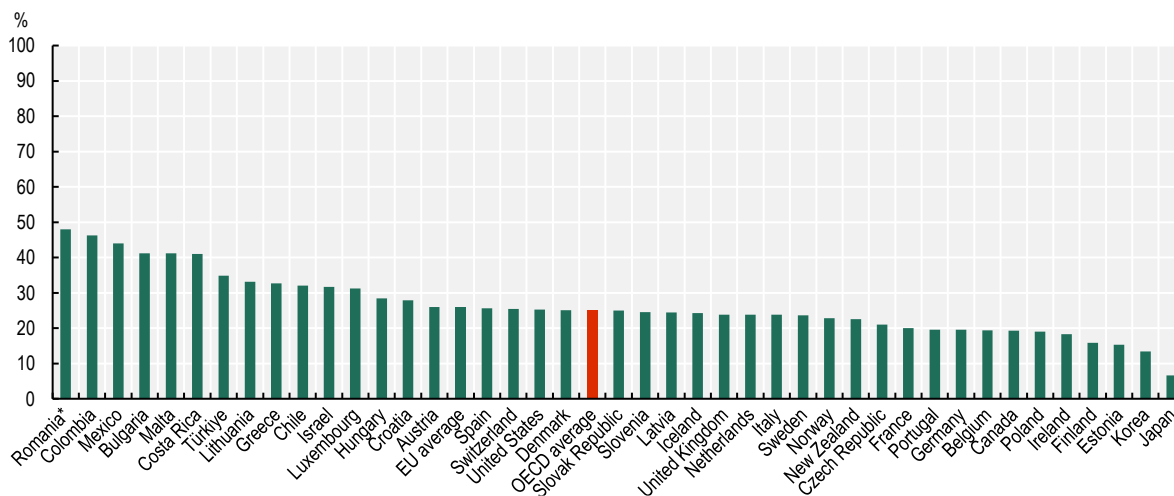Source: Calculations based on OECD (2018[67]), *PISA database 2018*, http://www.oecd.org/pisa/data/2018database/.

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5.3.3. Epistemic beliefs in science and trust in science and scientists

An important challenge of emerging new phenomena is the high degree of uncertainty that surrounds decision making when situations are new and unknown. This was the case, for example, when the coronavirus (COVID-19) emerged in early 2020, and little was known about how it spread, how infectious it was, how dangerous it was and what treatment, if any, could be adopted if infected. This led to differences in the advice given by different scientists and decision makers and to changes in such advice over time. Such changes could be expected as information about the virus increased alongside the knowledge of its properties and effects. Trusting scientists when there is lack of agreement among experts and when the advice any one expert gives changes over time requires an understanding of how the scientific process unfolds, the nature of knowledge in science and believing in the validity of scientific methods of enquiry as a source of knowing. In science, scientific explanations are true only until proven wrong through experimentation.

In 2015, 15-year-old students participating in the PISA study were asked to report if they strongly agreed, agreed, disagreed or strongly disagreed with the following statements: "A good way to know if something is true is to do an experiment"; "Ideas in science sometimes change"; "Good answers are based on evidence from many different experiments"; "It is good to try experiments more than once to make sure of [your] findings"; "Sometimes scientists change their minds about what is true in science"; and "The ideas in science books sometimes change". These statements are related to beliefs that scientific knowledge is tentative (to the extent that students recognise that scientific theories are not absolute truths but evolve over time) and to beliefs about the validity and limitations of empirical methods of enquiry as a source of knowing.

Figure 5.11 illustrates the mean index of students' epistemic beliefs about science (left y-axis). On average, in 2015, 15-year-olds in Canada, Iceland and Portugal had especially high levels of epistemic beliefs in science, meaning that, on average, they were better able than students in other OECD countries to recognise that scientific knowledge is tentative and to understand the validity and limitations of empirical methods of enquiry as a source of knowing. By contrast, students in the Slovak Republic, Hungary and Romania had comparatively low levels of epistemic beliefs in science.

Since the index of epistemic beliefs in science is a composite index that allows for a meaningful comparison of countries but is difficult to interpret, Figure 5.11 also illustrates the percentage of 15-year-old students in each country who reported agreeing or strongly agreeing that "Sometimes scientists change their minds about what is true in science". This statement is highly correlated with the overall index and describes the situation many young people found themselves in during the COVID-19 pandemic. On average, across OECD countries, 79% of young people agreed or strongly agreed that sometimes scientists change their minds about what is true in science. Portugal, Denmark, Canada and Korea are the countries with the highest percentage; in Portugal and Denmark, 89% of 15-year-old students agreed or strongly agreed that sometimes scientists change their minds about what is true in science; in Canada and Korea, 88% did. By contrast, in Hungary, Luxembourg, Austria, Romania and Germany, between 65% and 68% of 15-year-old students agreed or strongly agreed that sometimes scientists change their minds about what is true in science.

Figure 5.11. Students' trust in science in selected countries, 2015

Mean index of epistemic beliefs about science (left y-axis) and percentage of 15-year-old students who agree or strongly agree with the statement, "Sometimes scientists change their minds about what is true in science" (right y-axis)
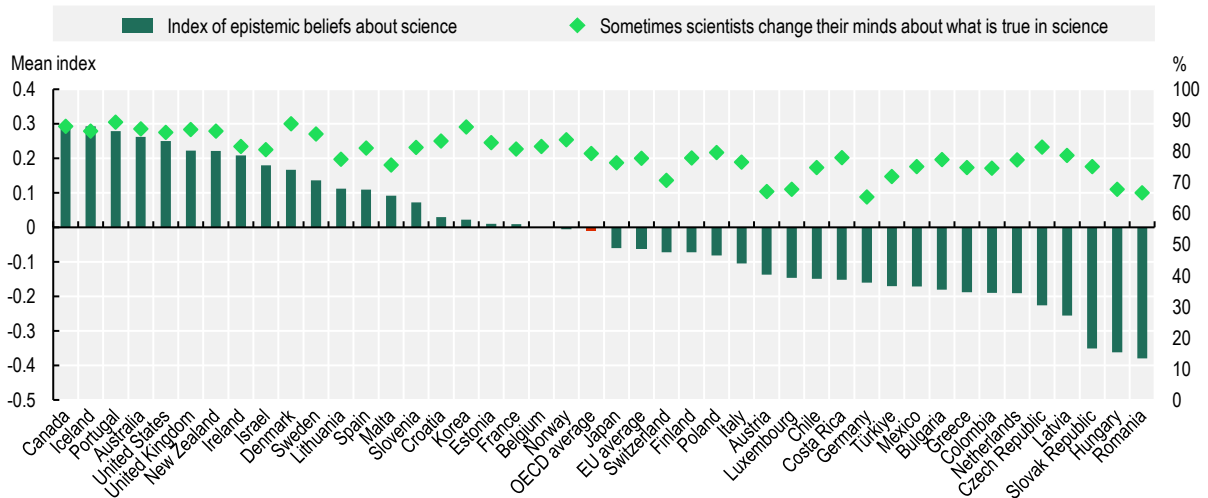
Note: The figure shows the mean index of epistemic beliefs about science (left y-axis) and the percentage of 15-year-old students who agree or strongly agree with the statement, "Sometimes scientists change their minds about what is true in science" (right y-axis). The other statements included in the statement are: "Ideas in [broad science] sometimes change"; "Good answers are based on evidence from many different experiments"; "It is good to try experiments more than once to make sure of your findings"; "A good way to know if something is true is to do an experiment"; and "The ideas in [broad science] science books sometimes change". Countries are sorted in descending order in the index of epistemic beliefs.
Source: Calculations based on OECD (2015[65]), *PISA database 2015*, www.oecd.org/pisa/data/2015database/.

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In addition to grasping the essence of scientific exploration, adopting specific attitudes towards science and scientists can assist individuals in navigating a complex and swiftly evolving information landscape where scientific facts and advice coexist with sources of misinformation and disinformation. One such attitude is trusting science and scientists.

In 2018, participants in the Wellcome Global Monitor were surveyed using a four-point Likert scale ("a lot", "some", "not much", and "not at all"), where they were asked to rate the following statements: "How much do you trust scientists in this country?"; "In general, would you say that you trust science?"; "In general, how much do you trust scientists to find accurate information about the world?"; "Scientists work with the intention of benefiting the public"; and "Scientists are open and honest about who is paying for their work".

Figure 5.12 illustrates average levels of a cross-country comparable trust in science index that was developed using information provided by respondents to the five statements and the percentage who reported that, in general, they trust scientists a lot to find accurate information about the world. On average, across OECD countries, levels of trust in science were highest in Finland, Australia and Norway and lowest in Korea, Colombia and Greece. The percentage of the adult population who reported that, in general, they trust scientists a lot to find accurate information about the world ranged from 15% in Korea and 68% in Spain, with an average across OECD countries of 43%.

Figure 5.12. Adults' trust in science index and percentage trusting scientists in selected countries, 2018

Mean index of trust in science (left y-axis) and percentage of adults who report trusting scientists (right y-axis)
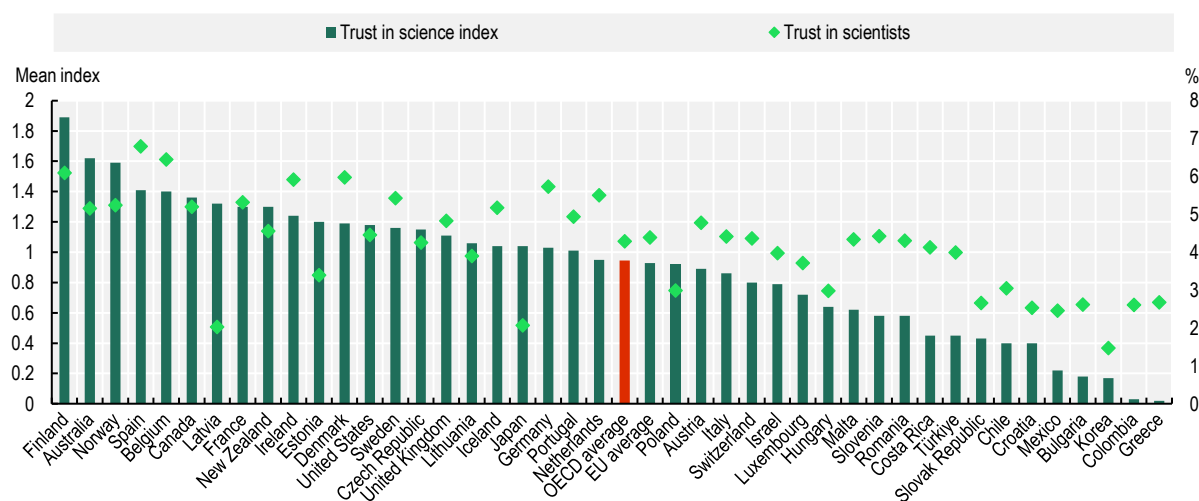
Note: The figure shows the mean index of trust in science on the left y-axis. This figure shows the percentage of adults (aged 15 years or older) reporting that they trust scientists on the right y-axis. The share is based on adults who answer "a lot" to the following statement, "How much do you trust scientists in this country?". Countries are sorted in descending order of the trust in science index.
Source: Wellcome Trust (2018[73]), *Wellcome Global Monitor 2018*, https://wellcome.org/reports/wellcome-global-monitor/2018.; Borgonovi and Pokropek, (2020[74]), *Can we rely on trust in science to beat the COVID-19 pandemic?*, https://doi.org/10.31234/osf.io/yq287.

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In countries where young people were more likely to believe that scientific knowledge is tentative and understand the validity and limitations of empirical methods of enquiry as a source of knowing, adults also had higher levels of trust in science and scientists (Figure 5.13). These results are correlational but suggest that trust in science and scientists is higher in countries with a more solid understanding of the nature of scientific knowledge.

Figure 5.13. The cross-country association between epistemic beliefs in science and trust in science and scientists

Mean levels of epistemic beliefs in science among 15-year-old students in 2015 and mean levels of trust in science among 15+ adults in 2018
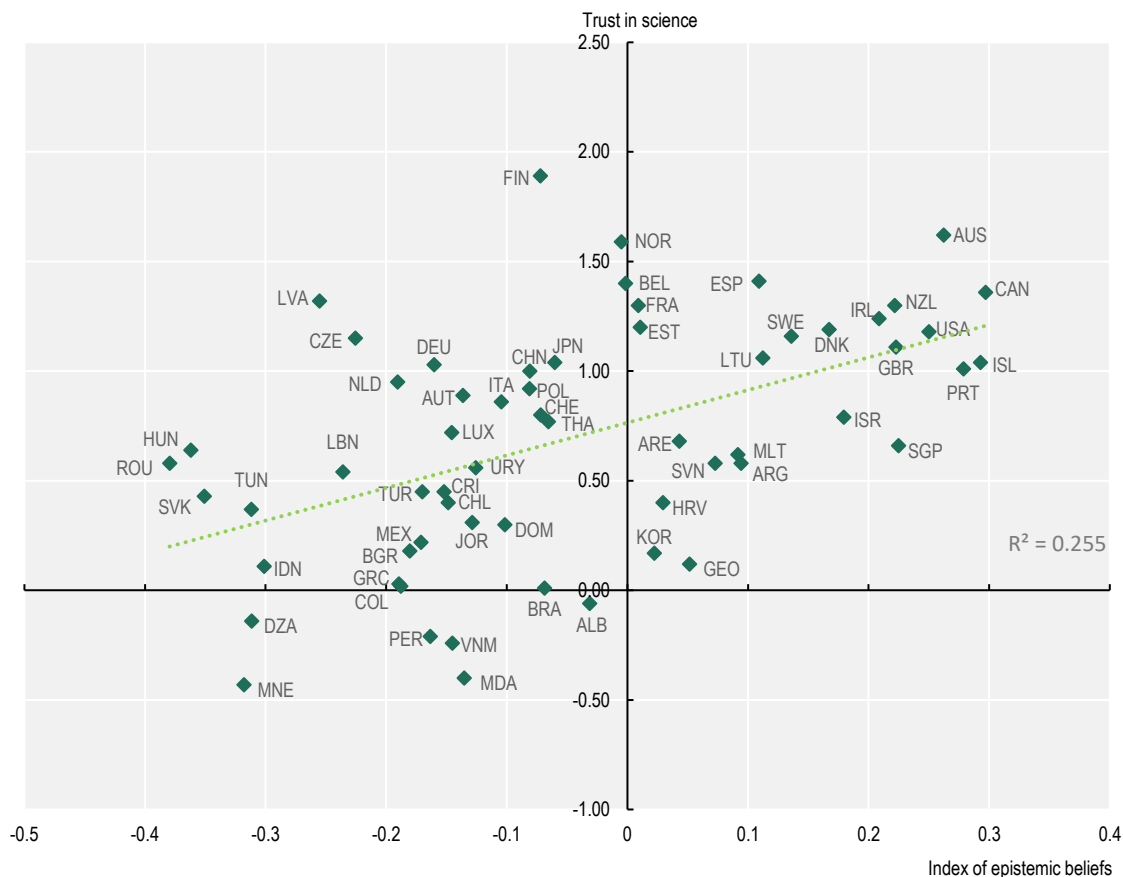
Note: Index of epistemic beliefs about science refers to the composite epistemic beliefs indicator reflecting the extent to which 15-year-old students agree with statements such as "Sometimes scientists change their minds about what is true in science", "Ideas in [broad science] sometimes change"; "Good answers are based on evidence from many different experiments"; "It is good to try experiments more than once to make sure of your findings"; "A good way to know if something is true is to do an experiment"; and "The ideas in [broad science] science books sometimes change". Countries are sorted in descending order in the index of epistemic beliefs. Trust in science refers to the composite trust in science indicator reflecting the extent to which adults reported trusting science and scientists in 2018.
Source: Calculations based on OECD (2015[65]), *PISA database 2015*, www.oecd.org/pisa/data/2015database/. Borgonovi and Pokropek (2020[74]), *Can we rely on trust in science to beat the COVID-19 pandemic?*, https://doi.org/10.31234/osf.io/yq287.

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Figure 5.14 uses data from the 63 countries with data on epistemic beliefs in science collected in the PISA 2015 study and estimates of excess mortality due to COVID-19 modelled by *The Economist* to illustrate the correlation between epistemic beliefs and adherence to pharmaceutical and non-pharmaceutical interventions that could lower excess mortality. While the first phase of the pandemic witnessed considerable discrepancies across countries in terms of knowledge gaps and accessibility to face masks, vaccines and other preventive measures to curb the virus spread among vulnerable populations, 2021 brought a relaxation of constraints on the adoption of pharmaceutical and non-pharmaceutical interventions in many countries. Figure 5.14 reveals that in countries where a larger share of young people before the pandemic indicated an understanding that scientific knowledge is tentative, as well as the validity

and limitations of empirical methods of enquiry as a source of knowing, fewer excess deaths due to COVID-19 in 2021 were recorded.

Figure 5.14. The cross-country association between trust in science and estimated excess mortality due to COVID-19 between the end of 2020 and the end of 2021

Trust in science and excess mortality between the end of 2020 and the end of 2021
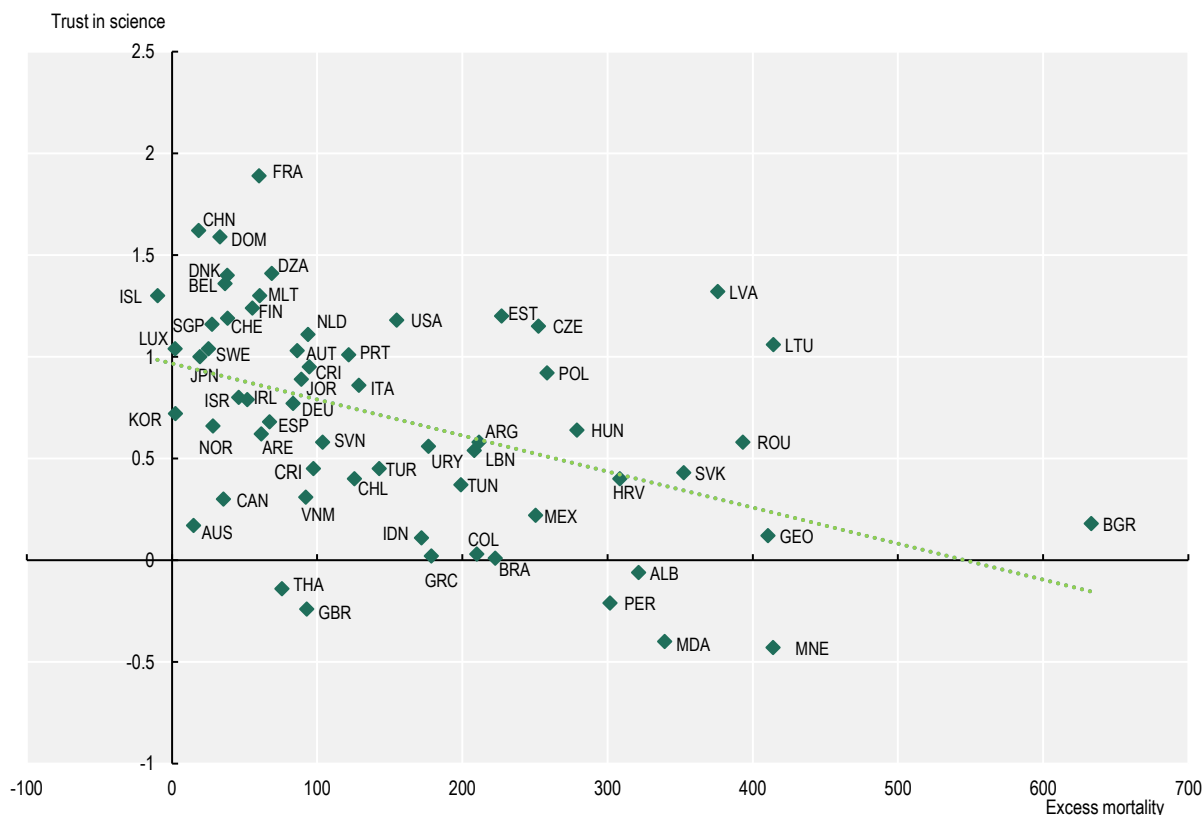
Note: Excess mortality refers to the percentage increase in all-cause mortality recorded in 2021 compared to the pre-pandemic period. Trust in science refers to the composite trust in science indicator reflecting the extent to which adults reported trusting science and scientists in 2018. Source: Wellcome Trust, (2018[73]), *Wellcome Global Monitor 2018*, https://wellcome.org/reports/wellcome-global-monitor/2018; Borgonovi and Pokropek, (2020[74]), *Can we rely on trust in science to beat the COVID-19 pandemic?*, https://doi.org/10.31234/osf.io/yq287; The Economist (2021[75]), "Tracking COVID-19 excess deaths across countries", www.economist.com/graphic-detail/coronavirus-excess-deaths-tracker.

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5.4. How much are young people being taught to deal with digital information?

In its 2018 round, PISA surveyed 15-year-old students to assess various methods young people have been taught to deal with digital information. On average, across OECD countries, 69% of 15-year-old students have been taught strategies on "how to decide whether to trust information from the Internet", with the highest percentage of students taught how to do this in Sweden (92%) and the lowest percentage in Poland (39%) (Figure 5.15). In addition, on average across OECD countries, 76% of 15-year-old students have been taught strategies on how "to understand the consequences of making information publicly available on line on Facebook, Instagram, etc." The highest percentage of students taught such strategies was in the United Kingdom (90%), and the lowest was in Korea (46%). On average, 54% of 15-year-old students in OECD countries have been taught strategies on "how to detect whether information is subjective or

biased". The United States has the highest percentage of students who have been taught strategies to deal with subjective or biased information (79%), while Latvia has the lowest percentage (38%). Finally, 41% of students aged 15 in OECD countries have been taught strategies on "how to detect phishing or spam emails". Malta has the highest percentage of students taught this (76%), whereas Norway has the smallest percentage of students taught such strategies (22%).

Figure 5.15. Countries in which young people are being taught strategies to deal with digital information, 2018
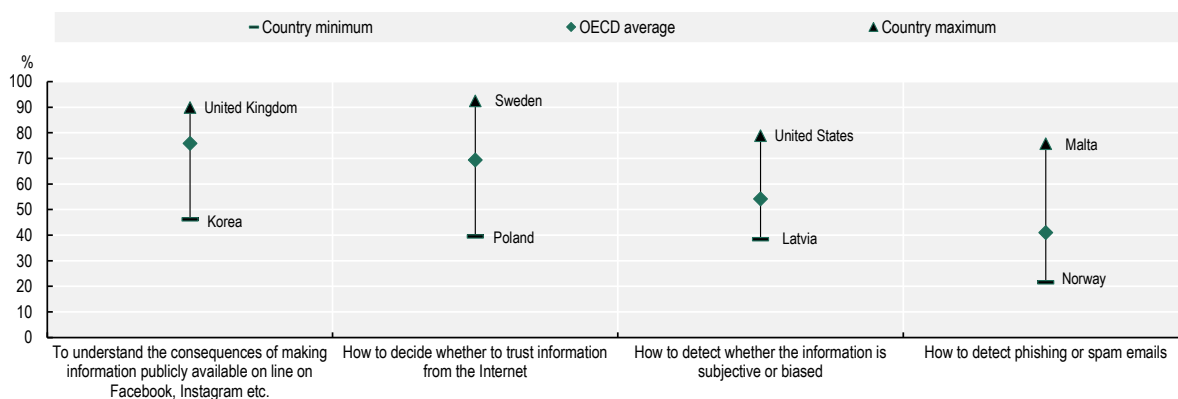
Note: The figure illustrates the percentage of students who reported having been taught different strategies to deal with digital information at school. Strategies are sorted in descending order of OECD average values.
Source: Calculations based on OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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Figure 5.16 shows the percentage of students aged 15 that have been taught strategies to deal with digital information by economic, social and cultural status (ESCS). On average, across OECD countries, 71% of 15-year-old students with high ESCS have been taught strategies on "how to decide whether to trust information from the Internet" versus 68% of students with low ESCS. In addition, 77% of 15-year-old students within the group with high ESCS have been taught strategies on "how to understand the consequences of making information publicly available on line on Facebook, Instagram, etc." versus 74% of students with low ESCS. Further, 58% of 15-year-old students within the group with high ESCS have been taught strategies related to detecting whether information is subjective or biased compared to 50% of 15-year-old students within the group with low ESCS. Finally, both the high and low ESCS groups had an equal percentage (41%) of 15-year-old students taught strategies for detecting phishing or spam emails.

Figure 5.16. Students' acquisition of strategies to deal with digital information, by economic, social and cultural status, 2018
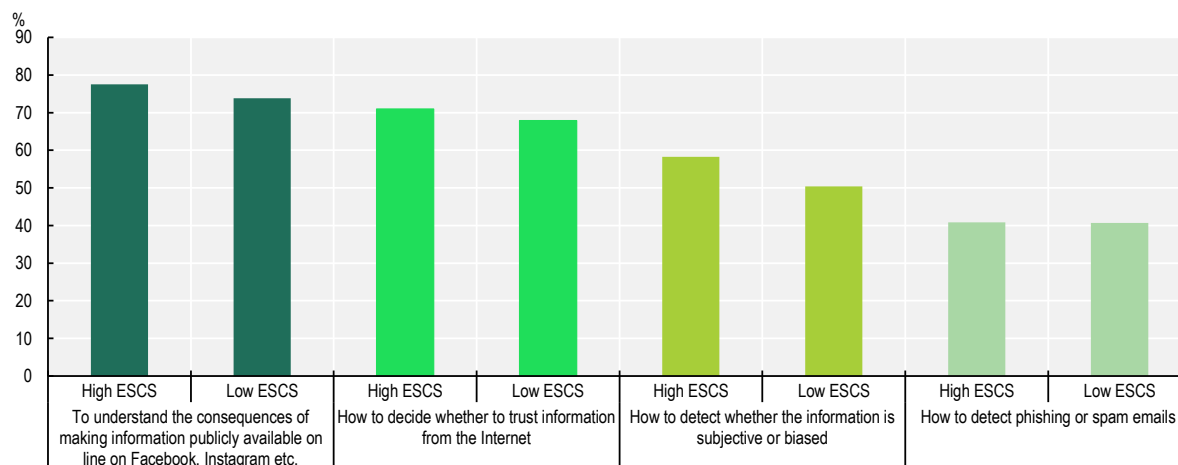
Note: The figure shows the percentage of students taught one of the strategies to deal with digital information by economic, social and cultural status (ESCS), as labelled above. Strategies are sorted in descending order of the percentage of "High ESCS" students being taught strategies. Students are categorised as High ESCS if they belong to the upper 25% of the ESCS distribution in their country, while they are categorised as belonging to the "Low ESCS" group if they belong to the bottom 25% of the distribution in their country.
Source: Calculations based on OECD (2018[67]), *PISA database 2018*, www.oecd.org/pisa/data/2018database/.

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5.5. Conclusions

With the rise of social media, the decline of traditional news outlets and the development of new deep-fake and AI-generative technologies, there has been a proliferation of information available to individuals around the world. However, the increased quantity of information available has not been accompanied by an increase in the quality of such information. Instead, there has been an increase in the amount of false or misleading information individuals are routinely exposed to due to the proliferation of misinformation, disinformation and malinformation. Most people in OECD countries worry about being exposed to false or misleading information.

The persistence of individuals' beliefs in false and inaccurate information can pose challenges in terms of changing those beliefs, leading to a breakdown of social cohesion and undermining the effectiveness of policy action, as exemplified during the pandemic. In fact, beliefs in false and inaccurate information can persist and even sometimes be reinforced when individuals are exposed to corrective information (Swire-Thompson, DeGutis and Lazer, 2020[76]). Given that beliefs in false or misleading information can persist and that we have entered what some have named a "post-truth" era, this chapter considered the extent to which individuals in OECD countries have developed some of the skills needed to reduce their vulnerability to false and misleading information. The chapter argues that alongside high levels of information-processing abilities, individuals will need high levels of metacognitive skills and an awareness of the limits of human cognition.

Mapping the distribution of these skills in the population is critical to empowering people and communities. On the one hand, identifying how many and who is most vulnerable can be used to target policy action. On the other hand, mapping the "scale of the problem" can be used to mobilise structural efforts to reduce exposure to false and misleading information and promote a high-quality information landscape. Even when individuals could theoretically use their skills to identify the source and veracity of information, doing

so systematically would be practically impossible for individuals. Implementing measures to enhance people's information-processing skills, such as utilising technology to clearly indicate the source of online information, similar to the traceability chain used for food products, would significantly empower information users.

The results reported in this chapter indicate that one in four students is at high risk of believing misinformation due to their excessive confidence in their information retrieval and inference skills, despite their low proficiency in reading. Similarly, almost one in three students with mathematics proficiency at Level 2 or below report knowing a concept in maths that does not exist. High levels of information-processing skills, such as high levels of reading, maths and science, should be accompanied by the habit (or skill) of critically evaluating one's understanding and knowledge when accessing complex information of variable quality on line. The large between-country variation in the share of young people who have low levels of information-processing skills but high levels of confidence in their abilities suggests that it is possible to reduce this source of vulnerability to low-quality information. Crucially, because individuals can both receive and actively participate in spreading information, reducing overconfidence can reduce both individual and broader societal vulnerabilities. Building people's information-processing skills should be accompanied by efforts to promote their ability to reflect critically on their understanding of complex information.

The data also reveal that on average, across OECD countries, 69% of 15-year-old students report having been taught strategies on "how to decide whether to trust information from the Internet"; 76% have been taught strategies on how "to understand the consequences of making information publicly available on line on Facebook, Instagram, etc."; 54% have been taught strategies on "how to detect whether the information is subjective or biased"; and 41% have been taught strategies on "how to detect phishing or spam emails". These results suggest that there is considerable room to further develop strategies to empower young people with the set of specific skills that could help them stop consuming and spreading false or misleading information.

Across OECD countries, many young people do not have a good understanding of the scientific process and the validity of different forms of information-gathering processes. In fact, as many as 21% of 15-year-old students indicate disagreeing or strongly disagreeing that sometimes scientists change their minds about what is true in science. Learning this lesson would develop trust in the changing position of science and scientists on specific facts. Trust is essential to any information and communication exchange.

Although a defining characteristic of trust is that trust is, *prima facie*, a source of vulnerability, trust should not be equated with gullibility. Trust, whether in science, interpersonal relationships, or governments and institutions, is based on the cognitive ability of individuals to discern the trustworthiness of particular individuals or institutions within specific contexts. Information-processing abilities empower people to perform better at the problem-solving tasks represented by information and communication exchanges, thus reducing the likelihood of misplaced trust (Borgonovi and Pokropek, 2022[77]). Knowing how the scientific process works is critical for individuals to understand why scientists can change their advice and recommendations when new evidence emerges that disproves previously held ideas. This, in turn, is critical to sustain and maintain trust in scientific information even though scientists may not agree with each other or may change their views over time.

Finally, analyses suggest that empowering individuals to become better users and producers of information would require abandoning a "fixed" view of individuals' skills and abilities and considering that individuals can differ in their capacity to deploy their skills in different situations and in response to environmental stimuli. This is critical because individuals are required to spend an increasing amount of time processing complex information off and on line. However, their ability to accurately process and use such information to perform different tasks declines as they grow tired and fatigued. Students and adults should develop an awareness of the fact that their proficiency is not fixed, but rather that it depends on their cognitive exhaustion and can depend on other circumstances they face in their environment. Building task

persistence should be a priority, but so should promoting awareness about fluctuations in information-processing abilities. Developing an awareness of when one's accuracy in processing information is high and when it is low is critical to ensuring that individuals are empowered to make decisions on consequential matters or perform difficult tasks when their cognitive abilities are at their highest (when they are refreshed and have taken a break).

Media literacy was identified as a key component to managing misinformation. However, addressing the societal challenge related to false and misleading content cannot be achieved through media literacy alone. Instead, the simultaneous combination of multiple "literacies" brought together under a clear framework is required for societies to function in a rapidly changing media environment (Jones-Jang, Mortensen and Liu, 2019[29]). Furthermore, media/digital/information literacy education is not a "silver bullet" to solving the disinformation challenge (Jang et al., 2018[78]). Literacy development is only a part of a broader suite of policies that can help countries respond to the threat of false and misleading information. Policy options must consider each country's social context, including differing legal systems, precedents and approaches to the protection of freedom of speech.

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Note

[1] Declines in levels of accuracy between the Survey of Adult Skills (PIAAC) and the PISA study cannot be compared because the two tests differ in terms of items as well as in test administration conditions. The PISA test is timed and lasts two hours, whereas the Survey of Adult Skills (PIAAC) is untimed (it is designed to last around 40 minutes, but participants can take as much time as they wish to complete the test). Results only for mathematics and science are considered for the PISA 2018 assessment, even though reading was the main domain due to the adaptive design adopted for the reading assessment.

6 Empowering through health literacy: Skills to navigate health information and make informed decisions

This chapter focuses on health literacy, a key skill individuals need to acquire in order to deal with the increasing complexity of the health-related information landscape. Health literacy is an important determinant of how much health-related knowledge and information individuals can acquire and how they use such knowledge and information to promote and maintain their health. The chapter maps individuals' health literacy levels in 15 OECD countries and the relevance of health literacy for health outcomes. It also presents initiatives developed by countries to promote health literacy and improve the quality of communication and information in the healthcare sector to ensure the sector adequately serves the needs of individuals with diverse levels of health literacy.

Key messages

Health literacy encompasses the knowledge, motivation and skills required to access, comprehend, assess and apply information to make informed decisions regarding healthcare, disease prevention and the enhancement of overall well-being over the life course. It has far-reaching consequences for individuals' ability to manage their health, use preventive services and take part in decision making regarding their health and well-being. At the societal level, health literacy impacts healthcare use, prevention and health promotion programmes, equity and social justice, as well as productivity. This chapter maps levels of self-reported health literacy in 15 OECD countries that took part in the European Health Literacy Population Survey 2019-2021 (HLS19), evaluates disparities in health literacy and identifies associations between health literacy and health outcomes.

The chapter also explores the policies and initiatives that Austria, Germany, Ireland and Portugal have implemented in recent years to promote health literacy among their populations and improve the capacity of healthcare systems to deliver information and services in ways that are better aligned with the capacity of communities to access, understand, appraise and apply such information.

Key empirical findings include:

- On average, across the 15 participating countries, 44% of respondents indicated that they would find it difficult or very difficult to judge the advantages and disadvantages of different treatment options. In addition, 42% indicated that they would find it difficult or very difficult to decide how to protect themselves from illness using information from the mass media, and 38% indicated that they would find it difficult or very difficult to find information on how to handle mental health problems. By contrast, only 8% indicated that they would find it difficult or very difficult to act on advice from their doctor or pharmacist.

- Differences in health literacy across socio-economic characteristics such as gender, age and level of education are minor. In contrast, more socio-economically deprived individuals tend to report lower levels of health literacy than those without financial deprivation.

- Individuals with higher levels of health literacy tend to engage in and adopt healthier lifestyles, such as consuming more fruits and vegetables and exercising more. They are also more likely to report being in good or very good health and are less likely to report suffering from at least one long-term illness or health problem; to have used emergency healthcare services in the two years preceding the survey; and to have used medical or surgical specialists. For example, a difference of 10 percentage points in the number of health-related tasks individuals perceive as very easy or easy is associated with a difference of around 1.4 percentage points in the likelihood of consuming fruit and vegetables, a 1.9 percentage-point difference in the likelihood of engaging in physical exercise, 2.4 percentage points in the likelihood of reporting being in good or very good health and 1.3 percentage points in the likelihood of suffering from a long-term illness or condition.

6.1. Introduction

Technology, such as health apps, wearable devices, and online health platforms, provides individuals with unprecedented access to health information and tools that allow them to monitor and manage their health and well-being. However, the effectiveness of these resources hinges on users' ability to comprehend, evaluate and apply the information they encounter. If individuals misinterpret health data or rely on inaccurate information, they can make wrong self-diagnoses, inadequate treatment adherence or

misguided health decisions. While technological developments in generative artificial intelligence might improve early disease detection and treatment options, they also run the risk of amplifying online misinformation, amplifying the importance for individuals to have the ability to critically evaluate and discern health information. In an era of rampant digital misinformation, individuals lacking strong health literacy skills are more susceptible to becoming the victims of false and misleading claims, potentially compromising their health and undermining the effectiveness of evidence-based medical practices.

Enhanced health literacy empowers individuals to make informed decisions about their health, enabling them to harness technology effectively. By comprehending medical terms, understanding treatment options and critically evaluating digital health information, individuals can optimise their engagement with technology-driven healthcare, leading to better health outcomes and improved overall well-being. In an era where technology increasingly intertwines with healthcare, cultivating strong health literacy has become an essential tool for navigating the intricate intersection of medicine and innovation.

Health literacy is an important determinant of how much health-related knowledge individuals can acquire, the behaviours they engage in, how healthy they are and how costly it is to promote and maintain one's health (Mancuso, 2009[1]). Individuals with low health literacy generally experience poorer health outcomes than those with higher health literacy (Berkman et al., 2011[2]). This has significant implications not only for individuals but also for societies directly due to healthcare expenditures and indirectly due to lower productivity and lower fiscal contributions (Mårtensson and Hensing, 2011[3]). Health literacy and its promotion have, therefore, become a public policy priority at both the national and international levels.

Until recently, many countries did not have formal policies related to the development of population-wide health literacy or were in the early stages of developing programmes (Heijmans et al., 2015[4]). However, the importance of health literacy as a key factor that can support public health is increasingly recognised. For example, the United States released the National Action to Improve Health Literacy in 2010, which "seeks to engage organizations, professionals, policymakers, communities, individuals, and families in a linked, multi-sector effort to improve health literacy" (Centers for Disease Control and Prevention, 2010[5]), and in 2021, Australia introduced the National Preventive Health Strategy 2021-2030 (Australian Government - Department of Health, 2021[6]).

At the international level, health literacy has gradually been included in international frameworks and global declarations. For instance, the need to improve health literacy was included in the World Health Organization's (WHO) Health 2020 European framework (WHO, 2013[7]), in the Shanghai Declaration (WHO, 2016[8]) and in the WHO's "Roadmap for Implementing Health Literacy Initiatives across Europe" (Schaeffer and Gille, 2021[9]; WHO, 2019[10]). In addition, at the 2017 OECD Health Ministerial meeting, ministers agreed that in order to make health systems more people-centred, "efforts are needed to address barriers to health literacy of the population" (OECD, 2017[11]). Furthermore, the WHO recognised the role played by health literacy in reducing the burden of non-communicable diseases and in accelerating progress towards the targets on non-communicable diseases in the Sustainable Development Goals and disseminated a large number of case studies and interventions aimed at promoting health literacy development for the prevention and control of non-communicable diseases (WHO, 2022[12]).

Policy makers' growing interest in how health literacy can be promoted and nurtured follows the publication of multiple studies revealing insufficient levels of health literacy in many countries (Schaeffer et al., 2021[13]). For example, studies found that in the United States, about half of adults have inadequate health-related literacy (Morrow et al., 2006[14]). In addition, a more recent health literacy survey conducted in the United States documented that "more than one-third of adults cannot determine the proper way to take prescription medicines based on typical instructions found on container labels" (Parker and Ratzan, 2010[15]). Data from the European Health Literacy Survey (HLS-EU), conducted in 2011, revealed that one in ten respondents had insufficient health literacy and almost one in two had limited health literacy in the eight EU member states surveyed (Sørensen et al., 2015[16]). Meanwhile, almost 60% of adults in Australia had low health literacy (Nakayama et al., 2015[17]). More broadly, an OECD study found that in 18 OECD

countries, at least one-third of the population has poor health literacy levels, and in 12 of those countries, that share is higher than half (Moreira, 2018[18]). The European Health Literacy Population Survey 2019-2021 (HLS19) report also notes that there are considerable variations in levels of general health literacy[1] across countries, indicating that health literacy is a contextual concept that must be measured individually at the country level (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]).

Yet, to date, no single survey exists that provides large-scale cross-country comparable measures of health literacy across all OECD countries. HLS19 (Pelikan et al., 2022[20]) is the first multinational standardised study that uses standardised instruments across countries and establishes a framework to conduct comparisons over time (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]). At the same time, the variety of sampling and data collection procedures used in HLS19 means that country comparisons should be interpreted with caution. Cross-country comparisons remain limited, and there is not yet a "gold standard" to measure health literacy (Moreira, 2018[18]). For example, in Australia, Canada and the United States, health literacy is calculated using proxies from general skills surveys, while many European countries rely on the HLS-EU (Moreira, 2018[18]).

6.2. What is health literacy?

Having high levels of health literacy means that an individual knows when and where to seek help and has the ability to understand healthcare providers' instructions and explanations regarding their health conditions and treatment options (Mancuso, 2009[1]; Mårtensson and Hensing, 2011[3]). It also means that an individual has the skill set necessary to navigate and adequately use complex healthcare systems (Griese et al., 2020[21]; 2022[22]; Parker and Ratzan, 2010[15]; Sørensen et al., 2015[16]). In addition, being health literate enables people to make decisions concerning their healthcare options, disease prevention and ways in which they would like to maintain or improve their health throughout their lives (Heijmans et al., 2015[4]).

Several formal definitions of health literacy exist. In this report, the definition put forth by Sørensen and colleagues in 2012 was adopted. Sørensen and colleagues (2012[23]) conducted a systematic review of the literature and existing definitions to identify the central health literacy dimensions. This definition is, therefore, inclusive and comprehensive. Furthermore, this definition was the basis of the framework that guided data collection on health literacy in OECD countries as part of the HLS19, a project of the WHO Action Network on Measuring Population and Organizational Health Literacy (M-POHL) (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]).

Thus, health literacy, for the purposes of this report, is "the **knowledge, motivation and competences** to **access, understand, appraise and apply** health information in order to **make judgements and take decisions** in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life throughout the course of life" (Sørensen et al., 2012[23]).

According to this definition, health literacy is characterised by four dimensions relevant for healthcare, disease prevention and health promotion. The first is **access**, which reflects individuals' ability to search for and obtain health information. The second is **understand**, which reflects individuals' ability to make sense of the health information they have at their disposal. The third is **appraise**, which describes the ability to evaluate and interpret health information. The fourth is **apply**, which reflects the ability to communicate and use such information to make an informed decision in order to maintain and improve health (Sørensen et al., 2012[23]) (Figure 6.1).

Understood as a relational concept (Parker, 2009[24]; Parker and Ratzan, 2010[15]), health literacy does not only emerge from personal skills and abilities but in conjunction with the availability, comprehensibility, accessibility and practicability of health-related information, communications and offers.

Figure 6.1. Health literacy components

Reflects individuals' ability to search and obtain health information

Access

Health literacy components

Understand

Reflects individuals' ability to make sense of the health information they have at their disposal

Describes the ability to evaluate and interpret health information

Appraise

Apply

Reflects the ability to communicate and use such information to make an informed decision in order to maintain and improve health

6.3. Health literacy matters

Health literacy has several consequences for individuals and societies. At the individual level, health literacy has far-reaching consequences for individuals' ability to participate in the self-management of their health problems, preventive care, health promotion and healthcare decision making. At the societal level, health literacy impacts healthcare use, prevention and health promotion programmes, equity and social justice, as well as productivity.

6.3.1. Health literacy supports individuals' self-management, use of preventive care and decision making

Limited levels of health literacy are related to poorer adherence to medication regimens (Baker, 2007[25]), a lower ability to take medications appropriately, poorer ability to interpret labels and health messages (Berkman et al., 2011[2]), and missed doctor visits (Mancuso, 2009[1]; Mårtensson and Hensing, 2011[3]). This is particularly problematic in the management of chronic conditions such as hypertension, diabetes and acute respiratory conditions, which require self-management on a day-to-day basis or during acute episodes (Baker, 2007[25]; Paasche-Orlow and Wolf, 2007[26]; Schaeffer, 2017[27]).

Individuals with low levels of health literacy also use fewer preventive services than individuals with higher health literacy (Kim and Xie, 2017[28]). For example, studies find that individuals with low levels of health literacy are less likely to take part in recommended screenings (Herndon, Chaney and Carden, 2011[29]) and vaccinations (Baker, 2007[25]; Berkman et al., 2011[2]; The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]) and to delay seeking medical care because they do not understand preventive care and/or are unaware of the symptoms that require action (Paasche-Orlow and Wolf, 2007[26]). Individuals with limited health literacy experience greater difficulty taking part in shared decision making when interacting with healthcare professionals than individuals with higher levels of health literacy (Seo et al., 2016[30]). The lack of shared decision making may be especially consequential in situations where medical professionals' biases may lead them to provide varying levels of care to different patients. In fact, different levels of care by gender and ethnic status have been documented.

Higher levels of general health literacy are also important for health promotion, which refers to the "ability to regularly update oneself on determinants of health in the social and physical environment, to understand health-related information and derive meaning, to interpret and evaluate information on determinants of

health in the social and physical environment, and to make informed decisions on health determinants in the social and physical environment, and also engage in joint action" (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]).

6.3.2. Health literacy benefits society

The literature indicates that individuals with high health literacy make greater use of preventive services and engage more often in the self-management of chronic conditions, leading them to seek care only when the symptoms of diseases make such contact unavoidable (Weiss and Palmer, 2004[31]). This makes treatment regimens more expensive and prolonged and could potentially result in the development of longstanding and limiting conditions, which could lead to excessive human and financial resources being allocated to healthcare (Rondia et al., 2019[32]). In fact, evidence from the United States suggests that low levels of health literacy lead to unnecessary resource utilisation and expenditure (Rasu et al., 2015[33]), costing the healthcare system between USD 106 billion to USD 236 billion annually (Vernon et al., 2007[34]).

Lower participation in preventive screenings among individuals with lower levels of health literacy can mean that individuals may involuntarily put the broader community as well as themselves at risk (Van den Broucke, 2014[35]). Similarly, individuals with low levels of health literacy could transmit infectious diseases, such as COVID-19, by failing to wash their hands or wearing a face mask, failing to remain at home when they have symptoms or failing to respect other protective behaviours. A recent study in Ireland found that young people who had sufficient levels of health literacy about COVID-19 and the way the disease was transmitted adhered to most precautionary measures (Griebler, Dietscher and Flaschberger, 2022[36]; Nearchou et al., 2022[37]). Similarly, a study from Portugal shows that higher levels of health literacy were associated with better attitudes towards COVID-19 preventive strategies (Silva and Santos, 2021[38]).

Health literacy also impacts productivity and, thus, economic growth. By promoting health, health literacy enhances productivity (Sørensen et al., 2012[23]), and estimates suggest that at the population level, health problems and limitations reduce productive capacities by about 5-8% of gross domestic product (GDP) depending on the country (Llena-Nozal, Martin and Murtin, 2019[39]).

6.4. Factors that shape the development of health literacy and how well health literacy translates into health

A number of factors shape the likelihood that individuals will accumulate health literacy and how effectively health literacy will promote individuals' health and well-being. These include information-processing skills, individual background characteristics and contextual factors.

6.4.1. Information-processing skills

Information-processing skills are crucial precursors of health literacy. For example, skills such as **reading literacy and numeracy skills** are necessary if individuals are to be able to read medicine labels, information pamphlets, appointment slips, and insurance and consent forms. In fact, studies have found that improving individuals' health literacy and subsequent health status is dependent on individuals reaching minimum standards of general literacy (Quaglio et al., 2016[40]). At the same time, health literacy is a key bridge between an individual's general literacy skills and their health context (Nielsen-Bohlman, Panzer and Kindig, 2004[41]). In addition to reading literacy and numeracy skills, individuals need **oral communication skills** (speaking and listening abilities) (Cavanaugh, 2011[42]; Jain and Green, 2016[43]; Oxley, 2009[44]) as well as **comprehension skills** so that they can describe their symptoms, ask appropriate follow-up questions and accurately interpret the information and instructions shared with them (Mancuso, 2008[45]). **Critical thinking, analysis, decision making, problem solving**, and **the ability to seek guidance** are also skills that underpin health literacy (Mancuso, 2008[45]; Speros, 2005[46]; Wilson, 2001[47]).

6.4.2. Individual factors

Disparities in health literacy exist between individuals from different socio-economic and demographic backgrounds.

Older individuals tend to have lower levels of health literacy (Baker et al., 2002[48]; Berens et al., 2016[49]; Kutner et al., 2006[50]; Vogt, Schaeffer and Berens, 2019[51]; Zamora and Clingerman, 2011[52]) and suffer more negative consequences when they lack health literacy because they are more likely to take medications and interact with health services (Quaglio et al., 2016[40]); are more likely to live with chronic diseases and health-related demands; and may experience other difficulties when dealing with healthcare systems. Therefore, older individuals, i.e. individuals who in general have the greatest healthcare needs, are also the ones that are the least prepared to navigate the healthcare system. In fact, there is evidence that health literacy may be lowest among individuals aged 65 or older and that a rapid decline in health literacy skills starts after the age of 55 (Manafo and Wong, 2012[53]).

This could be because being health literate involves certain cognitive skills that become increasingly challenged as one ages, especially as age-related conditions such as dementia increase (Manafo and Wong, 2012[53]; Oxley, 2009[44]). Furthermore, older people tend to process and learn information more slowly (Speros, 2009[54]). They also have less working memory, experience greater difficulty handling multiple bits of information at one time, and have a harder time completing tasks that require inference or reasoning (Speros, 2009[54]). With age, individuals also experience declines in their vision, hearing and mobility, which can directly affect how they gather and process information and prevent them from carrying out the necessary measures needed to manage their health (Speros, 2009[54]). At the same time, difficulties in dealing with a healthcare system may become more visible when demands in this regard increase.

Studies also reveal that women have, on average, higher levels of health literacy than men (Bazrafkan et al., 2018[55]; Kutner et al., 2006[50]; Van der Heide et al., 2013[56]). The health literacy gap between men and women could be a result of women's increased familiarity with navigating the healthcare system, given that women tend to report more health issues and use healthcare services more often than men (Bertakis et al., 2000[57]; Kalseth and Halvorsen, 2020[58]; Lee, Lee and Kim, 2014[59]) and/or because women have traditionally had caregiver roles (whether of children or elderly relatives) and thus have had more contact with the healthcare system (Lee, Lee and Kim, 2014[59]; Sudore et al., 2006[60]). Finally, women may develop higher levels of health literacy as a response to the fact that healthcare professionals treat men and women differently, are less likely to involve women in decision making, and are more likely to discount their reports of ailments (Criado Perez, 2019[61]; Samulowitz et al., 2018[62]).

Health literacy is also higher among individuals with higher levels of educational attainment because of the greater cognitive, economic and social resources individuals with higher levels of educational attainment possess (Morrow et al., 2006[14]; Quenzel, 2017[63]; Kutner et al., 2006[50]; WHO, 2013[64]; Van der Heide et al., 2013[56]). In addition, studies have identified differences in health literacy across ethnic and income groups, differences that can, in part, explain disparities in health outcomes across such groups (Chaudhry et al., 2011[65]; Kutner et al., 2006[50]; Schillinger, 2020[66]; Sentell and Halpin, 2006[67]; Sørensen et al., 2015[16]; Van der Heide et al., 2013[56]).

6.4.3. Contextual factors

Socio-economic and demographic characteristics influence a person's health literacy and can help a person navigate their healthcare context, but the ability to use a healthcare system and understand healthcare information also depends on context, including the way in which information is communicated (Griese, Schaeffer and Berens, 2022[68]; Moreira, 2018[18]; Rondia et al., 2019[32]). Health literacy is a shared responsibility that emerges from the interaction of individuals' skills and the demands of healthcare systems (Sørensen et al., 2012[23]).

Understanding and addressing health literacy is important as people are faced with more health information than ever before (Nielsen-Bohlman, Panzer and Kindig, 2004[41]). People can now obtain information from national media, the Internet, social media, healthcare providers or health education. In addition, people are able to access diverse health information and, more worryingly, health misinformation in a variety of ways (Nakayama et al., 2015[17]). Recent research on COVID-19 and health literacy in Japan found that low levels of health literacy are associated with high susceptibility to misinformation (Cheng and Nishikawa, 2022[69]).

Furthermore, chronic diseases require complicated self-management regimens, thus shaping the importance for societies to invest in health literacy and the specific demands that individuals and healthcare systems face (WHO, 2022[12]). Changes in the information landscape and in the incidence of chronic diseases have occurred at a time in which there has been an increased push for more consumer-driven care, and as a result, individuals must play a more active role in managing their health (Rondia et al., 2019[32]; Weishaar et al., 2019[70]), such as seeking out information, understanding rights and responsibilities and making health decisions (Nielsen-Bohlman, Panzer and Kindig, 2004[41]). The underlying assumption behind these demands and responsibilities is that people have the knowledge and skills to be active agents and decision makers in their health context. However, studies reveal that there is a "mismatch" between people's health literacy skills and the demands of health systems: many health-related materials, such as consent forms and medication instructions, often exceed the reading skills of the average high-school graduate (Nielsen-Bohlman, Panzer and Kindig, 2004[41]).

6.5. Disparities in health literacy within and across countries

This section aims to compare self-reported health literacy levels across countries and sheds light on disparities. While large-scale assessments or surveys allow for cross-country comparison of various skills, cross-country comparison of health literacy remains limited. To allow comparison across a broad range of countries, this section draws on information obtained from the HLS19, a cross-sectional multi-centre survey that was conducted in 17 countries between November 2019 and June 2021 (15 of them OECD countries) (information on sampling and the target population can be found in The HLS19 Consortium of the WHO Action Network M-POHL (2021[19])).

Health literacy was measured in the HLS19 by asking participants to indicate how easy or difficult they found performing a series of 12 general health literacy tasks. Answers were based on a four-point Likert scale with the following options: "very easy", "easy", "difficult" and "very difficult". This information was also combined into a **health literacy score** of items with valid responses that were answered to be "very easy" or "easy". The health literacy score ranges from 0 to 100, with higher numbers denoting a higher level of health literacy (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]). Thus, the scores measure health literacy as the percentage of health-related tasks experienced as "very easy" or "easy" by a respondent. A detailed description of survey instruments and technical details on administration, implementation and scaling is available in the technical chapters of the HLS19 report (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]).

Two caveats need to be considered when evaluating results. First, although data collection was originally planned for 2019-20, this had to be extended and adjusted due to the COVID-19 pandemic. Only data collection for Germany was completed before the pandemic began. All other participating countries started or completed data collection during the pandemic, which reached different intensity levels at different times in different countries. Tables 2.15, 2.16, 2.17 and 2.18 in the HLS19 International Report (The HLS19 Consortium of the WHO Action Network M-POHL, 2021[19]) detail data collection instruments and dates for participating countries. As a result, country comparisons of HLS19 data should be interpreted with caution. Figure 6.2 shows the percentage of respondents across the 15 countries who reported that it would be "very difficult" or "difficult" to perform 12 health literacy tasks, as well as the country with the highest and

lowest shares. Second, results reflect self-reports of participants rather than whether participants in the study were able to complete health literacy tasks or not.

Figure 6.2. Percentage of respondents who responded "very difficult" or "difficult" when asked to rate performing 12 health literacy tasks, selected OECD countries, 2019-20

HLS19-Q12 items, by country
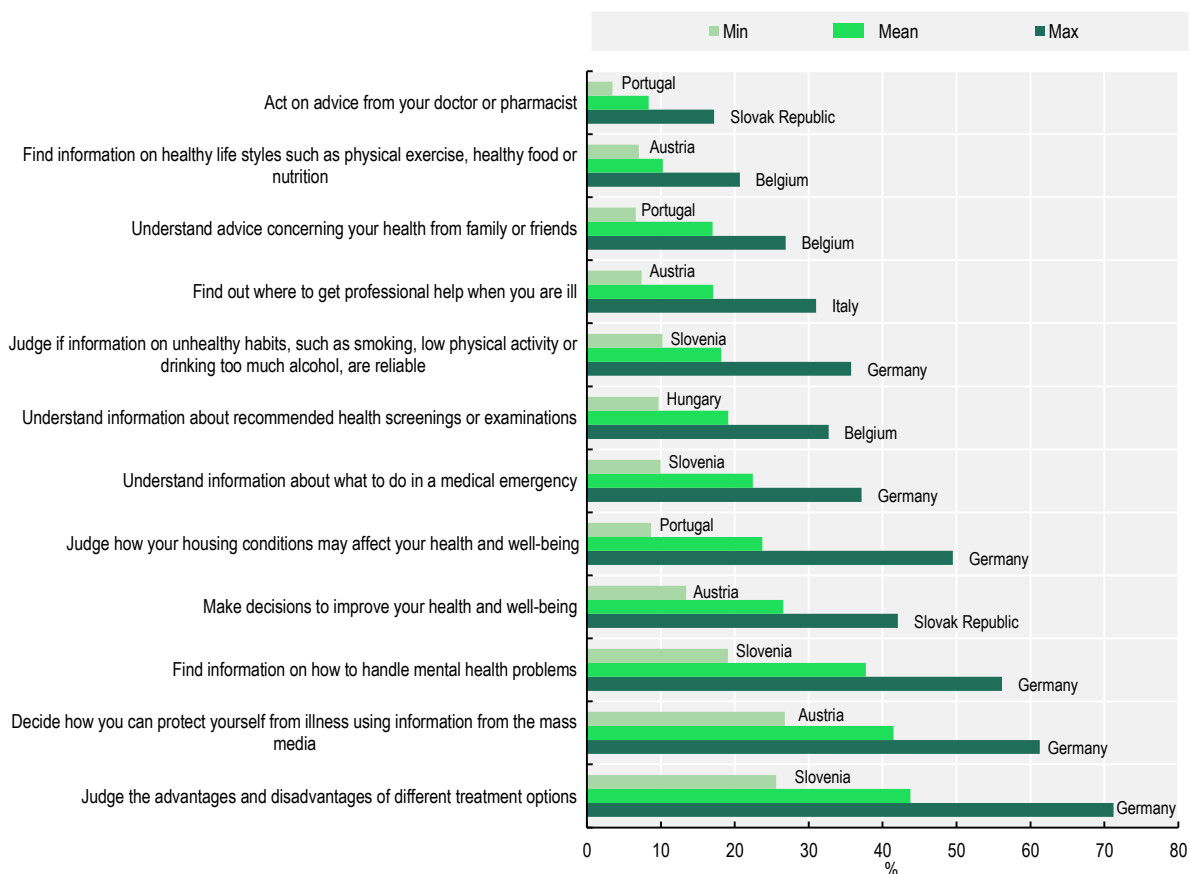
Note: The figure illustrates the percentage of respondents who responded that they would find it "very difficult" or "difficult" to perform each of the 12 tasks that were part of the core health literacy assessment instrument. The middle bar indicates the HLS19 OECD average, while the long (short) bars indicate for each task, the percentage of respondents who indicated that they would find "very difficult" or "difficult" to perform each of the 12 tasks in the country where this percentage was highest (and lowest). Due to the wide variety of sampling and data collection procedures across countries, country differences should be interpreted with caution.
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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On average, individuals found it most difficult to "judge the advantages and disadvantages of different treatment options" (44%); "decide how you can protect yourself from illness using information from the mass media" (42%); and "find information on how to handle mental health problems" (38%). In Germany, as many as 71% of respondents indicated that they would find it "very difficult" or "difficult" to judge the advantages and disadvantages of different treatments compared to 26% of respondents in Slovenia. Similarly, 61% of respondents in Germany found deciding how one can protect oneself from illness using information from the mass media" to be "very difficult" or "difficult", compared to 27% of respondents in

Austria. Of the 15 countries, Germany also had the highest share of respondents who indicated that they would find "very difficult" or "difficult" (56%) to find information on how to handle mental health problems, while Slovenia had the lowest share of respondents (19%). In contrast, individuals generally found it least difficult to "act on advice from your doctor or pharmacist" (8%); "find information on healthy lifestyles such as physical exercise, healthy food or nutrition" (10%); and "understand advice concerning your health from family or friends" (17%).

Individual responses were used to derive a composite health literacy score. Table 6.1 reveals that, on average, respondents in the countries with available data experienced 76.3% of the health literacy tasks they were presented with to be "very easy" or "easy". Levels of health literacy vary. In Slovenia, Portugal and Austria, on average, participants experienced 86%, 85% and 85% of the health literacy tasks as "very easy" or "easy". By contrast, in Italy, Belgium and Germany, on average, participants experienced 69%, 66% and 65% of the tasks as "very easy" or "easy". However, country comparisons of HLS19 data should be interpreted with caution due to the above-mentioned limitations.

Table 6.1. Mean score values of health literacy proficiency, selected OECD countries, 2019-20

Percentage of HLS19-Q12 items that respondents found to be easy or very easy

Country	Mean (%)
Austria	85
Belgium	66
Switzerland	77
Czech Republic	76
Germany	65
Denmark	77
France	78
Hungary	80
Ireland	79
Israel	73
Italy	69
Norway	79
Portugal	85
Slovenia	86
Slovak Republic	70
HLS19 OECD average	76

Note: Due to the wide variety of sampling and data collection procedures across countries, country comparisons and comparisons with the HLS19 OECD average should be interpreted with caution.
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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6.5.1. Disparities in levels of health literacy

Figure 6.3 suggests that men and women have broadly similar levels of health literacy across the 15 HLS19 OECD countries with data available. For example, 84% of male respondents in Austria perceived health literacy tasks as "very easy" or "easy" compared to 85% of female respondents. Similarly, 77% of male and female respondents in France and Switzerland perceived health literacy tasks as "very easy" or "easy".

Figure 6.3. Mean score values of health literacy proficiency by gender, selected OECD countries, 2019-20

Note: The figure illustrates the health literacy index by gender in each of the HLS19 OECD countries. Specifically, the figure illustrates the percentage of male and female respondents who perceived health literacy tasks as "very easy" or "easy".
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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By contrast, Figure 6.4 suggests that health literacy differs across individuals with varying levels of financial deprivation. Financial deprivation was calculated by summarising the scores of respondents on the following three questions: "How easy or difficult is it usually for you to afford medication if needed?", "How easy or difficult is it usually for you to afford medical examinations and treatments if needed?" and "How easy or difficult is it for you to pay all bills at the end of the month?" The response categories were "very easy", "easy", "difficult", and "very difficult".

On average, individuals with no or some financial deprivation perceived 79% of the health literacy tasks as "very easy" or "easy", whereas individuals with considerable or severe financial deprivation considered 68% of the health literacy tasks as "very easy" or "easy". In Slovenia, respondents with no or some financial deprivation perceived 90% of the health literacy tasks as "very easy" or "easy", while in Austria, Hungary, Ireland, and Portugal, individuals with no or some financial deprivation perceived slightly more than 80% of the health literacy tasks as "very easy" or "easy". In Slovenia, respondents with considerable or severe financial deprivation perceived 80% of the health literacy tasks as "very easy" or "easy". Individuals with considerable or severe financial deprivation in Austria, the Czech Republic, Denmark, France, Hungary, Ireland, Portugal and Switzerland perceived two-thirds of the health literacy tasks as "very easy" or "easy". Again, country comparisons of HLS19 data should be interpreted with caution due to the above-mentioned limitations.

Figure 6.4. Mean score values of health literacy, by levels of financial deprivation, selected OECD countries, 2019-20
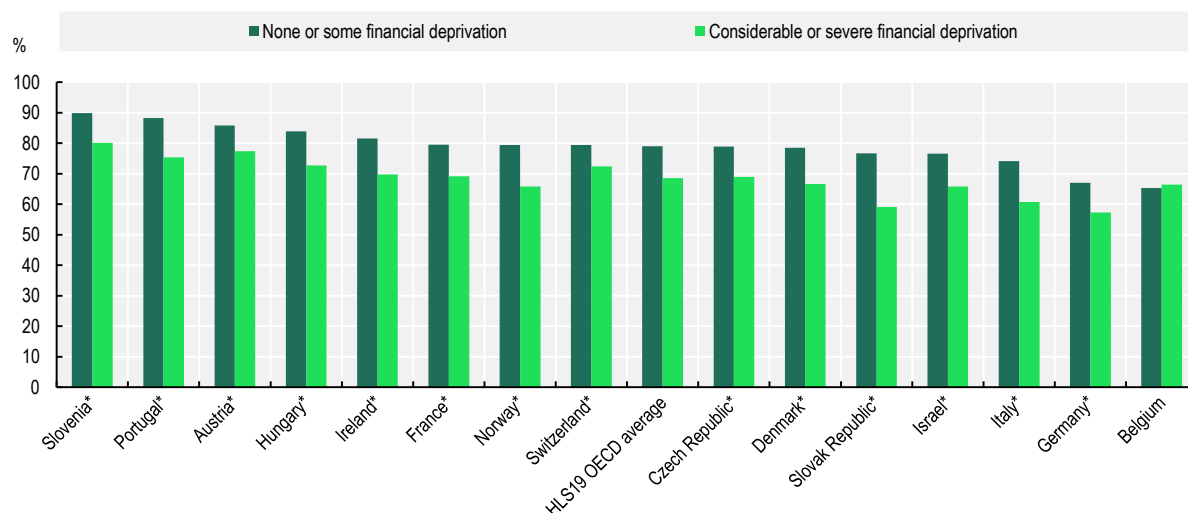
Note: The figure shows the percentage of respondents who perceived health literacy tasks as "very easy" or "easy", depending on their financial deprivation. Financial deprivation was calculated by summarising the scores of respondents who answered "very difficult" or "difficult" to the following three questions: "How easy or difficult is it usually for you to afford medication if needed?", "How easy or difficult is it usually for you to afford medical examinations and treatments if needed?" and "How easy or difficult is it for you to pay all bills at the end of the month?" The dark green bars represent the percentage of respondents who experience none or some financial deprivation, whereas the light green bars represent the percentage of respondents who experience considerable or severe financial deprivation. The asterisk (*) means that the differences in mean levels of health literacy between those who have none or some financial deprivation and those who have considerable or severe financial deprivation are statistically significant at the 5% level. Due to the wide variety of sampling and data collection procedures across countries, country comparisons should be interpreted with caution.
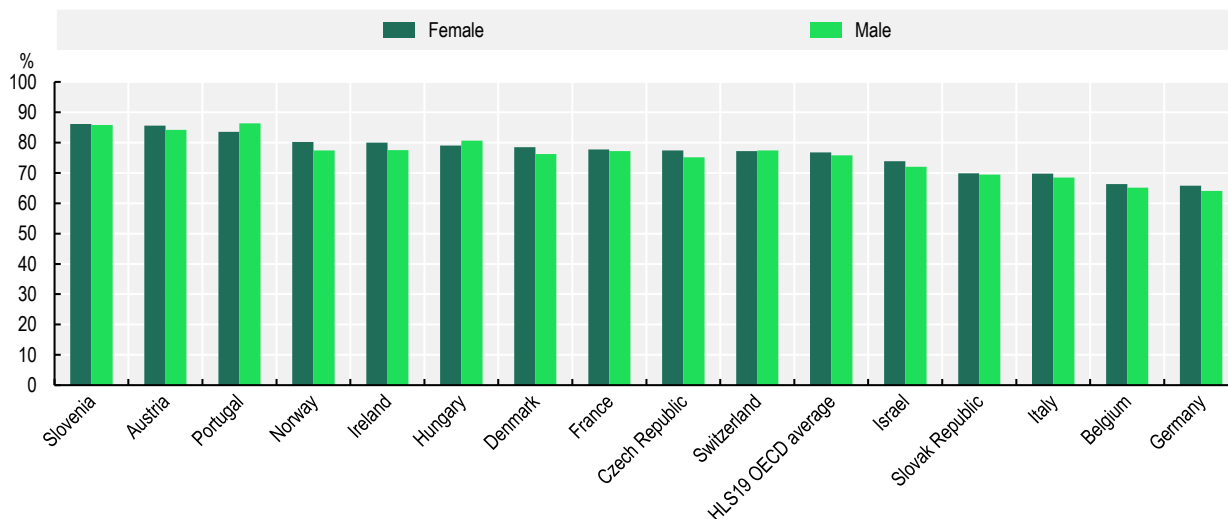
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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Differences in health literacy across individuals with different levels of educational attainment are generally small. Figure 6.5 indicates that, on average, 73% of the health literacy tasks were perceived as "very easy" or "easy" among individuals with at most a lower secondary education degree; 76% among individuals with an upper secondary degree; and 78% among individuals with a post-secondary or a short-cycle tertiary programme degree as well as individuals with a tertiary degree. In HLS19, educational attainment was measured using the International Standard Classification of Education (ISCED) scale, which also incorporates professional experiences. It could be that other measures like, e.g. years in education, would have yielded slightly different results. The finding that health literacy differs depending on whether individuals face financial deprivation or not but not depending on their educational qualifications could reflect the fact that although health literacy is correlated with academic skills, it is a different construct which has not been prioritised in formal education. Individuals who experience financial deprivation may have fewer opportunities than those who have not had the opportunity to invest in the acquisition of health literacy over the life course.

Figure 6.5. Mean score values of health literacy, by educational attainment, selected OECD countries, 2019-20
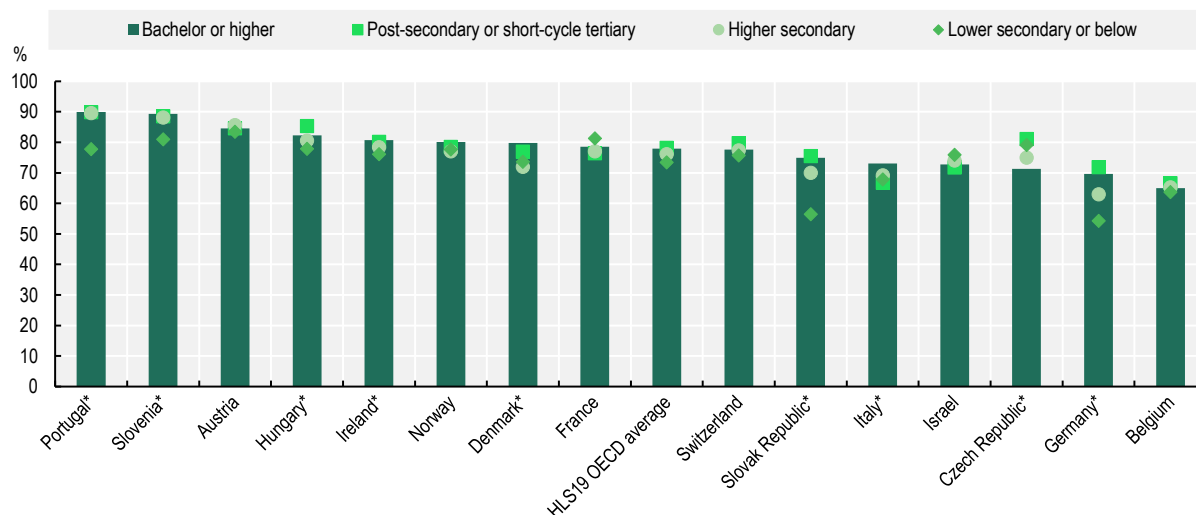
Note: The figure shows the percentage of respondents who perceived health literacy tasks as "very easy" or "easy", depending on their educational attainment. Education attainment was measured using the ISCED. The green diamond represents the percentage of respondents that completed lower secondary or below. The light green circles represent the percentage of respondents who completed higher secondary. The green squares represent the percentage of respondents who completed post-secondary or short-cycle tertiary. The dark green bars represent the percentage of respondents who completed either lower secondary or below. The asterisk (*) means that the differences in the mean level of health literacy based on educational attainment are statistically significant at the 5% level. Due to the wide variety of sampling and data collection procedures across countries, country comparisons should be interpreted with caution.
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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Figure 6.6 indicates that the mean score values of health literacy do not differ greatly across age groups. On average across HLS19 OECD countries, 76% of the health literacy tasks were perceived as "very easy" or "easy" among 18-35 year-olds; 77% among 36-75 year-olds; and 74% among more mature individuals.

Figure 6.6. Mean score values of health literacy by age in selected OECD countries, 2019-20
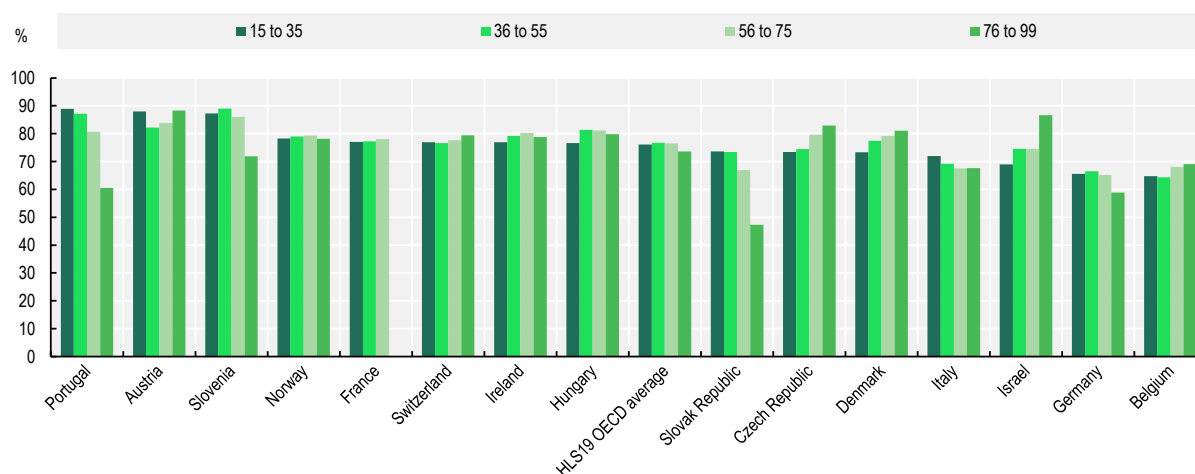
Note: The figure illustrates the percentage of respondents in an age bracket who perceived health literacy tasks as "very easy" or "easy". Age was measured in years but grouped into four categories. Each bar represents an age bracket, starting with 15-35, followed by 36-55, then 56-75, and finally 76 and older. Due to the wide variety of sampling and data collection procedures across countries, country comparisons should be interpreted with caution.

Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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Box 6.1. Health Literacy in selected Asian and Latin American countries

Instruments used in the HLS19 produced by HLS-EU have been used in Japan to compare health literacy levels in the country to those observed in the European context (Nakayama et al., 2015[17]). In line with Europe, levels of general health literacy in Japan predicted health status even after controlling for gender, age group, education, income, occupation, self-assessed living conditions and municipality size (Nakayama et al., 2015[17]). However, analyses revealed that although Japan is one of the countries with the longest life expectancy in the world, health literacy in the Japanese population is lower than in Europe, with Japanese respondents rating all test items as more difficult than European respondents: Japanese respondents found 22% more tasks to be difficult or very difficult than their European counterparts (Nakayama et al., 2015[17]). The difference in health literacy levels between Japan and European countries was attributed to the greater difficulty in accessing reliable and understandable health information in Japan because of the lack of a comprehensive national platform to aid individuals in locating information about treatments and illnesses (Nakayama et al., 2015[17]).

In Latin America, few studies have been conducted on health literacy. When such studies are conducted, they use different surveys and differ in terms of target population, sampling and instruments to assess health literacy levels, all of which reduce cross-country comparability. Therefore, there is considerable variation in estimates of levels of health literacy in the population, ranging between 5.0% and 73.3% (Arrighi et al., 2021[71]). In Mexico, for example, Mávita-Corral and colleagues conducted a cross-sectional study using the European Health Literacy Survey Questionnaire produced by the HLS-EU. The questionnaire was administered to a sample of 477 individuals that included students, academics and administrative staff. The study found that 9% of individuals had excellent health literacy;

40% had sufficient levels of health literacy; 43% had problematic levels of health literacy; and 8% had inadequate health literacy levels (Mávita-Corral, 2017[72]; Nakayama et al., 2015[17]). In Argentina, by contrast, a random sample of patients in a University Hospital was assessed and interviewed using the Short Assessment of Health Literacy for Spanish-speaking Adults. The Short Assessment of Health Literacy is a validated health literacy assessment tool containing 50 items designed to assess a Spanish-speaking adult's ability to read and understand common medical terms (Agency for Healthcare Research and Quality, 2022[73]), which is based on the Rapid Estimate of Adult Literacy in Medicine (REALM) tool (Lee et al., 2006[74]). The study found that about 30% of patients had inadequate health literacy levels (Konfino et al., 2009[75]). In Brazil, Coelho and colleagues assessed functional health literacy, which they define as the "degree to which individuals can obtain, process, and understand basic information and services necessary for making appropriate health-related decisions" (Coelho et al., 2014[76]). They measure functional health literacy using the Brief Test of Functional Health Literacy in Adults, which is a shortened version of the Test of Functional Health Literacy (TOFHLA) – another tool that was developed to screen levels of health literacy and that divides people into categories with low or high levels of health literacy (Sørensen et al., 2013[77]). The Brief Test of Functional Health Literacy in Adults was administered to patients in two Brazilian public hospitals in 2009. The study found that 58% of patients had inadequate functional health literacy (Coelho et al., 2014[76]). In addition to the test, the researchers conducted two dialogue rounds with the patients with adequate functional health literacy (Group 1) and inadequate functional health literacy (Group 2) in order to evaluate each group's understanding of food serving sizes. Overall, those with inadequate functional health literacy had greater difficulty understanding the food guide. Such findings demonstrate that low levels of health literacy can impact self-management and awareness of how to lead a healthy life more broadly.

In the United States, a literacy assessment conducted by the US Department of Education found that nearly 90% of US adults are not proficient in reading, understanding and acting on medical information. More specifically, according to the survey, "one in three patients has 'basic' or 'below basic' health literacy". Similarly, in 2006, the Australian Bureau of Statistics found that almost 60% of adult Australians had low health literacy and that "a total of 59% of 17-74 year-olds did not have adequate health literacy skills to effectively and efficiently understand and apply health-related information in their daily lives" (Choudhry et al., 2019[78]). Canada is no different – results from the International Adult Literacy and Skills published by the Canadian Council on Learning indicate that "six in ten Canadian adults do not have the skills needed to adequately manage their health and health-care needs" (Canadian Council on Learning, 2008[79]).

The surveys conducted in Japan and Mexico translated the instruments used in the HLS19 produced by HLS-EU and, as such, can be used to similarly compare results. However, the other surveys conducted in Argentina, Brazil, the United States, Australia and Canada do not use translated versions of the EU-HLS, nor do they use indicators that are comparable to the EU-HLS, which limits the ability to compare health literacy levels across OECD countries that are not part of Europe and that are thus not part of the EU-HLS.

6.5.2. Disparities in health behaviours, health status and healthcare utilisation across individuals with different levels of health literacy

The data suggest that individuals with higher levels of health literacy tend to engage in healthier lifestyles: they consume fruits and vegetables more frequently and exercise more than individuals with lower levels of health literacy (Table 6.2). They are also more likely to report being in good general health and are less likely to report suffering from long-term illnesses or health problems (Table 6.3). Finally, they are less likely to use emergency healthcare services and surgical specialists (Table 6.4).

For example, on average, across the 15 HLS19 OECD countries with available data, a difference of 10 percentage points in the number of health literacy tasks individuals perceive as "very easy" or "easy" is associated with a difference of 2 percentage points in the likelihood that respondents reported consuming fruits and vegetables at least four days a week. This difference corresponds to 1.4 percentage points when comparing individuals with different levels of health literacy and the same age, gender, level of educational attainment and financial deprivation. Similarly, on average, across the HLS19 OECD countries, a difference of 10 percentage points in the number of health literacy tasks individuals perceive as "very easy" or "easy" is associated with a difference of 2.1 percentage points increase in the likelihood that respondents reported exercising at least four days a week. This difference corresponds to 1.9 percentage points when individuals with different levels of health literacy and the same age, gender, level of educational attainment and financial deprivation are compared.

Table 6.2. The association between health literacy and health lifestyles, in selected OECD countries, 2019-20

Differences in the percentage of adults who consumed fruits and vegetables at least four days a week and the percentage of adults who are engaged in physical activity at least four days a week as a function of 1 percentage point difference in the number of health literacy tasks that an individual perceives as "very easy" or "easy"

	Fruit and vegetable consumption		Engagement in physical activity	
	No controls	With socio-economic controls	No controls	With socio-economic controls
Austria	0.32*	0.27*	0.29*	0.25*
Belgium	0.18*	0.12*	0.17*	0.15*
Czech Republic	0.15*	0.04	0.22*	0.20*
Denmark	0.26*	0.18*	0.25*	0.22*
France	0.16*	0.11*	0.09	0.07
Germany	0.26*	0.19*	0.19*	0.17*
HLS19 OECD average	0.20*	0.14*	0.21*	0.19*
Hungary	0.21*	0.11	0.17*	0.24*
Ireland	0.11*	0.05	0.15*	0.13*
Israel	0.28*	0.17*	0.20*	0.09
Italy	0.21*	0.20*	0.25*	0.23*
Norway	0.15*	0.09*	0.24*	0.22*
Portugal	0.02	0.05	0.19*	0.11
Slovak Republic	0.34*	0.28*	0.33*	0.26*
Slovenia	0.19*	0.19*	0.34*	0.36*
Switzerland	0.15*	0.09	0.14*	0.10

Note: Socio-economic controls include age, gender, level of educational attainment and financial deprivation.
Results are based on linear probability models. The choice to use linear probability models instead of logistic models or probit models, given the dichotomous nature of the dependent variable was driven by interpretability and the fact that estimates from different sets of linear probability models are more comparable across models than estimates from logistic or probit regression estimates (Mood, 2009[80]). However, estimates might not be valid for values close to the edges. The asterisk (*) indicates statistical significance at the 5% level.
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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Health literacy is also positively associated with health status: for example, across the 15 HLS19 OECD countries, a difference of 10 percentage points in the number of health literacy tasks individuals perceive as "very easy" or "easy" is associated with on average, a 3.9 percentage points increase in the likelihood that respondents reported being in very good or good health. This difference corresponds to a

2.4 percentage-point increase when individuals with different levels of health literacy and the same age, gender, level of educational attainment and financial deprivation are compared.

Table 6.3. The association between health literacy and health, selected OECD countries, 2019-20

Differences in the percentage of adults who report being in very good or good health and who report suffering from at least one long-term illness or health problem as a function of 1 percentage point difference in the number of health literacy tasks that an individual perceives as "very easy" or "easy"

	Adults reporting being in very good or good health		Adults reporting suffering from at least one long-term illness or health problem	
	No controls	With socio-economic controls	No controls	With socio-economic controls
Austria	0.43*	0.31*	-0.32*	-0.19*
Belgium	0.32*	0.25*	-0.03	-0.03
Czech Republic	0.15*	0.15*	-0.04	-0.05
Denmark	0.59*	0.45*	-0.24*	-0.19*
France	0.41*	0.31*	-0.15*	-0.11*
Germany	0.52*	0.31*	-0.19*	-0.04
HLS19 OECD average	0.39*	0.24*	-0.22*	-0.13*
Hungary	0.36*	0.24*	-0.23*	-0.18*
Ireland	0.32*	0.2*	-0.15*	-0.1*
Israel	0.2*	0.15*	-0.15*	-0.17*
Italy	0.31*	0.2*	-0.15*	-0.08*
Norway	0.31*	0.23*	-0.15*	-0.09
Portugal	0.63*	0.2*	-0.63*	-0.32*
Slovak Republic	0.42*	0.1*	-0.27*	-0.04
Slovenia	0.62*	0.31*	-0.42*	-0.18*
Switzerland	0.33*	0.24*	-0.14*	-0.11

Note: Socio-economic controls include age, gender, level of educational attainment and financial deprivation.
Results are based on linear probability models. The choice to use linear probability models instead of logistic models or probit models, given the dichotomous nature of the dependent variable was driven by interpretability and the fact that estimates from different sets of linear probability models are more comparable across models than estimates from logistic or probit regression estimates (Mood, 2009[80]). However, estimates might not be valid for values close to the edges. The asterisk (*) indicates statistical significance at the 5% level.
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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Because individuals with higher levels of health literacy adopt healthier lifestyles, are in better overall health and are better at managing their conditions, other things being similar, individuals with higher levels of health literacy are less likely to use emergency services or surgical specialists (Table 6.4). At a time of tight public health budgets, reducing the need for individuals to use emergency services and specialist care can contribute to lower healthcare costs.

Table 6.4. The association between health literacy and the use of emergency healthcare services and surgical specialists, selected OECD countries, 2019-20

Differences in the percentage of adults who report having used emergency healthcare services in the past 24 months and who report having used medical or surgical specialists at least once in the past 12 months as a function of 1 percentage point difference in the number of health literacy tasks that an individual perceives as "very easy" or "easy"

| | Adults using emergency healthcare services | | Adults using medical or surgical specialists | |
	No controls	With socio-economic controls	No controls	With socio-economic controls
Austria	-0.27*	-0.23*	-0.04	-0.04
Belgium	-0.19*	-0.15*	0.09	0.08
Czech Republic	-0.05	0.02	0	-0.01
Denmark	-0.09*	-0.04	-0.12*	-0.15*
France	-0.13*	-0.09*	-0.08	-0.09
Germany	-0.11*	-0.02	-0.16*	-0.11*
HLS19 OECD average	-0.17*	-0.12*	-0.07	-0.04
Hungary	-0.23*	-0.2*	-0.08	-0.07
Ireland	-0.18*	-0.09	-0.18*	-0.21*
Israel	-0.19*	-0.13	-0.04	-0.03
Italy	-0.07*	-0.03	0.01	0.01
Norway	-0.13*	-0.1*	-0.08	-0.064
Portugal	-0.34*	-0.3*	-0.12	-0.12
Slovak Republic	-0.23*	-0.18*	-0.14*	-0.05
Slovenia	-0.14*	-0.1*	-0.13*	-0.04
Switzerland	-0.13*	-0.09	-0.12*	-0.09

Note: Socio-economic controls include age, gender, level of educational attainment and financial deprivation.
Results are based on linear probability models. The choice to use linear probability models instead of logistic models or probit models, given the dichotomous nature of the dependent variable, was driven by interpretability and the fact that estimates from different sets of linear probability models are more comparable across models than estimates from logistic or probit regression estimates (Mood, 2009[80]). However, estimates might not be valid for values close to the edges. The asterisk (*) indicates statistical significance at the 5% level.
Source: The HLS19 Consortium of the WHO Action Network M-POHL (2021[19]), *International Report on the Methodology, Results, and Recommendations of the European Health Literacy Population Survey 2019-2021 (HLS19) of M-POHL*, https://m-pohl.net/sites/m-pohl.net/files/inline-files/HLS19%20International%20Report.pdf.

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6.6. Policy efforts to promote health literacy and improve access to healthcare information and services

Austria, Germany, Ireland and Portugal have taken measures to promote health literacy among their populations and/or adapt how they disseminate information to ensure individuals with varying levels of health literacy can access services and make the most of healthcare. The following section focuses on these four countries and the policies and initiatives they have implemented in recent years.

6.6.1. Austria

Health literacy in Austria received nationwide attention after the preliminary results of the HLS-EU released in 2011/12 revealed that health literacy in the country was significantly lower than the government had expected (Dietscher, Nowak and Pelikan, 2020[81]). Some 56% of all Austrians only had limited health literacy – a share that was higher than the international average of 48% (HLS-EU-Consortium, 2012[82];

Sørensen et al., 2015[16]). The same year, two fundamental health reform processes were launched in Austria with the aim of increasing in the following 20 years the number of "healthy years" lived by individuals in Austria. The health reforms included ten public-health-oriented national health targets developed in consultation with stakeholders from different sectors, relevant institutions and civil society (Dietscher, Nowak and Pelikan, 2020[81]). Improving health literacy in the population was one of the ten national health targets[2] (Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz, 2022[83]).

In order to achieve higher health literacy among Austrians, a working group composed of representatives from different policy fields, expert organisations, non-governmental organisations and social security institutions was established. The group was tasked with developing three sub-targets and adopting matching interventions in different sectors, including healthcare, education, community settings and extracurricular youth work (Dietscher, Nowak and Pelikan, 2020[81]). Applying the "management by targets" approach, the Austrian Ministry of Health, the Austrian provinces and social security institutions representatives defined intervention areas that were further developed during the second period of the national reform strategy (2017-21) (Dietscher, Nowak and Pelikan, 2020[81]).

The group aimed to improve the quality of communication and information in the healthcare sector by using a national health information website[3] and setting national priorities. Moreover, the Austrian Health Literacy Alliance (Österreichische Plattform Gesundheitskompetenz) was implemented as a national health literacy co-ordination structure. Funded through mechanisms of the ongoing Austrian healthcare reform, the partners started some new interventions and contributed to interventions already initiated by the national health targets (Dietscher, Nowak and Pelikan, 2020[81]). In addition, the group envisaged that Austria would continue to participate in the HLS-EU. In the second period of Austria's reform strategy, the goal of enhancing the organisational structure of health literacy was added as an intervention area (Bundesministerium für Gesundheit und Frauen, 2017[84]; Dietscher, Nowak and Pelikan, 2020[81]).

The above-mentioned Austrian Health Literacy Alliance was implemented in 2015 and has since become essential to the development of health literacy. A core team chaired by a representative from the Austrian Federal Ministry of Social Affairs, Health, Care and Consumer Protection and composed of representatives from the federal government, federal states, social security institutions and Health in All Policies partners acts as the Alliance's decision-making body. Organisations and individuals whose activities and projects contribute to improving the population's health literacy are encouraged to become members of the Alliance (Österreichische Plattform Gesundheitskompetenz, 2022[85]).

In addition to an annual national health literacy conference that the Alliance organises, it established intersectoral working groups to create activities, guidelines and tools in five focus areas. The focus areas include: 1) high-quality health information (such as developing materials that a wide range of people can understand); 2) high-quality communication in healthcare (such as improving healthcare professionals' conversation skills and enabling patients to ask more clarifying questions; 3) health-literate organisations; 4) empowerment of citizens and patients; and 5) measuring health literacy through the continuing participation in HLS-EU, and follow-up surveys such as HLS19, and development of other health literacy surveys (e.g. with a focus on SARS-CoV-2 or children's health literacy) (Österreichische Plattform Gesundheitskompetenz, 2022[85]; 2022[86]).

The HLS-EU study found that many Austrians struggle to understand the extent to which the health-related information they are exposed to is trustworthy (Pelikan, Röthlin and Ganahl, 2013[87]). Considering that a study from 2015 suggested that only 11% of articles about health and diseases in online and print media in Austria reported scientific knowledge correctly, whereas 60% either exaggerated or understated the scientific facts, the Austrians' insecurity about their ability to assess the quality of written health information is not surprising (Kerschner et al., 2015[88]). In order to ensure high-quality health information, the Alliance defined 15 quality criteria for good health information that organisations are encouraged to use when producing health information in brochures, videos, websites or other formats (Box 6.2.). Moreover, the Alliance created a factsheet with practical guidelines on comprehensible language for written health

information. In addition, two checklists that the Alliance developed help individuals and healthcare providers assess whether the written health information they receive or want to pass on to their patients is trustworthy and of high quality. Furthermore, to increase health literacy among refugees who do not speak German, the Alliance prepared short videos about the Austrian health system in Arabic, Dari and Somali (Österreichische Plattform Gesundheitskompetenz, 2022[89]).

Box 6.2. The Austrian Health Literacy Alliance's criteria for publishing high-quality health information

The Austrian Health Literacy Alliance developed a brochure to guide organisations that want to produce high-quality health information. Moreover, the Austrian Health Literacy Alliance encourages organisations to write and publish method papers in which they describe how the quality criteria defined by the Alliance have been taken into consideration in their health information publications. This, in turn, can be expected to increase the organisations' credibility and allow them to act as role models (Österreichische Plattform Gesundheitskompetenz, 2020[90]).

The 15 criteria are grouped into basic criteria (Criteria 1-3), selection and presentation of facts criteria (Criteria 4-11) and credibility criteria (Criteria 12-15) (Österreichische Plattform Gesundheitskompetenz, 2020[90]):

Basic criteria

1. **Identification of special information needs.** The health information should be tailored, comprehensible and useful for its respective target group.
2. **Systematic research.** The used sources should be appropriately chosen for the respective question and easily verifiable.
3. **Selection of the evidence.** The target group should receive the most up-to-date information from the best available studies while being informed about potential research gaps and biases.

Selection and presentation of facts criteria

4. **Choice and presentation of results (endpoints).** The target group should receive information through the selected endpoints to assess impacts on their daily lives.
5. **Choice and presentation of comparisons.** Individuals should be able to use the facts to make informed choices for or against an examination or treatment.
6. **Dealing with numbers and risk information.** Benefits and harms should be presented in a balanced, gender-appropriate and comprehensible manner that includes absolute risk information, such as meaningful and uniform reference values like 1 in 1 000).
7. **Consideration of age and gender differences.** The target group should be informed about the natural course of the disease and about the intervention's effects, benefits, harms and risks, considering their age and gender.
8. **Adaptation to the target group.** Content, cultural aspects, language, design and medium should be adapted to the target group.
9. **Objectively appropriate presentation.** An appropriate and realistic presentation in language and image should offer the target group a basis for decision making, while any uncertainties should be named.
10. **Ratings and recommendations.** Through the clear separation of information and recommendations, the target group should be able to make health decisions in line with their needs and values.

11. **Procedure for the preparation of decision aids.** The target group should be able to make informed choices for or against different examination and treatment options.

Credibility criteria

12. **Transparency about responsible persons.** Users should be able to assess the source and reliability of health information.

13. **Disclosure of conflicts of interest.** Users should be able to identify conflicts of interest behind the information.

14. **Description of formats and contents.** Individuals should be able to quickly decide whether they want to use the health information.

15. **Updating the contents.** Users should be able to assess the topicality and updating process of the information.

Source: Österreichische Plattform Gesundheitskompetenz (2020[90]), *Gute Gesundheitsinformation Österreich: Die 15 Qualitätskriterien (Good Health Information Austria: The 15 Quality Criteria)*, https://oepgk.at/wp-content/uploads/2020/12/2020_11_18_die-gute-gesundheitsinformation.pdf.

However, clear communication does not only concern written or recorded health information. According to the HLS-EU survey from 2011/12, 22% of the respondents indicated that they found it challenging to understand what their doctor was telling them, while 32% of the respondents said that, based on the information their doctor gave them, they considered it difficult to decide about medical procedures (HLS-EU-Consortium, 2012[82]). The HLS-EU study from 2019 identified challenges in active patient participation, which include sufficient conversation time, easy-to-understand language, encouraging the patients to share their personal views and ideas, actively listening to them and involving them in decision-making processes (Griebler et al., 2021[91]). In order to enhance conversation quality in healthcare and create a more patient-centred healthcare culture, the Alliance developed a comprehensive national strategy, focusing on four fields of action: staff empowerment, patient empowerment, organisational and process development, and health system and culture development (Österreichische Plattform Gesundheitskompetenz, 2022[92]).

More concretely, health professionals should be able to improve their conversation competences during all stages of their career – be it in education, training, further education or at the workplace. Communication skills courses and "train-the-trainer" programmes were developed for this purpose, as well as a nationwide trainer network. The participants evaluated the trainings very positively and indicated a significant increase in their self-assessed competences following the completion of the training (Ammentorp et al., 2021[93]; Österreichische Plattform Gesundheitskompetenz, 2022[92]; Sator, Holler and Rosenbaum, 2021[94]).

As communication should not be one-sided, patients are equally encouraged to actively participate in their healthcare. In order to support the empowerment of patients, the Alliance introduced an Austrian adaptation of the international "Ask me 3" initiative, which encourages patients to ask at least three questions during their medical appointment: 1) "What is my health problem?"; 2) "What can I do?"; 3) "Why should I do this?" At the same time, health professionals should ensure that patients feel comfortable enough to ask questions and understand the answers to them (Österreichische Plattform Gesundheitskompetenz, 2022[95]). Some social security institutions also offer patient training and coaching to prepare patients for medical appointments (Dietscher, Nowak and Pelikan, 2020[81]; Österreichische Plattform Gesundheitskompetenz, 2022[92]). Another important aspect of patients' empowerment is well-designed and well-implemented patient rights. Following the first research results from 2020 that uncovered a need to improve the design and implementation of patients' rights, more concrete implementation proposals are currently being developed (Österreichische Plattform Gesundheitskompetenz, 2022[95]; Schmotzer and Nowak, 2021[96]).

The Alliance also aims to enhance the organisational aspect of health literacy. By creating a starter kit, which includes a flexible practice guide describing nine different sub-processes and four self-assessment tools that can be used by healthcare institutions, primary care units, companies, as well as institutions offering extracurricular youth work, the Alliance wants to support organisations in achieving this goal. Moreover, the Alliance is developing and testing recognition processes that organisations can apply for to be awarded a "health-competent organisation" recognition (Österreichische Plattform Gesundheitskompetenz, 2022[97]).

All in all, the fortunate publication timing of the first HLS-EU in 2011/12 enabled health literacy to be incorporated into the health targets and "management by targets" approach within the Austrian health reform processes, which resulted in the identification of several focus areas and the development of matching activities to improve the Austrian population's health literacy. However, despite being recognised that health literacy interventions should be carried out in different sectors influencing health literacy outcomes, such as education or community settings, most discussions focused on the healthcare sector. Moreover, while the pioneering pilot projects were considered successful, health literacy interventions have yet to prove to be efficient in the long term, as well as to maintain public funding and interest.

The results of the HLS19 study in which Austria participated together with 16 other countries show that Austria's position in European health literacy saw some clear improvement. These results are promising and show that the efforts taken are worthwhile. Currently, priorities for the next healthcare reform period (2024-28/9) are being negotiated, and it is hoped that health literacy will remain high on the agenda.

6.6.2. Germany

Following the results of the HLS-EU in 2012 (HLS-EU-Consortium, 2012[82]) as well as studies on health literacy in Germany (Jordan and Hoebel, 2015[98]; Schaeffer et al., 2016[99]), an independent civil society initiative was established to set up an action plan to promote population-level health literacy (Schaeffer et al., 2021[13]).

The initiative convened a group of independent experts and a series of working group workshops with representatives from different sectors and established a monitoring office. The expert group helped develop the framework of the National Action Plan by reviewing the literature on definitions of health literacy and its determinants, reviewing existing action plans established to promote health literacy and analysing the effectiveness of different interventions. The scoping phase led to the identification of four thematic priorities – referred to as action areas – and the establishment of working groups to develop a set of recommendations and guiding principles for the implementation of initiatives undertaken to advance the thematic priorities (Box 6.3 describes the recommendations within the four thematic priorities and the guiding principles for the implementation of such recommendations) (Schaeffer et al., 2021[13]).

The core elements of the National Action Plan were then discussed and further developed in two workshops and individual consultations with potential partners, stakeholders, interest groups and patient representatives. The first workshop involved stakeholders from the health and education systems and the Alliance for Health Literacy, whereas the second workshop involved patient and self-help organisations. In the workshops, the experts and workshop participants discussed the core elements of the National Action Plan, using three guiding questions: 1) "Has the importance of the field of action for Germany been adequately defined?"; 2) "Which fields of action should be at the centre of the action plan?"; and 3) "Which actors and partners can promote these lines of action?" The main goals of the workshops and individual consultations were to include different perspectives in finalising the Action Plan, establish collaborations with important stakeholders from different sectors and create motivation to implement the Action Plan (Schaeffer et al., 2021[13]).

The final version of the National Action Plan, published in 2018, consists of a section explaining health literacy's political and social relevance, the concepts and definitions of health literacy, crucial empirical

findings and 15 recommendations within 4 action areas. The action areas focus on: 1) promoting health literacy in all areas of everyday life; 2) creating a user-friendly and user-centred, health-literate healthcare system; 3) living a health-literate life coping with chronic illness; and 4) systematically expanding health literacy research. In addition to explaining why each recommendation is relevant, the report suggested concrete actions that could be undertaken and which actors should implement each recommendation (Schaeffer et al., 2018[100]). Box 6.3 lists the 15 recommendations and the 5 guiding principles to apply when implementing the National Action Plan.

Box 6.3. Germany's National Action Plan: 15 recommendations to improve the population's health literacy

Action field 1: Promote health literacy in all areas of everyday life

1. **Enable the education system to promote health literacy early on in life**. This can be achieved by placing health literacy in the curricula of elementary schools, secondary schools, universities, as well as in vocational training institutions and adult education.

2. **Promote health literacy in professional life and at the workplace**. This could be done by organising health literacy learning and training opportunities in the workplace.

3. **Strengthen health literacy regarding food consumption and nutrition**. One of the recommendations to strengthen health literacy with regard to nutrition in Germany was to label consumer products, especially food, beverages, and dietary supplements, more clearly and comprehensibly and to introduce a traffic light system that is mandatory for food manufacturers in order to indicate how nutritious different foods are.

4. **Facilitate the handling of health information in the media**. The suggestion by Germany's National Action Plan was to empower health professionals to recommend quality-assured print and digital health information.

5. **Empower communities to strengthen the health literacy of citizens in their living environment**. A proposed approach, put forward by the National Action Plan, to strengthen the health literacy of citizens is to collaborate with educational institutions, sports clubs, fitness studios, citizens' initiatives and self-help groups in order to develop attractive events to discuss health problems in the residential neighbourhood/at the community level.

Action field 2: Create a user-friendly and health-literate healthcare system

6. **Integrate health literacy as a standard at all levels of the healthcare system**. This can be done by including the promotion of health literacy structurally in the healthcare system and removing obstacles to its implementation by organisations and healthcare professions, for example, through adequate further development of the remuneration system.

7. **Facilitate navigation within the healthcare system, increase transparency and reduce administrative barriers**. A proposed approach in Germany is to make navigation within and between healthcare organisations easier and simplify administrative procedures such as forms and contracts.

8. **Create comprehensible, effective communication between health professionals and users**. An example of what can be done in Germany to create more user-friendly health information is to establish interpreting services and translation aids so that language is not a barrier for migrants, immigrants or refugees.

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9. **Create user-friendly health information**. In Germany, the suggestion is to consider simplifying health-related information, for instance, by writing in plain or easy language or providing it in a visual format so that people who have difficulties reading and understanding language can also access and understand it.

10. **Facilitate and strengthen patient participation**. This can be done by developing standardised practices on how to take into account patients' voices and opinions throughout the treatment and care process and by more clearly stipulating patients' rights in relation to care providers.

Action field 3: Living a health-literate life with chronic illness

11. **Integrate health literacy into caring for the chronically ill**. An approach is to design care programmes and facilities for those with chronic illnesses in such a way that it addresses not only the physical aspects of the illness but also the psychological, social and economic challenges of living with a chronic disease.

12. **Facilitate and support a health-literate handling of disease progression and its consequences**. A suggested approach is to promote initiatives that make a prescribed course of medical treatment, such as the intake of required medication, more comprehensible and co-designable so that pharmaceuticals can be packed in the same package in case individuals are required to take several of them. In doing so, the goal would be to promote health literacy of people with chronic illnesses in dealing with their medication(s).

13. **Strengthen the self-management ability of people with chronic illness and their families**. It is proposed in Germany to consider adapting self-management programmes so that they focus on not only the expert's view but also the perspective and problems of those with the disease and their relatives.

14. **Promote health literacy for coping with everyday life and chronic illness**. A proposal is to use mass media communication to increase public awareness about the importance and impact of chronic illness and make people with chronic illness and their families visible so that people are aware of the (sometimes invisible) struggles individuals with chronic diseases have.

Action field 4: Systematically research health literacy

15. **Develop health literacy research**. As part of the action plan, the proposal is to measure the population's health literacy regularly and examine individual, societal and organisational determinants of health literacy, all in an effort to develop evidence-based interventions.

Basic principles to consider when implementing the National Action Plan

1. Reduce social and health inequality.

2. Change individual as well as structural conditions.

3. Enable user participation and shared decision making.

4. Use the possibilities digitalisation offers.

5. Establish the co-operation of actors from all sectors of society.

Source: Schaeffer et al. (2018[100]), *National Action Plan Health Literacy: Promoting Health Literacy in Germany*, www.hlca-consortium.de/wp-content/uploads/2018/06/National-Action-Plan-Health-Literacy.pdf; Nationaler Aktionsplan Gesundheitskompetenz Geschäftsstelle (2020[101]), *15 konkrete Empfehlungen, um die Gesundheitskompetenz zu stärken (15 concrete recommendations to strengthen health literacy)*, www.nap-gesundheitskompetenz.de/aktionsplan/.

In order to increase the National Action Plan's impact on health literacy, a three-part collaborative and co-productive diffusion, dissemination, and implementation strategy was developed. Following a successful event aimed at representatives from media, politics, science and the administration, the

National Action Plan was circulated by mail and electronically. Moreover, the National Action Plan was disseminated through publications in relevant journals and presentations at conferences to reach key implementation actors, including politicians and decision makers at the federal and federal state levels, executives of healthcare sector associations and organisations, as well as representatives from the education and training sectors. A dedicated website[4] was created to further inform the general public about the National Action Plan and to provide extensive and up-to-date information on its development, fields of action, recommendations, future and past events, and the topic of health literacy in general (Schaeffer, Gille and Hurrelmann, 2020[102]).

Implementing the National Action Plan involved translating the 15 recommendations into concrete measures and relying on stakeholder support. To this end, consecutive strategy and policy papers have further developed specific recommendations and examined certain aspects of health literacy and specific population groups. Therefore, several workshops were conducted, which gathered experts from science and practice to specify selected recommendations of the National Action Plan. A total of eight strategy papers and four policy papers have been published so far, one of the latest additions being a call for putting greater efforts into the promotion of health literacy against the backdrop of the COVID-19 pandemic and considering the recommendations of the National Action Plan on Health Literacy and its strategy papers (Schaeffer et al., 2022[103]).

Since the publication of the National Action Plan, several health literacy projects have been developed and implemented to promote health literacy. In addition to the National Action Plan, there are other networks and interest groups in Germany working on health literacy (Schaeffer and Gille, 2021[9]). For example, the Federal Ministry of Health (MoH), together with the stakeholders of the German healthcare system, launched the "Alliance for Health Literacy" (Bundesministerium für Gesundheit, n.d.[104]) in 2017. The members have committed themselves to developing new projects to improve health literacy. The German Network for Health Literacy, founded in 2019 (Schaefer and Ollenschläger, 2019[105]), the working group on health literacy in the German Network for Health Services Research (Ernstmann et al., 2020[106]) and the division of patient information and participation within the German Network for Evidence-Based Medicine (Lühnen et al., 2017[107]) are also worth mentioning in this context. In addition, the "Alliance Health Literacy and School" since recently advocates for developing a co-ordinated strategy for the holistic promotion of health literacy in schools and the systematic implementation of it (Okan et al., 2021[108]). Most of the initiatives are relatively young.

Although the discussion on health literacy started in Germany somewhat more than only ten years ago – later than in many other countries – a wide body of research on health literacy has developed. Meanwhile, several studies on population health literacy in Germany are available, as well as results on specific population groups (e.g. children and adolescents, people with migration backgrounds, etc.) and many other aspects of health literacy. Intervention research has also been slowly developing. For a considerable while, particular attention has been paid to the area of organisational health literacy and, most recently, to the health literacy of health professionals (Schaeffer, Haarmann and Griese, 2023[109]). Despite this progress, the expansion of research funding in the area of health literacy would be desirable.

6.6.3. Ireland

In Ireland, health literacy is an important element of the Healthy Ireland Framework. Part of this framework was created by a host of partners (the Department of Health, the Department of Children and Youth Affairs, the Department of Education and Skills, the Health Service Executive Directorates, statutory agencies, community and voluntary bodies, and the private sector), focusing on the goal of addressing and prioritising health literacy in developing future policy, such as education and information interventions (Department of Health Ireland, 2013[110]). Within this framework, several action plans were proposed, most notably, the Healthy Ireland Action Plan 2021-2025 (Healthy Ireland, 2021[111]), the Sláintecare Action Plan 2019 (Department of Health Ireland, 2019[112]) and the Sláintecare Implementation Strategy and Action Plan

2021-2023 (Department of Health Ireland, 2021[113]). These action plans aimed to strengthen the ease with which individuals could access the health sector and benefit from it and create a modern, responsive and integrated public health system. As part of the action plans, a series of initiatives were developed to promote health literacy among children and adults.

The Irish Heart Foundation's (IHF) Health Literacy in Schools Project focused on promoting health literacy among young people aged 12 to 16 in post-primary schools that were part of the Delivering Equality of Opportunity in Schools programme,[5] their families and teachers. Adolescents from disadvantaged communities in Ireland often experience poorer health and worse educational outcomes than their peers from more advantaged communities. For this reason, the WHO, University College Dublin, Dublin City University, National University of Ireland, Galway, and Swinburne Technological University created a tailored literacy measurement tool to track health literacy levels among adolescent populations; measure the effectiveness of interventions aimed at promoting health literacy in schools in Ireland; and create instruments to develop a national study to measure health literacy, its determinants and consequences for post-primary school-aged children. On top of measurement efforts, the project aimed to create a framework to build capacity within the schooling system to promote health literacy and an out-of-school lab experience (LifeLab) for adolescents to explore health and health literacy.[6] The IHF recruited over 60 schools to participate in the project and rolled out the measurement instrument to over 1 500 adolescents in late 2021 and early 2022 (Irish Heart Foundation, 2021[114]; WHO, 2019[115]).

The Department of Health, the National Treatment Purchase Fund, the Health Service Executive, and the National Adult Literacy Agency (NALA), as well as experts in behavioural science, collaborated to create the Better Letter Initiative (BLI) to improve communication and decrease the burden faced by individuals accessing health services. It did so by implementing the use of plain English and behavioural science in healthcare. Therefore, the BLI did not directly seek to improve health literacy in the population but, rather, redesign services to make them more accessible, including to individuals with low levels of health literacy, and facilitate engagement despite cognitive heuristics and biases. Findings of the projects in the BLI indicated that by redesigning the content of Waiting List Validation Letters,[7] the number of patients who did not respond dropped from 24% to 19%. Furthermore, due to the redesign and redrafting of inpatient and day case appointment letters, the number of patients who confirmed their appointment rose from 67% to 76%, and the rate of patients who did not attend their appointment declined from 11% to 5.3%. Ongoing work is considering how outpatient appointment offer letters and text reminders could be redesigned to further strengthen patient engagement (Department of Health Ireland, 2021[116]).

NALA aims to improve health literacy. NALA created and introduced ten literacy-friendly standards (Box 6.4), a literacy audit tool to assess healthcare settings and identify areas for improvement, short one-hour webinars for healthcare professionals to make them more literacy-friendly, and the "Crystal Clear" mark to highlight pharmacies that have shown commitment to providing a literacy-friendly service to their customers. Furthermore, NALA offers a range of services to build health literacy among adult populations. These include free over-the-phone tuition for adults on literacy and numeracy and health literacy awareness videos tailored to cancer patients and their relatives (NALA, 2021[117]). Finally, NALA published a guide on improving communication in the health sector together with the Irish Health Information and Quality Authority (HIQA). The report includes detailed guidance documents for healthcare professionals and social care services to improve their communication with adults and children (HIQA, 2015[118]).

Box 6.4. Ireland's National Adult Literacy Agency's quality standards to become a literacy-friendly pharmacy

For a pharmacy to become "Crystal Clear," it has to follow ten quality standards which focus on four areas: 1) communication; 2) staff awareness and responding sensitively; 3) policies and procedures; and 4) evaluating and improving. NALA provides tips on how to achieve each of these standards and checklists for pharmacies to see whether they already fulfil these standards.

Communication

1. Use plain English when speaking with people.
2. Write a medication label in plain English.
3. Check that people understand what you have told them.
4. Improve the layout of your pharmacy.

Staff awareness and responding sensitively

5. Improve staff awareness of health literacy and literacy-friendly work practices.
6. Respond sensitively to people with literacy and numeracy needs.

Policies and procedures

7. Develop a literacy-friendly policy.
8. Help people find and use important information and instructions.
9. Support staff to improve their own literacy, numeracy and digital skills, if needed.

Evaluating and improving

10. Evaluate and continually improve your literacy-friendly service.

Source: NALA (2021[117]), *A Guide to Becoming a Crystal Clear Pharmacy*, www.nala.ie/publications/the-crystal-clear-pharmacy-programme-and-its-crystal-clear-mark/.

6.6.4. Portugal

Following the successful implementation of the HLS-EU, whose results were published in 2012, Portugal developed and administered a national Health Literacy Survey in 2014. To improve health literacy, the Portuguese Directorate-General of Health developed an action plan based on international best practices. The Health Literacy Action Plan (Plano de Ação para a Literacia em Saúde) aims to promote improvements in health literacy in Portugal as well as organisational reforms and the better communication capacity of the National Health Service (SNS) and the health system in general, so as to promote easier and higher-quality interactions, including among individuals with low levels of health literacy (Ministério da Saúde, 2018[119]).

The action plan is person-centred and uses a lifecycle approach, meaning that it considers how health literacy can be best promoted in childhood, adolescence, adulthood and elderly years. Furthermore, the action plan considers individuals in their social and relational context and how family relationships, peer groups and the broader community have the potential to shape an individual's health literacy but also, in turn, can benefit from the individual's health literacy. Finally, the action plan takes into account specific settings and contexts to define the following targeted strategic objectives: 1) promote the adoption of healthy lifestyles in everyday life; 2) train the population to make proper use of the health system;

3) promote the well-being of those affected by chronic disease; and 4) promote knowledge and research. For each objective, the action plan lists priority areas (e.g. nutrition or mental health); specific objectives according to the lifecycle (e.g. training parents and caretakers); transversal means (e.g. healthcare professionals or media); specific means (e.g. education professionals or social platforms); and products to use (e.g. websites or guidelines). The action plan also emphasises the importance of building close co-ordination between different strategic partners, including ministries, academia, professional bodies, scientific societies, media and civil society (Ministério da Saúde, 2018[119]).

The action plan aims to equip health professionals with tools to effectively promote health literacy, develop campaigns and thematic interventions that speak to the population, and strengthen the network of stakeholders promoting health literacy. It does so by implementing a variety of measures and programmes. For example, the Literacy, Health and Well-Being Division in the General Directorate of Health and the Care Integration Programme focus on improving people's autonomy and critical thinking regarding health. Furthermore, the *Good Practices Handbook for Health Literacy – Empowering Health Professionals* was introduced to support health professionals in better understanding what health literacy entails, how they can promote the acquisition of health literacy in the population, and how they can help break barriers faced by and promote positive outcomes of people with low levels of health literacy. The overall strategy of the action plan, in conjunction with the SNS+Proximity programme, which aims to put patients at the centre of the health system, and the Health Literacy Library, a tool that simplifies and provides information for citizens, their friends, family, and health professionals, is not just to make the health system easier to use for patients and health professionals but also to improve trust in the system as a whole (Ministério da Saúde, 2019[120]).

During the COVID-19 pandemic, Portugal designed a Health Literacy Intervention Plan to empower individuals and communities facing the crisis. The plan had four axes:

- The first axis revolved around developing information material, in particular, good practices in health literacy. This information material was developed by looking at good practices in health literacy, using scientific evidence, and eventually establishing context-specific support tools to guide the implementation of these good practices.

- The second axis, called Health Literacy Intelligence, collected information on the population's perceptions of the pandemic, risks associated with exposure and infection, as well as on the communication channels used in order to eventually personalise communication formats and content to avoid the spread of misinformation.

- The third axis aimed to provide the population with the targeted information before, during, and after the emergency to influence behaviour to promote public health and control the crisis.

- The fourth axis, referred to as Social Mobilisation, focused on creating micro-influencers in local communities in order to tackle and avoid misinformation, clarify all preventive measures that could be taken to protect oneself and others during the crisis, promote adherence to public health guidance measures and create a bridge between the scientific community and civil society.

All in all, the strategy's multi-dimensional aspect intended to minimise social disruption and allow for different interventions based on the evolution of the crisis and local needs while maintaining a "the person at the centre of the system" approach (Ministério da Saúde, 2020[121]). Additionally, the government provided a guide for health professionals and scientists, specifically focused on communication strategies to promote adherence to vaccination against COVID-19. The guide argued that professionals should emphasise the benefits at an individual and collective level to their own patients and social circle. Furthermore, the document highlighted how best to promote vaccination take-up, including prioritising the users' perspective and clarifying and addressing potential doubts and concerns of patients without discounting individual worries and experiences (Ministério da Saúde, 2021[122]).

6.7. Conclusions

The pandemic highlighted that whether innovations in the prevention and treatment of disease are successful or not hinges on the ability of individuals to comprehend, evaluate and apply the information they have about disease prevention and treatment. Without health literacy, individuals are prone to misinterpret health data, fall prey to unfounded health claims and mistrust innovative treatment options and regimens, thus leading to misguided health decisions.

The chapter reveals that many individuals find it difficult to judge the advantages and disadvantages of different treatment options, decide how to protect themselves from illness using information from the mass media and find information on how to handle mental health problems. These results, alongside results on the positive association between health literacy and general health, between health literacy and the likelihood that individuals will engage in healthy lifestyle choices, and the negative association between health literacy and the utilisation of emergency services, point to the need to strengthen population-level health literacy.

Identifying individuals with low levels of health literacy is therefore critical to reducing health inequalities and as a public health measure since lack of health literacy can lead some individuals to engage in behaviours that place entire communities at risk. Moreover, strengthening population-level health literacy is likely to reduce health expenditures since it has been shown to reduce emergency care and help individuals reduce the likelihood of developing chronic conditions, which pose a heavy burden on healthcare systems and to more effectively manage these when developing such conditions. As people are exposed to more health information than ever before – including inaccurate and misleading information – health literacy can reduce susceptibility to misinformation, disinformation and malinformation.

Increases in complexity in the information individuals are exposed to and in the incidence of chronic diseases have occurred at a time in which there has been an increase in the expectation that individuals will play an active role in managing their health. Increased choices can only result in improved outcomes if individuals have the knowledge and skills to be active agents and decision makers and if relevant information is communicated in ways that are aligned with their knowledge and skills. Reducing the mismatch between people's health literacy skills and the demands of health systems can be pursued by, for example, strengthening the health literacy of individuals who currently have low levels of health literacy and improving the ability of healthcare providers to effectively communicate information in ways that best empower people's ability to make decisions about their health.

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Notes

[1] "General health literacy" refers to health literacy more broadly, as opposed to specific types of healthy literacies, such as digital health literacy or vaccination health literacy.

[2] The ten Austrian health targets are: 1) to provide health-promoting living and working conditions for all population groups through co-operation of all societal and political areas; 2) to promote fair and equal opportunities in health, irrespective of gender, socio-economic group, ethnic origin and age; 3) to enhance health literacy in the population; 4) to secure sustainable natural resources such as air, water and soil and healthy environments for future generations; 5) to strengthen social cohesion as a health enhancer; 6) to ensure conditions under which children and young people can grow up as healthy as possible; 7) to provide access to a healthy diet for all; 8) to promote healthy, safe exercise and activity in everyday life through appropriate environments; 9) to promote psychosocial health in all population groups; and 10) to secure sustainable and efficient healthcare services of high quality for all.

[3] See www.gesundheit.gv.at/.

[4] See www.nap-gesundheitskompetenz.de/.

[5] "Delivering Equality of Opportunity in Schools (DEIS), the Action Plan for Educational Inclusion, was launched by the Department of Education and Skills in May 2005. The plan focuses on addressing the educational needs of children and young people from disadvantaged communities, from pre-school through second-level education (3 to 18 years). Some 852 primary level and second level schools in

Ireland are included in the DEIS initiative. Of these, 658 are primary schools while 194 are secondary schools." (Dublin City University, 2020[124]).

[6.]LifeLab is a purpose-built educational laboratory showing young teenagers how their lifestyles may affect their future heart health; see www.bhf.org.uk/informationsupport/heart-matters-magazine/research/lifelab.

[7.]"The validation of waiting lists is a process whereby the accuracy of waiting lists is checked by asking patients whether they still require their procedure." (The National Treatment Purchase Fund, 2023[123]).

7 Bridging language barriers: Language skills in information-rich societies

The ability of individuals, societies, and economies to fully leverage advances in information and communications technologies depends on their ability to communicate effectively with others. This, in turn, relies on individuals having the language skills needed to exchange information with relevant parties or on them using digital and human mediators. This chapter identifies the demand for language skills in labour markets; maps the distribution of language skills proficiency and language skills training; and considers the implications of recent advances in artificial intelligence for knowledge workers, focusing on possible complementarities and substitution between machine translation tools and language professionals.

Key messages

Communication is indispensable in today's interconnected world. In particular, language is an important facilitator and barrier to both trade and the efficient and accurate exchange of information. Being able to understand and use a language is also a precondition for being able to access labour market opportunities offered in that language.

Exchanges of information between agents who primarily communicate in different languages can occur through either mediators or when some of these agents are bilingual. Mediators include language professionals such as translators, interpreters and linguists, as well as machine translation (MT) technologies.

This chapter illustrates the importance of language skills in today's labour markets. It maps self-reported levels of language proficiency of adult populations in European countries and details the provision of language learning in school systems. It also identifies the need for individuals and organisations to evaluate the capabilities and limitations of MT technologies in order to make informed decisions about when and how these can be used in different circumstances. Finally, the chapter discusses the implications of recent advances in artificial intelligence (AI) for knowledge workers.

Key empirical findings include:

- English is the most sought-after language in online job postings in selected European countries, with French, German, and Spanish following behind.
- On average, across OECD countries excluding countries in which English is an official language, one in two vacancies advertising managerial or professional occupations either explicitly or implicitly require applicants to have at least some knowledge of English.
- Whether or not adults can use a language other than their mother tongue varies across the 29 countries with available data. On average, 23% of respondents in 2016 reported that they could not use any language other than their mother tongue, compared to 29% in 2007.
- The share of adults who indicate not being able to use a language other than their mother tongue differs depending on educational attainment. On average, across countries in the sample, 10% of respondents with a tertiary degree reported that they could not use a language other than their mother tongue. However, this figure was 23% among individuals with an upper secondary degree and 41% among those with, at most, lower secondary qualifications.
- Proficiency levels vary among adults who know at least a language other than their mother tongue. In 2016, 32% of individuals indicated being able to master almost completely the non-mother-tongue language in which they felt most proficient.
- Schools are crucial to building language skills within populations. In virtually all education systems in Europe, learning at least one modern language in addition to the language of instruction is compulsory. In most education systems, learning a first modern language is compulsory for between 11 and 13 years of schooling. Depending on the evolution of generative AI systems' capabilities, language teaching and learning may change in the future.
- In the majority of countries, English is the modern language taught most in schools.
- Few individuals worldwide work as language professionals, such as interpreters and translators. However, evidence from the United States indicates that over the past 20 years, the employment of language professionals has almost tripled.
- Between 2015 and 2019, advances in MT technologies did not replace the work of language professionals, but there are increasing concerns over the shift in the tasks performed in language professions (such as the increase in post-editing tasks of translation work performed by MT technologies) may result in lower wages for language professionals.

- Post-editing, digital skills and communication skills are highly sought after skills in online vacancies for language professionals in selected English-speaking and European countries.

7.1. Introduction

Communication is indispensable in today's interconnected world. Being able to accurately exchange information with others is key to being able to make the most of digital information ecosystems. Of the estimated 8 billion people in the world at the end of 2022, about 5 billion were connected to the Internet. But whether on or offline, people's ability to access information and communicate with others depends on the language/s they understand and can use. Making the most of online information and advances in communications technologies requires individuals to be able to comprehend the text and speech in which information is delivered. Transaction costs associated with trade are rapidly decreasing due to the wide availability of affordable information and communications technology (ICT) and the speed of transportation (Hummels, 2007[1]). However, language – the medium through which trade between different agents occurs – remains an important facilitator and barrier to both trade and to the efficient exchange of information. Individuals, firms and organisations still rely on language to communicate with one another to exchange information, goods and services. Being able to understand and use a language is also a precondition for being able to access labour market opportunities offered in that language: labour market mobility depends on individuals having relevant language skills.

Technological advances increase the returns to communication and information exchange. At the same time, they change the set of skills individuals need to make the most of information rich societies and labour markets. This chapter considers three ways in which individuals can communicate, access, and exchange information across language groups and the sets of skills that underpin these three ways of accessing and exchanging information. The first way is for individuals to exchange information directly. The set of skills needed in this situation are 'internal to the communication partners': language skills enable individuals to communicate with each other in the language of their interlocutor. The second way is for individuals to rely on machine translation (MT) technologies. Communication is made possible by digital mediators when individuals choose to rely on such tools rather than their own language skills or the skills of human professionals. Using machine translation technologies requires individuals to possess a set of skills that are also 'internal to communication partners'. These comprise the knowledge to adequately use machine translation technologies, the awareness of their limitations and the quality of the translated output, and the skill to choose between alternative mediation opportunities. The third way is for individuals to rely on the work of language professionals. In this case communication is made possible by skills that are 'external to the communication partners' and comprise the skills human mediators possess– i.e. language professionals. Language professionals need skills to convey meaning on behalf of their clients, which comprise subject matter skills, language skills, communication skills to work alongside their clients, and skills to make the most of communication with their clients.

Effective communication across language groups has important benefits for individuals but also for societies more widely. At the individual level, the ability to communicate with others is associated with better labour market prospects, especially in occupations that strongly rely on communication exchange. An extensive review of the literature on the benefits of language learning, as well as estimates of the changing skill sets of language professionals, and the description of the approach to estimating the demand for language skills in European labour markets are available in the following technical working paper, which was developed to support the preparation of this chapter: Marconi, Vergolini and Borgonovi (2023[2]). Individuals who can communicate in more than one language are more likely to display a heightened intercultural understanding and actively participate in global issues than monolingual individuals. These are crucial skills that promote social cohesion in today's diverse societies. Multilingualism is also associated with positive economic outcomes, such as increased employability and higher wages. Such

returns could stem from the increased productivity of workers who possess such skills or because employers use language proficiency to identify characteristics such as adaptability and openness to other cultures, which are valuable but difficult to evaluate in hiring processes. Multilingual individuals also appear to exhibit higher linguistic capacity, superior divergent thinking skills – a facet of creativity – and enhanced attentional control, working memory, metalinguistic awareness, and abstract and symbolic representation skills, which are growing in importance with digital innovations and AI.

At the societal level, the benefits of interlanguage communication include increased economic growth and tax base arising from international trade as well as the availability of a larger amount of information from communities that are exposed to different challenges and opportunities. For example, language skills allow the scientific community to become aware of effective approaches to promote biodiversity that are common among indigenous communities and indigenous communities can become aware of effective approaches to promote biodiversity implemented in other parts of the world (Borgonovi, Hervé and Seitz, 2023[3]). Moreover, whenever mistranslated content is made available on line, whenever individuals misinterpret information made available on line because of their poor language skills, or whenever information is made available on line in low quality translations, communication is distorted, with potentially far reaching implications for social cohesion and economic efficiency (see Chapter 5 on skills to navigate online information exchanges).

Language proficiency is a form of human capital. The returns to language proficiency increase with the number of speakers and vary depending on contextual factors, other forms of human capital that individuals possess, and the unique combination of individual and contextual circumstances. A key contextual factor is the development of machine translation technologies.

Over the past years, the landscape of digital mediators used to communicate, access, and exchange information across languages such as MT tools has undergone a remarkable transformation thanks to advances in natural language processing. On the one hand, the number of unique translatable language pairs increased from around 16 000 in 2019 to around 150 000 in 2022 (intento, 2022[4]). On the other hand, MT technologies today can translate some texts with a high level of accuracy. The quality of translations varies depending on the algorithms used by language models, as well as the quantity, quality, and variety of translations used to train the machine-learning algorithms that power AI MT tools. The complexity of the text being translated also plays a role. Variability in the output of machine translations and persistent problems associated with the fact that MT technologies are not able to take into account cultural subtleties and context means that the proliferation of automated translations on line can deteriorate the quality of the information landscape. As AI MT technologies are not completely accurate, information made available on line via text or speech and translated using these tools may contain inaccuracies or mistakes. An extensive review of the literature on artificial intelligence machine translation systems are available in the following technical working paper, which was developed to support the preparation of this chapter: Borgonovi, Hervé and Seitz (2023[3]).

Technological advances shift the boundaries of what digital mediators can do. By doing so, they change the opportunity cost for individuals to invest in language learning, to use digital rather than human mediators to access and exchange information but also change the set of skills individuals have to possess since interlinguistic communication mediated through technology requires a unique set of cognitive and metacognitive skills. Like for other emerging technologies, the use of machine translation technologies in fact requires knowledge and awareness about their capabilities and limitations for their use to be beneficial at the individual and societal levels and do not substitute but rather change the way in which skills are used.

At a minimum, individuals using online content should be able to determine whether the information they access is machine translated or not; if so, using which tools; and should develop an awareness of the continuously evolving capabilities, biases and limitations of AI MT technologies. Technological advances can bring benefits and create new problems, depending on individuals' abilities to understand how

technologies operate and the willingness of decision makers to regulate the use and applications of new technologies. This is particularly relevant given the results discussed in Chapter 5 on the increased complexity of the information landscape and the new challenges it poses for individuals in accessing, using, and exchanging information.

The chapter first illustrates the importance of language skills in today's labour markets by detailing the demand for language skills in vacancies posted on line by prospective employers. Second, the chapter maps self-reported levels of language proficiency of adult populations in European countries and details the provision of language learning in school systems. Third, the chapter identifies the need for individuals and organisations to evaluate the capabilities and limitations of MT technologies in order to make informed decisions about when and how these can be used in different circumstances. Finally, the chapter discusses the implications of recent advances in AI for knowledge workers, focusing on possible complementarities and substitution between MT tools and language professionals. It does so by identifying recent trends in demand for language professionals and by considering how technological advances in AI might impact the demand for skills.

7.2. Language skills are crucial for communication and information exchange

Language skills are highly sought after in labour markets, a reflection of the importance of information exchanges and inter-linguistic communication for service-oriented economies in which exchange of data and information is at the basis of innovation and growth. However, whether or not adults are able to speak another language besides the official language/s in their respective country of residence depends to a certain degree on whether school systems provide children and adolescents the necessary learning opportunities.

7.2.1. Language requirements in labour markets

Language requirements are key in labour markets, this includes not only the ability to speaking the official language/s of the country but also language skills beyond the official language/s. Previous work examining the demand for language skills in labour markets revealed that a knowledge of English was the sixth most-required skill in online job vacancies in European countries in 2021, making English one of the most widely requested transversal skills. The five skills that were mentioned more frequently than English in online job vacancies in 2021 were: the capacity to adapt to change; work in teams; use a computer; teamwork principles; and use Microsoft office (Marconi, Vergolini and Borgonovi, 2023[2]).

English language skills are often required in non-English speaking countries

Table 7.1 shows the percentage of vacancies posted in 2022 for each country that required at least some knowledge of one of the four languages that appear to be most in demand in the combined sample of online vacancies posted in selected European countries: English, French, German and Spanish. This percentage combines vacancies that explicitly required at least some knowledge of English, French, German or Spanish in the vacancy text and vacancies written in one of these languages (with language skills implicitly assumed). For example, a vacancy posted in Austria would be classified as requiring at least some knowledge of English if the vacancy was written in German but specified that applicants would need to be able to communicate in English to be considered. In addition, it would be classified as requiring some knowledge of English if it did not explicitly specify any language knowledge but was written in English. It is reasonable to expect that ads written in English refer to jobs where this language is to some extent used, even though they may not mention English as a specific requirement. Finally, the last column of Table 7.1 shows the percentage of vacancies that explicitly mentioned some knowledge of at least one language in the vacancy text (including languages other than English, French, German or Spanish) without considering the language in which the vacancy text was written.

When excluding countries in which English is an official language (Ireland and United Kingdom), knowledge of English was requested in 33% or more of online vacancies posted in 2022 in Austria, Hungary, Belgium, Denmark, Switzerland, Bulgaria, Greece, Romania, Portugal, Luxembourg. By contrast, knowledge of English was requested in 15% or less of online vacancies posted in 2022 in Croatia, Latvia and Finland.

Table 7.1. Explicit and implicit language requirements in online job vacancies in European countries, 2022

Percentage of online vacancies in which the vacancy was either written in a language (implicit requirement) or a knowledge of such language was required in the vacancy text (explicit requirement)

	Explicit or implicit requirement (English)	Explicit or implicit requirement (French)	Explicit or implicit requirement (German)	Explicit or implicit requirement (Spanish)	Explicit requirement (Any language)
Austria	34	1	92	2	48
Belgium	35	19	3	1	50
Bulgaria	44	2	11	5	47
Croatia	15	2	2	10	31
Czech Republic	26	1	4	1	40
Denmark	38	1	1	0	51
Estonia	18	0	6	0	21
EU average	31	5	4	3	37
Finland	13	0	1	0	19
France	32	98	1	1	56
Germany	33	1	96	1	49
Greece*	44	2	3	2	19
Hungary	34	2	6	2	36
Ireland	99	3	3	2	15
Italy	26	4	2	1	36
Latvia	15	0	2	0	34
Lithuania	24	1	5	1	35
Luxembourg	59	63	15	5	89
Netherlands	27	1	2	1	28
Poland	30	2	5	2	29
Portugal	54	6	7	19	51
Romania	46	3	5	3	36
Slovak Republic	23	1	3	1	25
Slovenia	21	0	1	0	25
Spain	30	3	3	76	26
Sweden	28	1	1	0	36
Switzerland	42	9	76	3	56
United Kingdom	99	3	2	1	15

Note: Countries are sorted alphabetically. The EU average includes countries that are members of the European Union in the sample. The EU average excludes for each column, countries with values higher than 80% in the respective language requirement (i.e. Ireland and the United Kingdom are excluded for English; Austria, Switzerland and Germany are excluded for German; Spain is excluded for Spanish; and France is excluded for French). The "English", "French", "German" and Spanish" columns include both ads explicitly requiring this language and implicitly requiring it (because they are written in that language). The column "Any language" includes only vacancies that explicitly require at least one language in the vacancy text.

*It is possible that the language model used to extract vacancies misclassifies non-roman alphabets such as Greek and Cyrillic.

Source: Calculations based on Lightcast, (2023[5]), Lightcast™, https://lightcast.io, (accessed April 2023), according to the methodology described in Marconi, Vergolini and Borgonovi, (2023[2]), "The demand for language skills in the European labour market: Evidence from online job vacancies", https://doi.org/10.1787/e1a5abe0-en.

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Figure 7.1 shows the percentage of online vacancies implicitly or explicitly requiring English language skills in professional occupations relative to the percentage of online vacancies implicitly or explicitly requiring English in all vacancies advertised on line. Workers in professional occupations often completed tertiary or upper secondary degrees and have high levels of foundational skills, technical skills and transversal skills to be able to complete challenging cognitive tasks (ILO, 2012[6]). On average, across OECD and European countries, almost one in two vacancies advertising professional occupations either explicitly or implicitly required applicants to have at least some knowledge of English. In Portugal, Romania and Luxembourg, over seven in ten online vacancies advertised for professional jobs explicitly or implicitly demanded at least some knowledge of English. English was also required in around one in two vacancies for professional occupations posted on line in Austria, Spain, the Slovak Republic, Belgium, Denmark, Hungary, Poland, Bulgaria, Denmark. By contrast, in Latvia and Finland, only around two in five vacancies posted on line for professionals explicitly or implicitly required at least some knowledge of English. In countries with compulsory English language learning in upper secondary education, like Sweden, employers may expect candidates to possess a good working knowledge of English and therefore not explicitly or implicitly require it in the job description.

Figure 7.1. The demand for English skills among professionals in European countries, 2022

Percentage of online vacancies implicitly or explicitly requiring at least some knowledge of English among professionals, and in all vacancies posted on line
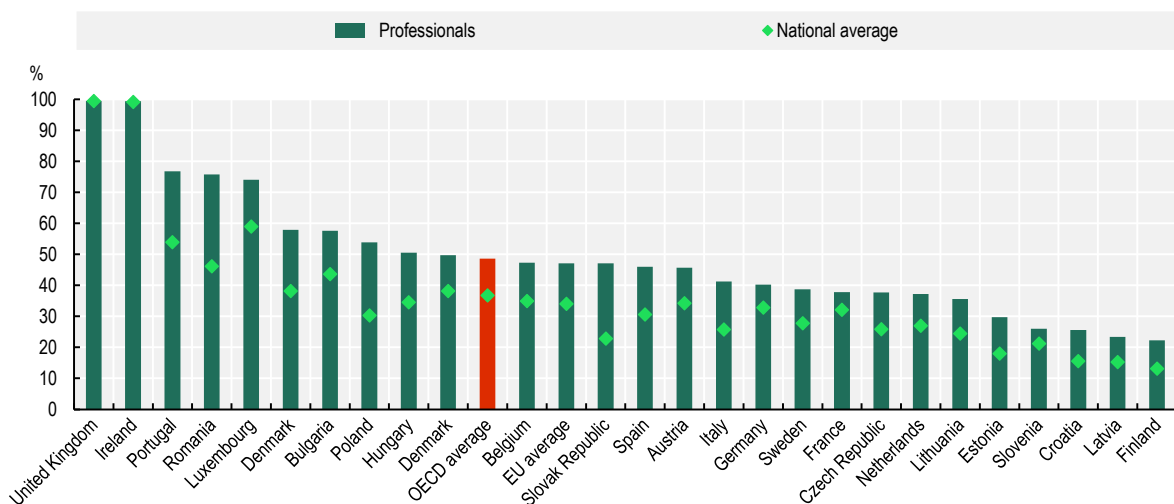
Note: Countries are sorted in descending order of the number of vacancies explicitly or implicitly requiring English among professionals. These are vacancies either specifying English as a required skill in the vacancy text or vacancies that were written in English. "National average" refers to the average in a specific country across all occupational groups.
Source: Calculations based on Lightcast, (2023[5]), Lightcast™, (accessed April 2023), https://lightcast.io, according to the methodology described in Marconi, Vergolini and Borgonovi, (2023[2]), "The demand for language skills in the European labour market: Evidence from online job vacancies", https://doi.org/10.1787/e1a5abe0-en

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Official languages remain critical for individuals to integrate in local labour markets

Countries around the world acknowledge the importance of language for exchange, cultural integration and labour market opportunities. Although language skills are important for effective information exchange across linguistic communities, and English language skills are critical in this respect, mastering the official

language/s of a country remains crucial for labour market and social integration. Proficiency in the official language/s of a country remains crucial if individuals are to be able to access labour market opportunities available in a country and, by extension, labour markets remain closed off to individuals who lack such language proficiency. Although in many countries, employers lament a lack of qualified workers to fill available positions, and, by contrast, many workers lament a lack of opportunities to use their skills effectively in the labour market, language remains an important barrier to tackle skill mismatch and skill shortages.

The importance of mastering the official language/s of a country has been extensively studied in the context of labour market and social integration of migrant communities. The literature has identified large returns for immigrant communities associated with acquiring the language spoken in the host country (Bleakley and Chin, 2004[7]; Chiswick and Miller, 1995[8]; Dustmann and Fabbri, 2003[9]; Dustmann and Soest, 2001[10]). This is especially the case in Europe, a large, linguistically diverse community of more than 500 million people and 24 official languages in which, thanks to the European Common market, the free movement of goods, capital, services, and people is guaranteed. According to the Council of the European Union "language competences contribute to the mobility, employability and personal development of European citizens, in particular young people, in line with the objectives of the Europe 2020 strategy for growth and jobs" (Council of the European Union, 2014, p. 2[11]).

Table 7.2 shows the percentage of job vacancies posted on line in 2022 that were written in the official language/s of the country as well as the percentage of vacancies that were written in English, German, Spanish or French. Results reflect language requirements in job offers posted on line and may, therefore, not fully represent labour market opportunities. In particular, it is possible that online vacancies may tailor employment profiles that are more likely to require basic levels of digital skills and greater language competencies. Whereas French, German and Spanish are little used as the language in which vacancies are written outside of the countries in which they are official languages, vacancies written in English make up around 5-10% of vacancies in many countries.

Table 7.2. Implicit language requirements in European countries, 2022

	Official language/s	English	German	French	Spanish
Austria	92.00	6.76	91.84	0.06	0.01
Belgium	90.58	8.98	0.53	14.93	0.01
Bulgaria	52.50	22.43	4.93	0.15	0.60
Croatia	87.84	6.05	0.22	0.35	0.06
Czech Republic	88.52	4.55	0.53	0.00	0.00
Denmark	80.57	18.64	0.17	0.01	0.00
Estonia	82.91	8.14	6.40	0.10	0.02
EU average	82.00	13.85	13.85	3.43	0.40
Finland	93.84	5.38	0.06	0.01	0.00
France	97.75	1.66	0.18	97.75	0.10
Germany	96.10	3.38	96.10	0.04	0.01
Greece*	53.31	34.86	1.71	1.33	0.89
Hungary	71.21	21.12	1.36	0.48	0.66
Ireland	98.94	98.94	0.27	0.14	0.06
Italy	89.81	7.56	0.64	0.91	0.16
Latvia	93.93	3.78	1.13	0.00	0.02
Lithuania	87.97	8.35	1.68	0.00	0.52
Luxembourg	61.22	38.25	3.90	57.32	0.02
Netherlands	90.74	8.07	0.71	0.08	0.01
Poland	82.20	17.49	0.08	0.00	0.00
Portugal	46.71	39.72	2.71	1.35	4.95
Romania	61.94	29.86	1.09	0.56	1.15

	Official language/s	English	German	French	Spanish
Slovak Republic	82.33	10.32	0.86	0.69	0.02
Slovenia	94.92	1.82	0.70	0.02	0.00
Spain	81.63	16.19	0.97	0.42	77.44
Sweden	90.54	9.15	0.04	0.01	0.01
Switzerland	82.58	15.98	74.41	7.34	0.02
United Kingdom	99.32	99.32	0.17	0.06	0.01

Notes: Countries are sorted alphabetically. The EU average includes countries that are members of the European Union in the sample. The EU average excludes for each column, countries with values higher than 80% in the respective language requirement (i.e. Ireland and the United Kingdom are excluded for English; Austria and Germany are excluded for German; Spain is excluded for Spanish; and France is excluded for French). *It is possible that the language model used to extract vacancies misclassifies non-roman alphabets such as Greek and Cyrillic.
Source: Calculations based on Lightcast, (2023[5]), Lightcast™, (accessed April 2023), https://lightcast.io, according to the methodology described in Marconi, Vergolini and Borgonovi, (2023[2]), "The demand for language skills in the European labour market: Evidence from online job vacancies", https://doi.org/10.1787/e1a5abe0-en.

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Many countries beyond Europe recognise the importance of knowing and understanding the local language in order to more successfully enter the labour market. For example, in Australia, it is crucial for prospective employees to speak English. A study found that an individual's English language skills influences their prospects of employment and contributes to their possibility of getting more "secure" and "better" jobs (Roshid and Chowdhury, 2013[12]). Meanwhile, in Canada to apply for a work permit, an individual must demonstrate that they have the minimum French and English language ability required for their job category (Government of Canada, 2014[13]; Government of Canada, 2023[14]). More generally, proficiency in one of the official languages (French or English) is an important factor for issuance of Canadian work, because a person's ability to communicate with other employers, customers, clients and emergency services is a basic requirement for most jobs (Karas, 2020[15]).

Japan also has a language requirement test – known as the Japanese Language Proficiency Test (JLPT) – that foreigners need to have completed in order to be eligible to work in the country. The level required to achieve depends on the company and the positions one applies for but conventionally it is considered that a JLPT level 2 is the minimum requirement for working in a company (with level 1 being the highest level) (CCI France Japon, n.d.[16]). Similarly, Korea requires foreigners to take the Test of Proficiency in Korean (TOPIK) language exam – a test to measure the Korean language proficiency of non-native speakers in South Korea (TOPIK Guide, n.d.[17]).

7.2.2. Adults' language skills proficiency varies across countries and by level of education

Whether or not adults can use a language other than their mother tongue varies across countries and the share of adults who cannot use a language other than their mother tongue has decreased over time. Figure 7.2 shows the share of the adult population in European countries who reported not being able to use any language that was not their mother tongue in 2007 and 2016 (the year with the latest available data). On average, across OECD countries in the sample, 23% of respondents in 2016 reported that they could not use any language other than their mother tongue, compared to 29% in 2007. The percentage of adults who could not use any language other than their mother tongue in 2016 was highest in the United Kingdom (65%) and lowest in Sweden (3%). Figure 7.2 further reveals that in Denmark, Estonia, Finland, Latvia, Lithuania, Luxembourg, Norway, Sweden and Switzerland in 2016, less than 10% of adults indicated being unable to use any language other than their mother tongue language/s. In most countries with available data in both 2007 and 2016, the share of adults who reported not being able to use any language that was not their mother tongue decreased. However, this share increased by over 30 percentage points in the United Kingdom, from 35% in 2007 to 65% in 2016.

Figure 7.2. Share of adults who do not know a language other than their mother tongue, 2007 and 2016

Percentage of 25 to 64 year-olds who reported that they could not use any non-mother-tongue language
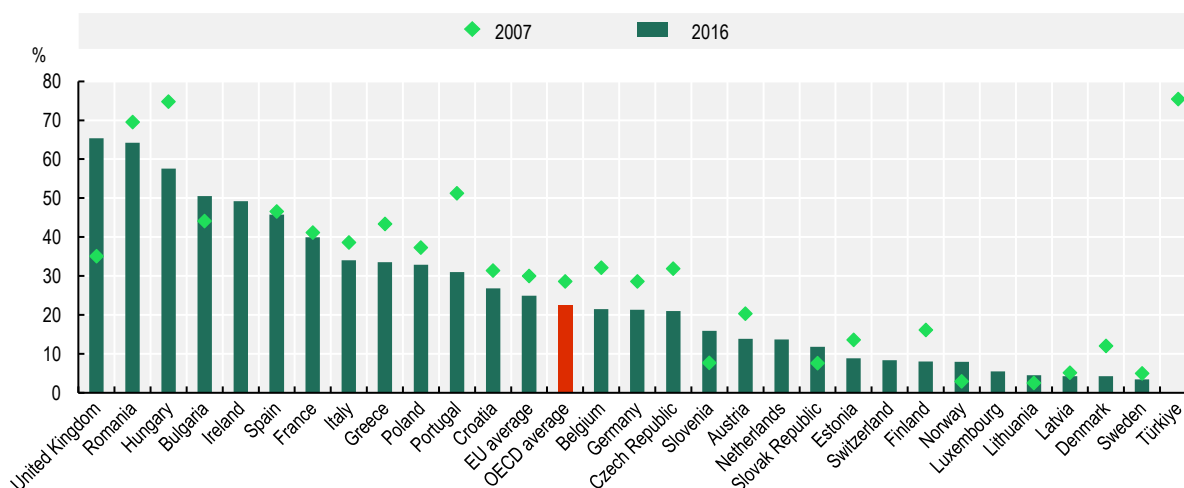
Note: Countries are ranked in descending order of the share of 25 to 64 year-olds who reported that they could not use any non-mother-tongue language in 2016. In 2007, estimates for the following countries were not available: Ireland, Luxembourg, the Netherlands and Switzerland. In 2016, estimates were not available for the Republic of Türkiye.
Source: Eurostat (2007[18]), *Adult Education Survey 2007*, https://ec.europa.eu/eurostat/web/microdata/adult-education-survey; Eurostat (2016[19]), *Adult Education Survey 2016*, https://ec.europa.eu/eurostat/web/microdata/adult-education-survey.

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The share of adults not able to use a language other than their mother tongue varies not only across countries but also across educational attainment, with higher educational levels decreasing the likelihood of not being able to use another language (other than one's mother tongue). Figure 7.3 illustrates that on average, across countries in the sample, 10% of respondents who indicated having obtained a tertiary degree reported that they could not use a language other than their mother tongue. This figure was 23% among individuals with an upper secondary degree and 41% among those with, at most, lower secondary qualifications. In all countries, individuals with tertiary qualifications were less likely to report being unable to use a language other than their mother tongue than those without tertiary qualifications. In the Netherlands, Estonia, Luxembourg, Croatia, Austria, Switzerland, Portugal, Finland, Denmark, the Czech Republic, Lithuania and Latvia, less than 5% of adults with a tertiary level qualification reported not being able to use any language other than their mother tongue, while in no country did less than 5% of individuals with less than an upper secondary degree report the same. Differences between tertiary-educated adults and adults who obtained at most a lower secondary degree were most pronounced in Romania, with 90% of individuals with less than an upper secondary degree not being able to use a language other than their mother tongue and 13% of individuals with a tertiary level qualification reporting the same.

Figure 7.3. Share of adults who do not know a language other than their mother tongue, by educational attainment, 2016

Percentage of 25 to 64 year-olds who reported that they could not use any non-mother-tongue language
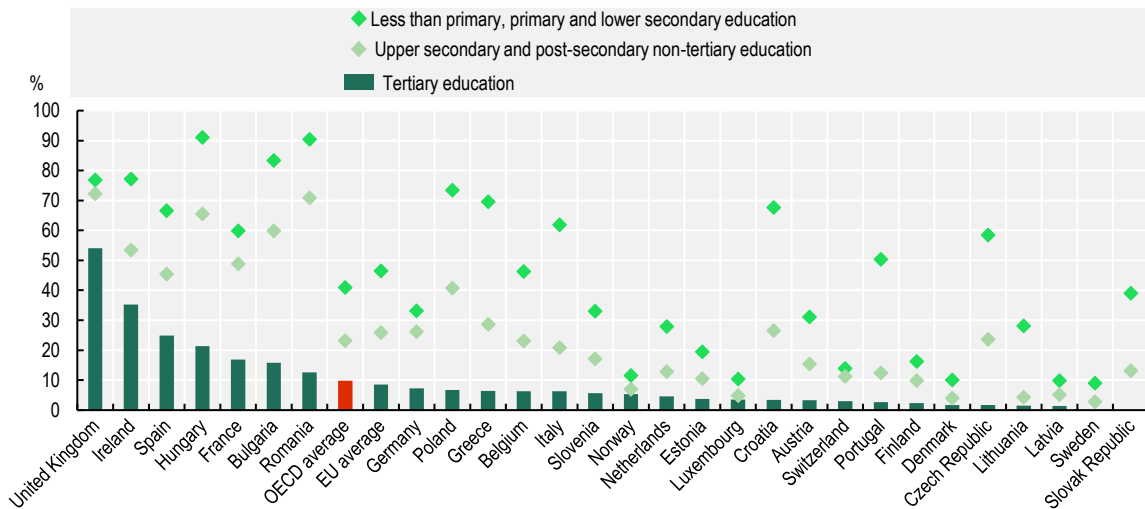
Note: Countries are ranked in descending order of the share of 25 to 64 year-olds with a tertiary level qualification who reported that they could not use any non-mother-tongue language. Data are not reported for Sweden and the Slovak Republic due to the low reliability of estimates. No information was available for the Republic of Türkiye.
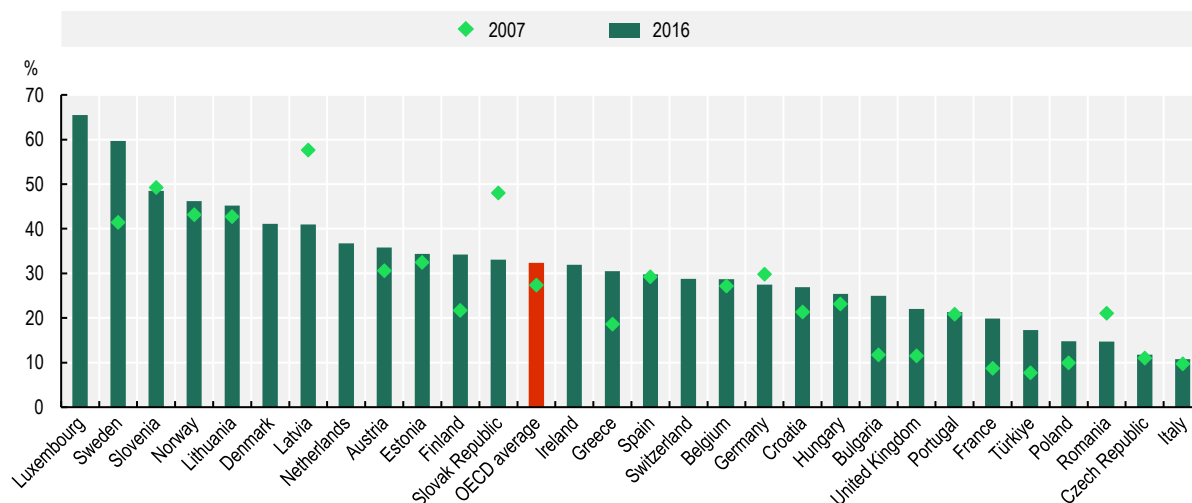
Source: Eurostat (2016[19]), *Adult Education Survey 2016*, https://ec.europa.eu/eurostat/web/microdata/adult-education-survey.

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Proficiency levels vary among adults who know another language other than their mother tongue. Figure 7.4 reveals the share of individuals who indicated being proficient (can understand a wide range of demanding texts and use the language flexibly) instead of having good (can understand the essentials of clear language and produce simple text) or basic (can understand and use the most common everyday expressions) levels of proficiency among individuals who indicated being able to use at least one non-mother-tongue language. On average, across countries with available data, in 2016, 32% of individuals indicated being able to master almost completely the non-mother-tongue language in which they felt most proficient, whereas, in 2007, 27% of individuals reported the same. In Luxembourg, Sweden, Slovenia, Norway, Lithuania, Latvia and Denmark, over 40% of adults who could use at least one non-mother-tongue language indicated being proficient users of such language in 2016. By contrast, in Poland, Romania, the Czech Republic and Italy, less than 15% of adults who could use at least one non-mother-tongue language indicated being proficient users of such language in 2016. These data could reflect differences in self-perceived ability rather than actual proficiency levels. In addition, the figure reveals that the share of proficient users has increased over time. Only in Latvia, the Slovak Republic, Germany and Romania did the share of proficient users decrease between 2007 and 2016. Box 7.1 illustrates efforts undertaken by the OECD's Programme for International Student Assessment (PISA) to assess English language proficiency in the context of its international benchmarking efforts.

Figure 7.4. Share of adults who are proficient in their best-known language after their mother tongue, 2007 and 2016

Percentage of 25 to 64 year-olds who reported being proficient in the non-mother-tongue language that they indicated knowing the best

Note: Countries are ranked in descending order of the share of 25 to 64 year-olds who indicated, "I can understand a wide range of demanding texts and use the language flexibly. I master the language almost completely" regarding the non-mother-tongue language that they considered to know the best in 2016. In 2007, estimates for the following countries were not available: Denmark, Ireland, Luxembourg, the Netherlands and Switzerland.

Source: Eurostat (2007[18]), *Adult Education Survey 2007*, https://ec.europa.eu/eurostat/web/microdata/adult-education-survey; Eurostat (2016[19]), *Adult Education Survey 2016*, https://ec.europa.eu/eurostat/web/microdata/adult-education-survey.

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Language proficiency also varies by educational attainment, with higher educational attainment levels being associated with a higher likelihood of being a proficient language user. Figure 7.5 illustrates differences in self-reported language skills proficiency among individuals with different levels of education. On average, across countries with available data, in 2016, 44% of 25-64 year-olds with a tertiary degree indicated being able to master almost completely the non-mother-tongue language in which they felt most proficient. Among 25-64 year-olds with an upper secondary degree, this figure was 26%, and among those with, at most, a lower-secondary degree, it was 24%. In Luxembourg and Sweden, over 70% of 25-64 year-olds with a tertiary degree indicated being able to master almost completely the non-mother-tongue language in which they felt most proficient, whereas in Italy and the Republic of Türkiye (hereafter 'Türkiye'), this share was 22% and 17%, respectively. Luxembourg and Sweden were the countries with the largest share of individuals with at most a lower secondary degree who indicated being able to master almost completely the non-mother-tongue language in which they felt most proficient: in Luxembourg, 40%, and in Sweden, 47% so reported. Differences related to educational attainment in self-reported language skills proficiency were largest in Greece, where 41% reported being proficient among those with a tertiary degree and 10% reported being proficient with, at most, a lower secondary degree.

Figure 7.5. Level of proficiency in the best-known non-mother-tongue language among adults in European countries, by educational attainment, 2016

Percentage of 25 to 64 year-olds reporting being proficient in the best-known non-mother-tongue language by educational level
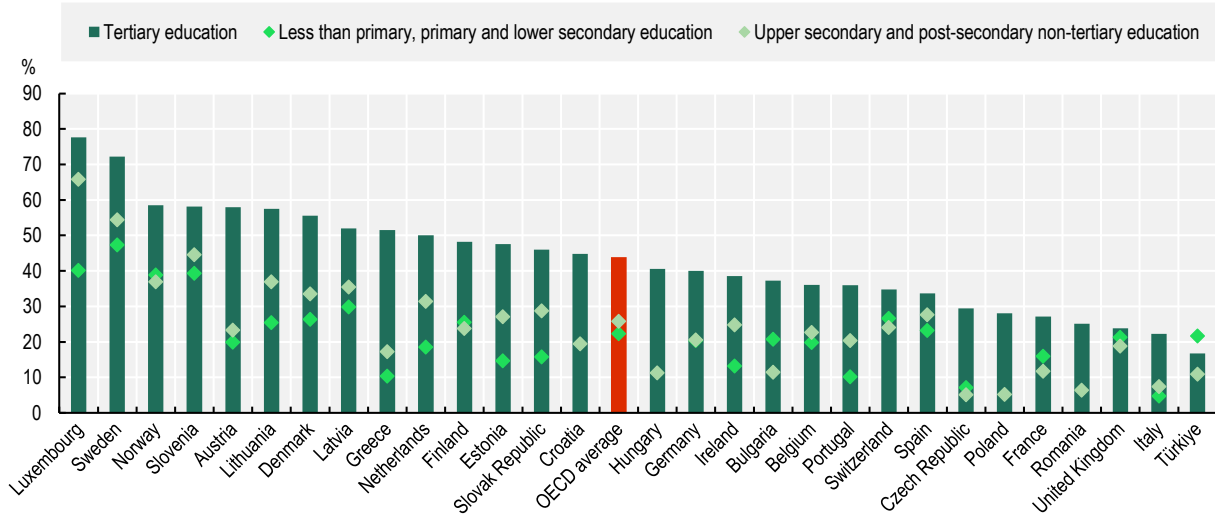
Note: Countries are ranked in descending order of the share of 25 to 64 year-olds with a tertiary degree who indicated, "I can understand a wide range of demanding texts and use the language flexibly. I master the language almost completely" regarding the non-mother-tongue language that they considered to know best in 2016. Data for "Less than primary, primary and lower-secondary education" are not available for the following countries: Croatia, Hungary, Poland and Romania.
Source: Eurostat (2016[19]), *Adult Education Survey 2016*, https://ec.europa.eu/eurostat/web/microdata/adult-education-survey.

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Box 7.1. The PISA 2025 Assessment of Foreign Language Skills

For the first time, the PISA 2025 cycle will include an optional foreign language assessment, which will assess the main foreign language competences needed to study and work in a globalised world. The assessment will be implemented every two PISA cycles, allowing for trend analyses. The assessment, which will first be implemented in PISA 2025, will provide policy makers and educators with comparable results of their students' foreign language competence and allow them to gain insights into the best practices and policies for teaching and learning a foreign language. Twenty-two countries and economies have signed up for this option in 2025, allowing for a diversity of contexts and richness in the analyses of best practices.

The first cycle will assess English as a foreign language and hence be referred to as the PISA 2025 Foreign Language Assessment-English. It will focus on the three skills of reading, listening and speaking (more specifically, on reading comprehension, listening comprehension and spoken production). The intention is to add other languages and skills in future cycles, subject to interest and technical feasibility.

The assessment will describe students' reading, speaking and listening proficiency in English as a foreign language, inter-correlations of these three skills, and correlations between reading in the language of instruction and reading in English as a foreign language.

The framework builds on other international experiences of assessing foreign languages, in particular, the Common European Framework of Reference for Languages (CEFR) descriptive scheme and a socio-cognitive model of language use. The results will be reported on the CEFR level descriptors, which correspond to a progression in language competence; for each level, a series of "can-do" statements indicate what language learners whose competence falls within that level are typically able to do. The levels covered in PISA 2025 will be from Pre-A1 to C1. The use of these globally recognised scales will facilitate easy and appropriate interpretation of PISA results by educators and policy makers.

In addition to the cognitive assessment, this option will collect data on the background factors related to foreign language teaching and learning.

Note: For more information on the cognitive framework, see the *PISA 2025 Foreign Language Assessment Framework* at www.oecd.org/pisa/foreign-language/PISA-2025-FLA-Framework.pdf and the Framework brochure at www.oecd.org/pisa/foreign-language/PISA-2025-FLA-Framework-Learning-Another-Language.pdf.

7.2.3. In most school systems in Europe, children learn at least one modern language at school

The use of language has complex implications for identity, social integration, education and development. Therefore, whether languages are preserved or not has important geopolitical implications in multicultural and globally connected societies. Estimates suggest that every two weeks, a language becomes extinct, often leaving little written record of the cultural and intellectual heritage accumulated with its use. Around 40% of the languages that remain in use are endangered, with only a few hundred languages being used in public education systems (UNESCO, 2010[20]). International efforts, such as the celebration of the International Year of Indigenous Languages in 2019, the International Decade of Indigenous Languages (2022-32) and the UNESCO Recommendation concerning the Promotion and Use of Multilingualism and Access to Cyberspace (UNESCO, 2003[21]) represent important attempts to preserve, revitalise and promote languages that are at risk of going extinct.

The period when young people learn a first language or an additional language in pre-primary, primary and general secondary education differs across European countries (Box 7.2 sheds light on language learning in selected countries outside Europe in particular in the United States, Japan and Colombia). Figure 7.6 shows that in virtually all education systems (excluding Ireland), learning at least one modern language in addition to the language of instruction is compulsory in school. In this chapter, the term modern language is used instead of the term foreign language since for some children this language may be their native language or one of their native languages. Moreover, the term foreign language would be incorrect in countries in which regional and/or minority languages are not treated separately from "foreign" languages. The duration of compulsory learning of a first modern language varies between 7 years in the Netherlands and 16 years in Luxembourg and Poland. In most education systems, learning a first modern language is compulsory for between 11 and 13 years of schooling.

Figure 7.6. Period during which learning a modern language other than the main language of instruction was compulsory in pre-primary, primary and/or general secondary education in 2021/22 in European countries

Starting age and finishing age during which learning a modern language was compulsory in pre-primary, primary and/or general secondary education.
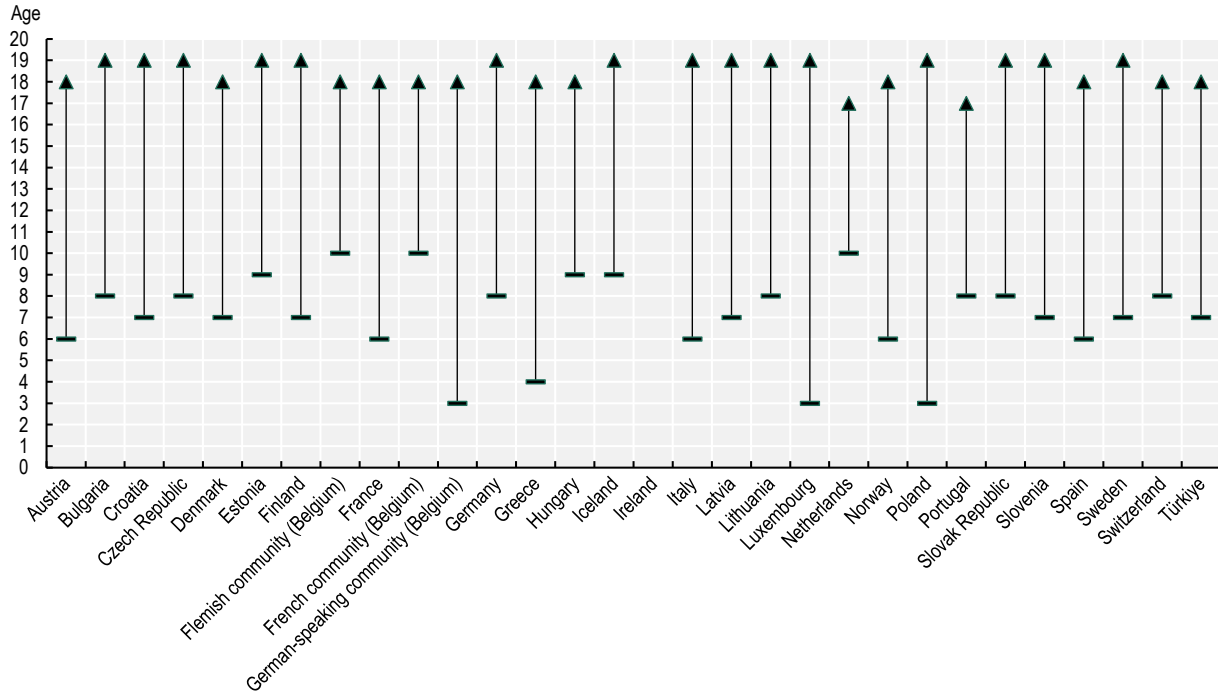
Note: Regional and/or minority languages and classical languages are included only when the curriculum designates them as alternatives to modern languages. Information is based on the curriculum or other steering documents issued by top-level education authorities. In Ireland, no compulsory modern/ language training exists.

Source: European Commission/EACEA/Eurydice (2023[22]), Key data on teaching languages at school in Europe – 2023 edition, https://eurydice.eacea.ec.europa.eu/publications/key-data-teaching-languages-school-europe-2023-edition.

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Figure 7.7. Period during which the learning of two modern languages was compulsory in pre-primary, primary and/or general secondary education in 2021/22 in European countries

Starting age and finishing age during which learning two modern languages was compulsory in primary and/or general secondary education
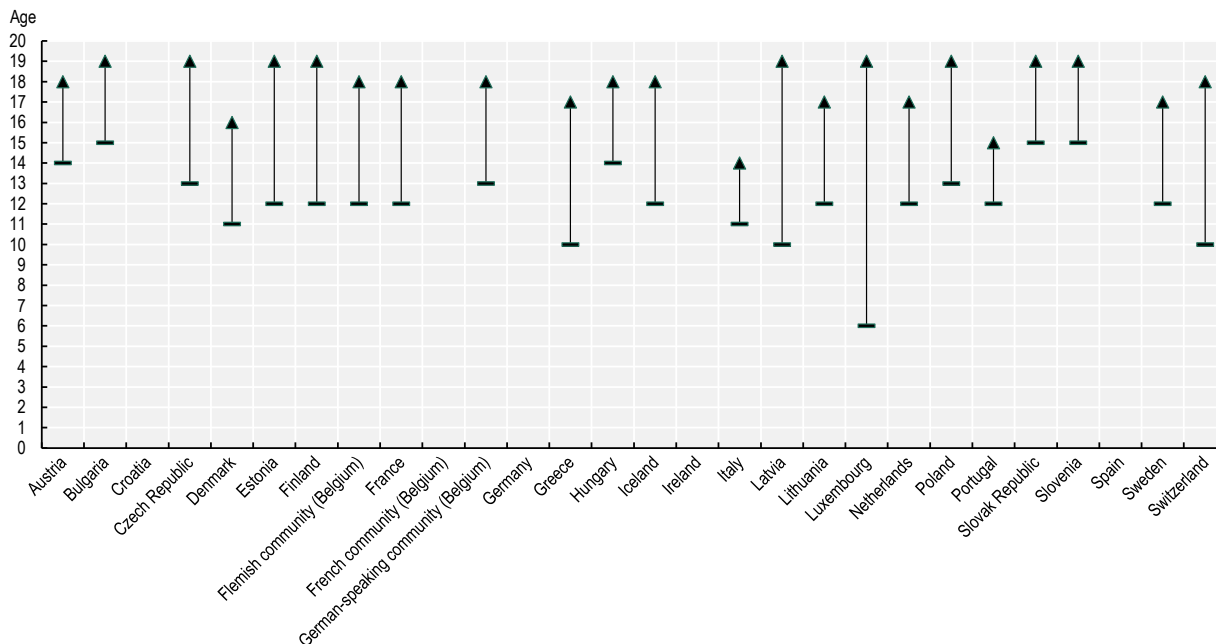

Note: Regional and/or minority languages and classical languages are included only when the curriculum designates them as alternatives to modern languages. Information is based on the curriculum or other steering documents issued by top-level education authorities. In Ireland, no compulsory modern language training exists. "Second language" means a language students learn in addition to a first modern language, resulting in students learning two modern languages simultaneously. In Belgium (French Community), Croatia, Germany, Ireland and Spain, a second modern language is not compulsory. Information on Sweden is based on Skollag (2010:800) 10 kap §4; Skolförordning (2011:185), 15 kap, § 3; Gymnasieförordningen (2010:2039).
Source: European Commission/EACEA/Eurydice (2023[22]), *Key data on teaching languages at school in Europe – 2023 edition*, https://eurydice.eacea.ec.europa.eu/publications/key-data-teaching-languages-school-europe-2023-edition.

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Children as young as three are expected to start learning a modern language in the German-speaking community of Belgium, Luxembourg and Poland. In contrast, language learning is not compulsory until the age of ten in the Netherlands. In many education systems, compulsory language learning starts at the beginning of primary education. In Austria, France, Italy, Norway and Spain, children start learning a modern language in addition to the language of instruction at the age of six, whereas, in Croatia, Denmark, Finland, Latvia, Slovenia, Sweden and Türkiye, children start at the age of seven.

There is less variation in the age until which learning a first modern language in addition to the language of instruction is compulsory. In all countries, students are required to learn a second language until between the age of 17 and 19. Figure 7.7 suggests that in many education systems, a second compulsory modern language is part of the curriculum and that such a second language is typically studied for between five and nine years of schooling. In many countries, studying a second modern language becomes compulsory only in secondary school; except for Luxembourg (where learning a second modern language is compulsory from age six), in all other education systems, learning a second modern language starts at age 12 or above.

Box 7.2. Language learning in the United States, Japan and Colombia

United States

In contrast to the majority of European countries in which learning modern languages is compulsory in pre-primary, primary and/or general secondary education (Figure 7.6), no such national standard exists in the United States. Instead, whether or not language learning requirements exists are determined at the school district or state level. Only 11 states have clear modern language graduation requirements (American Councils for International Education, 2017[23]). Therefore, enrolment in modern language education highly differs across states varying between 9.09% (Arkansas) and 51.18% (New Jersey) of the total school age population, with the majority of students being enrolled in Spanish language courses, followed by French and German.

Japan

Over the past years, the importance of international education in the school education curriculum in Japan has grown and the teaching and learning of modern languages expanded. The *English Education Reform Plan Corresponding to Globalization* by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) (MEXT: Ministry of Education, Culture, Sports, Science and Technology, 2014[24]) was released in 2013 and is to be implemented gradually until 2020. Following the reform, English language instruction begins in elementary school with English language activity classes 1-2 times per week in the third and fourth grades, English language classes 3 times per week in the fifth and sixth grades, and continue throughout lower and upper secondary school.

Colombia

Colombia is consistently updating its educational polices to promote language instruction in the country. While the introduction of English language instruction in the school curriculum dates back to 1979, several changes in the last two decades mark Colombia's path toward developing bilingual language skills among students (Cifuentes, Mejía and Nates, 2018[25]). In 2004, the National Bilingual Program NBP (Programa Nacional de Bilingüismo) was introduced, which among interventions, promoted the introduction of measures to evaluate student performance, defined English proficiency standards (e.g. B1 level for high school graduates by 2019) and developed projects for school teachers. In 2010, the NBP was updated through the Foreign Languages Competencies Development Program (PFDCLE) to further promote English language learning in Colombia, for example by setting specific English proficiency targets, such as the percentage of high school graduates achieving at least B1 and university graduates achieving B2 (Cifuentes, Mejía and Nates, 2018[25]; Universidad de Antioquia, n.d.[26]). The Bilingualism Law (Ley de Bilingüismo) was issued to adapt the General Education Law which regulates the supply of education to for example specify the goal of English language instruction (Universidad de Antioquia, 2013[27]). In 2015, the National Plan of English (Programa Nacional de Inglés) was launched. The Plan enhances English language learning in Colombia through three key components: 1) teacher training strategies and pedagogical materials for basic and secondary education (e.g. extension of hours of English lessons, provision of English lessons outside the classroom); 2) quality, support and financing of English learning in higher education (e.g. facilitate free access to a free virtual platform); 3) English learning outside school (e.g. communication campaign to promote English language training for businesses and individuals in the workforce) (Gómez Sará, 2017[28]; Universidad de Antioquia, n.d.[26]; Ministerio de Educación Nacional, n.d.[29]).

7.2.4. Adolescents enrolled in vocational education and training programmes are less likely to study modern languages

The opportunity to learn modern anguages differs depending on whether students enrol in general upper secondary education or vocational upper secondary education programmes. Figure 7.8 suggests that in all education systems, except for Portugal, Ireland, Denmark, Iceland and Greece, over 95% of students enrolled in general upper secondary education programmes undertake a modern language course. On the other hand, in most education systems in the same countries, students in vocational education and training programmes are much less likely to attend modern language courses.

In Denmark, Iceland, Spain and Germany, over 50% of students enrolled in vocational upper secondary programmes do not attend any modern language courses in their programme. By contrast, in many education systems, a large share of students enrolled in general upper secondary programmes learn two modern languages or more: in Slovenia, Estonia, France, Belgium (Flemish Community), the Czech Republic, Croatia, Finland, Norway and Luxembourg, 90% or more of students enrolled in general upper secondary programmes learn two modern languages or more. By contrast, very few students enrolled in vocational upper secondary programmes learn two modern languages or more.

In the majority of countries including Japan (Box 7.2), English is the modern language that is taught the most in school. Figure 7.9 reveals that in Norway, Spain, Austria, Poland, Greece, Latvia, France, Italy, Sweden and Croatia, over 90% of children in primary school learn English in class. By contrast, English was not part of the primary school curriculum in Luxembourg or Belgium (Flemish Community). These are countries with several official languages and where young children are expected to first gain mastery of such languages. In lower secondary schools, participation in English language classes remains high in countries with nearly universal provision at the primary level. It increases markedly in the remaining countries: at the lower secondary level, over 90% of students attend English language classes in all countries except Hungary, Belgium (French Community), Belgium (Flemish Community) and Luxembourg. In several countries, the percentage of students who learn English in upper secondary schools decreases: in Norway, it drops from 95% at the lower secondary level to 43% at the upper secondary level. Similarly, in Denmark, it drops from 100% at the lower secondary level to 54% at the upper secondary level. By contrast, in Belgium (French Community), Belgium (Flemish Community) and Luxembourg, the percentage of students learning English at the upper secondary level increases to 77%, 89% and 84%, respectively.

Figure 7.8. Number of modern languages learnt by students in upper secondary education in European countries, 2020

Percentage of students learning modern languages in general and vocational upper secondary education, by number of languages
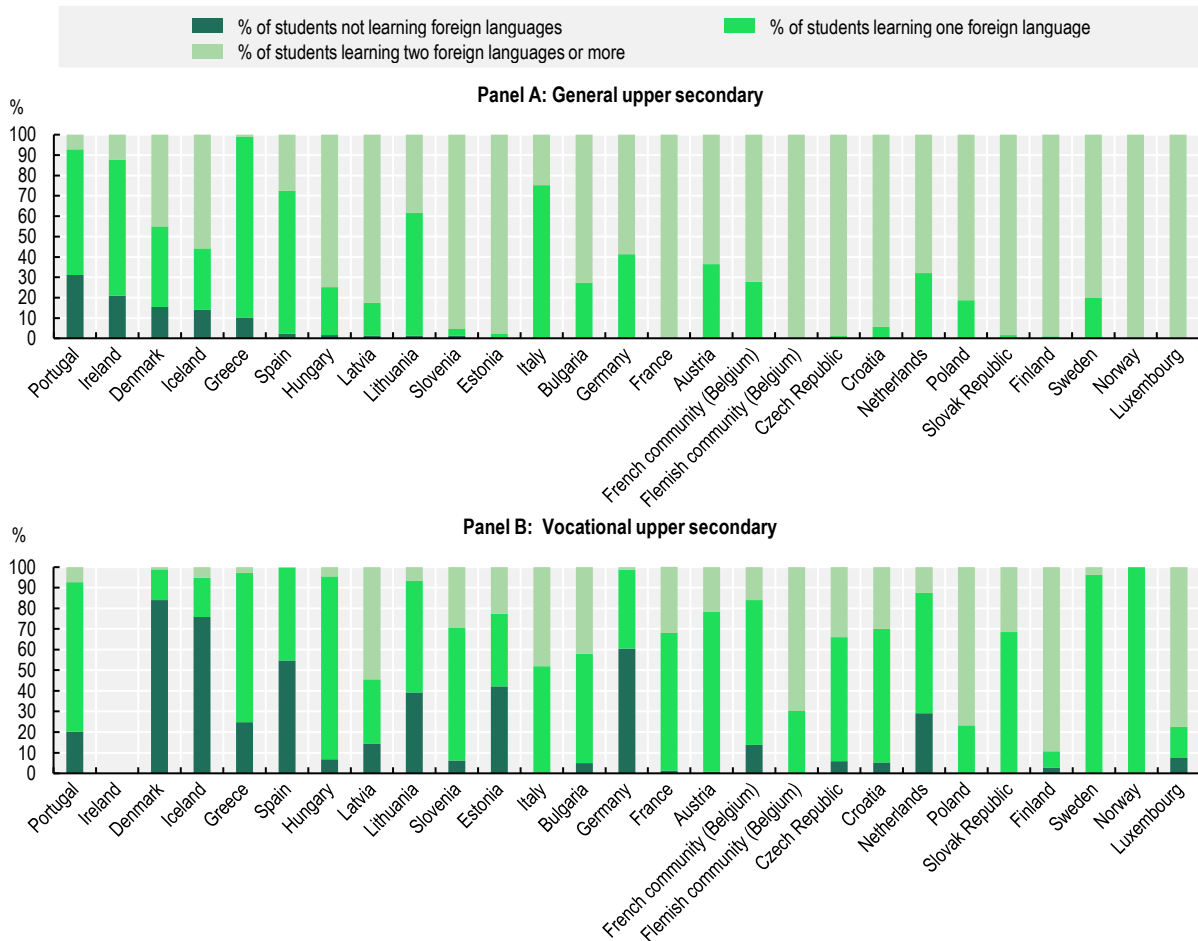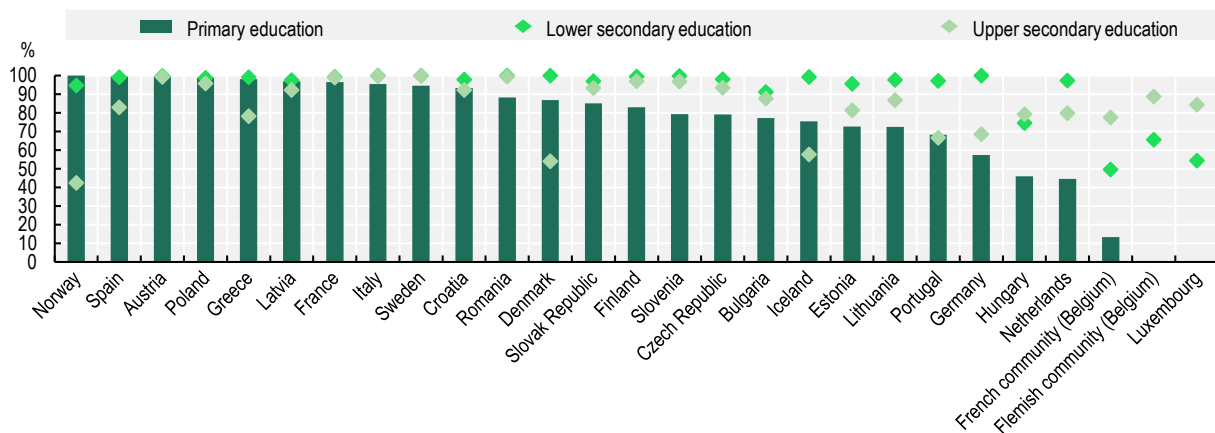

Note: The figure shows the percentage of students learning zero, one or two (or more) modern languages, with percentages being calculated with regard to all students in all years of general International Standard Classification of Education (ISCED) 3 or vocational ISCED 3, even where the language learning does not continue until the end of the level. More concretely, the number of students learning zero, one or two (or more) modern languages is divided by the sum of students learning zero, one or two (or more) modern languages in all years of general ISCED 3 or vocational ISCED 3. Data from Iceland are from 2019 instead of 2020. See Table C5 in European Commission/EACEA/Eurydice (2023[22]).
Source: European Commission/EACEA/Eurydice (2023[22]), Key data on teaching languages at school in Europe – 2023 edition, https://eurydice.eacea.ec.europa.eu/publications/key-data-teaching-languages-school-europe-2023-edition.

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Figure 7.9. Learning English at school in European countries, by educational level, 2020

Percentage of students learning English in primary, lower secondary and upper secondary education

Note: The figure shows the percentage of students learning English in primary, lower and upper secondary education. Belgium (German-speaking Community), Switzerland and the Republic of Türkiye did not participate in data collection. For Ireland, no data are available. For Belgium (Flemish Community), the reference year for ISCED 1 data is 2019 (2020 data on ISCED 1 are not available). For Iceland, the reference year for general and vocational ISCED 3 data is 2019. See Table C9 in European Commission/EACEA/Eurydice (2023[22]).
Source: European Commission/EACEA/Eurydice (2023[22]), *Key data on teaching languages at school in Europe – 2023 edition*, https://eurydice.eacea.ec.europa.eu/publications/key-data-teaching-languages-school-europe-2023-edition.

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7.3. Making the most of artificial machine translation technologies requires the development of new skills

Language skills are the foundational element of inter language communication. Digital mediators such as MT technologies are one of the means individuals have to enhance their communication potential whenever they are not proficient in a language. But in order to effectively use MT technologies, individuals should develop a good knowledge of these tools, their strengths and limitations in different contexts, as well as the ability to use them effectively to achieve their goals. Existing machine translation tools in fact suffer from a number of limitations that make them unsuitable to substitute language skills in many settings. Rather they are useful aids to be used by individuals who are fully aware of their potentials and limitations. Yet, despite the fact that machine translation systems are being used by individuals worldwide to engage in inter linguistic communication, existing language learning courses – whether tailored to young people in school or adults – do not equip learners with such knowledge and ability making language learning incomplete given the existing technological landscape. This section details key features of existing machine translation systems as well as their potentials and limitations to highlight the need for education and training systems to evolve in response to this important technological development.

7.3.1. What are machine translation systems and on what data are they trained on?

Machine translation is the process of automatically translating content from one language (the source) to another (the target). Translation was one of the first applications of computing power, starting in the 1930s. Since the 1980s, machine translation tools have undergone a remarkable transformation with large improvements in quality over time.

A key problem of many existing MT tools is that the quality of translated output differs markedly across languages because of differences in the amount of resources available to train AI systems and the fact that linguistic minorities are rarely represented among AI developers (Fan et al., 2022[30]; Haddow et al., 2022[31]; Lewis, 2020[32]; Time, 2023[33]). Diversity in the quality of the translations produced by MT tools for high-resource and low-resource languages is likely to become more pronounced since recent models used in MT tools such as neural network models produce translations of a higher quality but only when they can rely on large training datasets. Compiling large and diverse datasets for low-resource languages is expensive, logistically challenging or both (Kuwanto et al., 2021[34]; Nekoto et al., 2020[35]; Orife et al., 2020[36]). At the moment, high-resource languages, i.e. languages for which large quantities of training data are available in digital form and for which MT tools work best, are the same languages dominating scientific and social exchanges. Unless this changes, for example, because more digital examples of text become available, improvements in AI technologies could further exacerbate the concentration of prominence to a restricted set of languages rather than reduce existing disparities.

7.3.2. Environmental and social costs, caveats and challenges of machine translation systems

MT development and use have significant technological, cultural, environmental and societal impacts, and individuals and communities should therefore consider these alongside benefits when considering their use and when using them. AI systems, particularly systems that rely on extremely large data inputs, can have major negative environmental impacts (Costa-jussà et al., 2022[37]). MT systems also continue to suffer from linguistic limitations. In particular, MT systems generate low quality output whenever 'untranslatable words' are present and when text reflects a specific cultural context and cultural expectations. Additionally, MT technologies have difficulties evaluating or recognising metaphorical meanings, interpreting and translating hidden or subtle messages, or identifying contextual meanings that are not literal, such as humour, irony or sarcasm (Ducar and Schocket, 2018[38]; Wallace and Kertz, 2014[39]). MT tools are limited in their ability to adjust translations to the cultural context or meet cultural expectations (Ducar and Schocket, 2018[38]).

The development of MT technology is based on language models that require large amounts of data created by humans. Biases in data stemming from existing power structures are among the major issues of concern in AI and machine-learning models (Anaconda, 2020[40]). These biases in AI systems consequently result in incorrect output and discriminatory output and predictions for certain populations (Smith and Ishita, 2020[41]). One of the most prevalent biases is related to gender (Savoldi et al., 2021[42]). MT technology performs less accurately when words or texts translated from a rather gender-neutral text are translated into a language that is not. For example, this could lead to MT technology only providing a single-gendered translation or using a masculine translation by default in male-dominated fields. AI systems are created by humans. Hence, they may integrate and mirror the perspective and knowledge of society of those who develop AI systems (Smith and Ishita, 2020[41]) and women, linguistic and ethnic minorities are severely under-represented among AI developers (Smith and Ishita, 2020[41]).

A final set of limitations pertains to ethical and legal implications. Users should carefully consider issues related to ownership and privacy of the content inputted in MT systems data and the legal responsibility for the consequences associated with potential mistakes in translated documents remain key challenges for the use of machine translations in high-stakes settings.

Should MT technologies improve to the extent that their output will be on a par with the output of proficient language users or the output of language professionals, education systems will face important dilemma over the relevance of their current approaches to teaching and learning and how best they could support students. As technologies evolve, it is crucial for policy makers and educators to continually monitor the evolving capabilities of AI systems, identify the set of skills that will enable individuals to work and live alongside AI, and develop programmes to effectively support the acquisition of such skills.

7.4. The skills of language professionals

Relying on language professionals and their skills is a third way to enable communication, access and exchange information across language groups. Just as machine translation technologies change the set of skills individuals directly engaged in information exchange require, they also change the set of skills human mediators should possess to facilitate the communication of others. Language professionals have a crucial societal role as facilitators of communication across language boundaries as they facilitate trade across economic agents in different countries and language communities. Furthermore, the work of translators entails many of the non-routine tasks that previous waves of technological development did not expose to the threat of automation but which may be exposed due to AI's emerging capabilities related to language.

Worldwide, only few individuals work as language professionals. However, in line with the growing importance of information exchange across language boundaries, evidence from the United States indicates that over the past 20 years, the employment of interpreters and translators has almost tripled. While employment in 2001 amounted to around 20 000, in 2021, more than 50 000 people were employed as interpreters or translators. Furthermore, the employment of interpreters and translators is expected to grow by around 20% between 2021 and 2031, an increase of 15 percentage points above the average growth rate for all occupations (Bureau of Labor Statistics, US Department of Labor, 2022[43]). Similarly, evidence from online vacancies in selected English-speaking and European countries indicates that between 2015 and 2019 the demand for language professionals was relatively constant (Borgonovi, Hervé and Seitz, 2023[3]). At the same time, changes in the way workers carry out their jobs as a result of AI adoption might change the skills individuals need to master since the tasks they are engaged with will differ and, consequently, require workers to reskill or upskill (Lane and Saint-Martin, 2021[44]; Nedelkoska and Quintini, 2018[45]).

From an employer perspective, deploying MT technology is associated with beneficial effects. However, such beneficial effects are not necessarily shared by language professionals [see (Borgonovi, Hervé and Seitz, 2023[3]) for the view of language professionals on the adoption of MT technology in their work]. In particular, language professionals see their profession as being under pressure for three reasons: 1) individuals and institutions commissioning translations generally overestimate the quality of the output generated by AI MT tools and underestimate the amount of time and skills needed to ensure accuracy and quality through post-editing; 2) high levels of skills are needed to be able to work alongside machines – for example to rapidly post-edit text translators need to possess significant knowledge of subject areas the text deals with as well as detailed knowledge of how a particular MT tool operates – and acquiring high levels of skills in post-editing may not be possible without the extensive and direct experience of engaging in the original translation; and 3) some aspects of language proficiency may be lost without the daily use of such skills.

Post-editing skills are among the extended set of linguistic skills needed when MT tools are integrated into the workflow of language professionals (European Commission, 2022[46]; Koponen, Salmi and Nikulin, 2019[47]; Pym, 2014[48]; Rico and Torrejón, 2012[49]). Post-editing means that once MT output is generated, human translators conduct an editing, amending and correction process to achieve high-quality translations (Garcia, 2011[50]; O'Brien, 2002[51]). Because post-editing needs to be done by someone proficient in the target language, post-editing is mostly carried out by professional translators (Vieira, Alonso and Bywood, 2019[52]). With the increased need for post-editing MT output, attempts have been made to harmonise and standardise this process. In 2017, the International Organization of Standards (ISO) developed a standard for post-editing (ISO 18587:2017), which provides the requirements for the process of full human post-editing and post-editors' competences and qualifications (International Organization of Standards, 2017[53]).

Learning to post-edit machine-translated content is also finding its way into the education of language professionals, either as part of the formal education programme or non-formal training and education

(Guerberof Arenas and Moorkens, 2019[54]). Post-editing training, for example, includes knowledge of various kinds of MT systems or MT error analysis (Guerberof Arenas and Moorkens, 2019[54]). This is important since MT accuracy has, despite strong advances over past years, not been able to reach a human level of language proficiency due to limitations related to linguistics and biases.

Another set of skills comprises **instrumental competences** related to technology skills (Rico and Torrejón, 2012[49]). This involves, for example, raising awareness in the profession on the range of available technology that can be used in the translation process (Alcina, Soler and Granell, 2007[55]). Instrumental competences include understanding MT output and their integration into the workflow and knowledge about MT systems and their capabilities (European Commission, 2022[46]; Rico and Torrejón, 2012[49]).

Finally, communication and other socio-emotional skills are key skills for language professionals. A key shortcoming of existing MT tools is that they do not engage in communication. Although adaptive systems can incorporate "feedback" on the quality of their output in new translations, such adaptation is reactive and initiated by users rather than the system itself. MT systems do not have the capacity to express doubt and feel self-doubt, perceive uncertainty about their translation predictions or ask for help. Because existing MT tools cannot understand if, when, and what they do not understand, they do not engage in a process of co-creation with the aim of satisfying the needs and intentions of those who seek their service. Delivering meaningful translations requires mediators to assign meaning to language and adjust translations in response to verbal and non-verbal cues. When human mediators are involved, the language mediation process can become a collaborative effort between the mediator and the individual requesting the mediation. By proposing and weeding out alternatives and understanding context – whether technical and subject-specific circumstances or cultural factors – human mediators can improve quality and generate meaningful content adapted to individual situations. Digital mediators, so far, do not engage in extensive communication with clients. Transversal skills, such as the capacity to work with others, communicate and have cultural and situational awareness, are therefore crucial aspects of the skillset of human language mediators.

7.4.1. Evidence on the skills required of language professionals from online job vacancies

Figure 7.10 illustrates the percentage of online job postings for language professionals mentioning any of the broader skill groups of "knowledge", "transversal" and "digital". **Knowledge skills** represent theoretical and factual knowledge acquired as the outcome of assimilating information through learning (European Commission, Directorate-General for Employment, Social Affairs and Inclusion, 2017[56]). Knowledge-related skills keywords are mentioned most frequently in online job postings of language professionals. Between 2014 and 2019, the share of job postings mentioning knowledge skills was relatively stable: around 95% of job postings mentioned knowledge skills. **Transversal skills**, relevant to a broad range of occupations and economic sectors (European Commission, Directorate-General for Employment, Social Affairs and Inclusion, 2017[56]), are the second-most commonly mentioned skills group among language professionals. In 2015, 47% of postings mentioned transversal skills, while this share increased to around 70% in 2019, an increase of more than 20 percentage points. Finally, the share of **digital skills** remained relatively stable despite small fluctuations between 2015 and 2019. Between 2015 and 2019, the share of postings mentioning digital skills varied between 26% in 2015 and 33% in 2019.

These analyses show that while the demand for digital and knowledge skills remained stable over the study period, there was a slight increase in the demand for transversal skills. This suggests that the increase in the demand for transversal skills did not come at the expense of other skills but rather, that the range of skills required of individual professionals broadened over time.

Figure 7.10. Percentage of online job postings for language professionals mentioning knowledge, transversal and digital skills in English-speaking countries, 2015-19
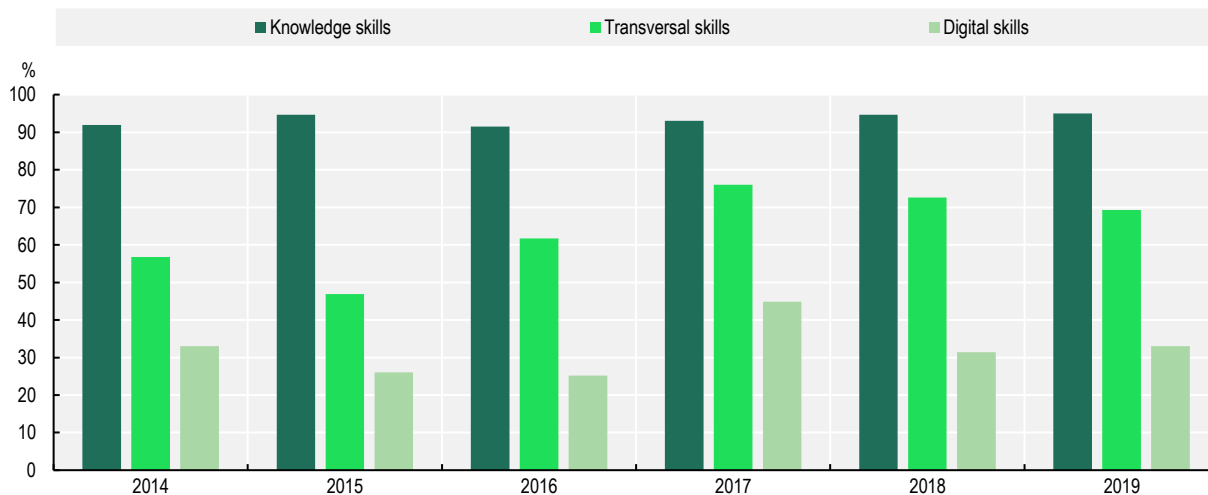
Note: The figure indicates the share of online job postings by language professionals mentioning knowledge, transversal and digital skills for English speaking countries (Australia, Canada, New Zealand, Singapore, United Kingdom, United States). Shares do not add up to 100% since several skills can be mentioned in one posting.
Source: Calculations based on Lightcast (2022[57]), Lightcast™, https://lightcast.io, (accessed December 2022), in Borgonovi, Hervé and Seitz, (2023[3]), "Not lost in translation: The implications of machine translation technologies for language professionals and for broader society", https://doi.org/10.1787/e1d1d170-en.

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Figure 7.11 provides a more granular picture of specific skills categories, in particular the digital skills group, given this chapter's focus on the impact of technology on skills. Even though Figure 7.10 did not show an increasing trend in the demand for digital skills, changes could occur within skills subgroups. Figure 7.11 provides an overview of seven skills groups reflecting digital skills: computer programming; digital data processing; digital content creation; office tools and collaboration software; telecommunications; web development; and writing. Digital skills are required in around one-fifth of online vacancies advertising positions for language professionals. For example, on average, 21% of online job postings requested writing skills; 15% requested skills related to office tools and collaboration software; and 12% requested telecommunication skills. For the remaining skills, they were requested in 10% or less of online vacancies although on average, around one in ten postings for language professionals in English speaking countries requested at least one of the very specific digital skills that are related to the development and use of AI applications (Borgonovi, Hervé and Seitz, 2023[3]).

Examples of highly demanded writing skills include: editing and post-editing; computational linguistics; MT; computer-assisted translation (CAT); and consecutive translation. Examples of highly demanded digital data processing skills include: machine learning; big data; metadata; ArcGIS; and data science. Examples of highly demanded computer programming skills include: AI, C++, Linux, Java and JavaScript.

Figure 7.11. Digital skills groups required in online job postings for language professionals in English-speaking countries, 2015-19

Percentage of online job postings containing at least one skill that belongs to each of the categories
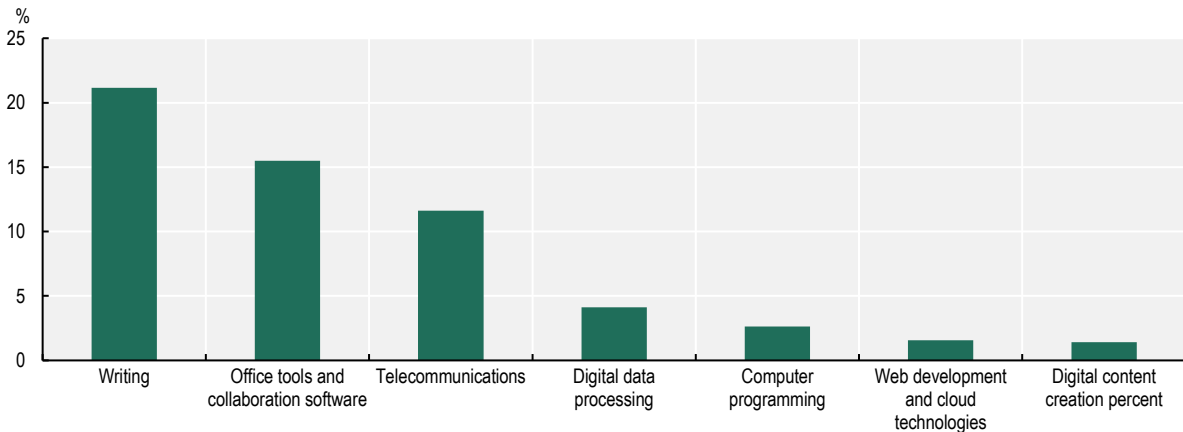
Note: The figure presents the average percentage of online job postings containing at least one skill in each category. For each country – Australia, Canada, New Zealand, the United Kingdom and the United States – the average over the 2015-19 period was calculated, and then the average over the five countries was calculated.
Source: Calculations based on Lightcast (2022[57]), Lightcast™, https://lightcast.io, (accessed December 2022), in Borgonovi, Hervé and Seitz, (2023[3]), "Not lost in translation: The implications of machine translation technologies for language professionals and for broader society", https://doi.org/10.1787/e1d1d170-en.

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Figure 7.12 shows the top 20 out of 60 most frequently mentioned skills groups in online job postings of language professionals between 2015 and 2019. Among the top 20 skills groups, 45% represent transversal skills; 40% represent knowledge skills; and 15% represent digital skills. Among the 20 most frequently mentioned skills groups in postings of language professionals, the top 5 skills groups mentioned in more than 1 out of 5 vacancies were: language skills (84%); communications and media (31%); speaking (23%); medicine and dentistry (22%); and writing (21%). Writing is grouped into the digital skills group because many of the detailed skills in that group have technology aspects. For instance, skills keywords such as computational linguistics, MT and CAT all belong to the writing skills category.

Figure 7.12. The top 20 skills groups demanded of language professionals by employers in English-speaking countries, 2015-19

Percentage of online job postings mentioning one of the top 20 skill groups, by skills group
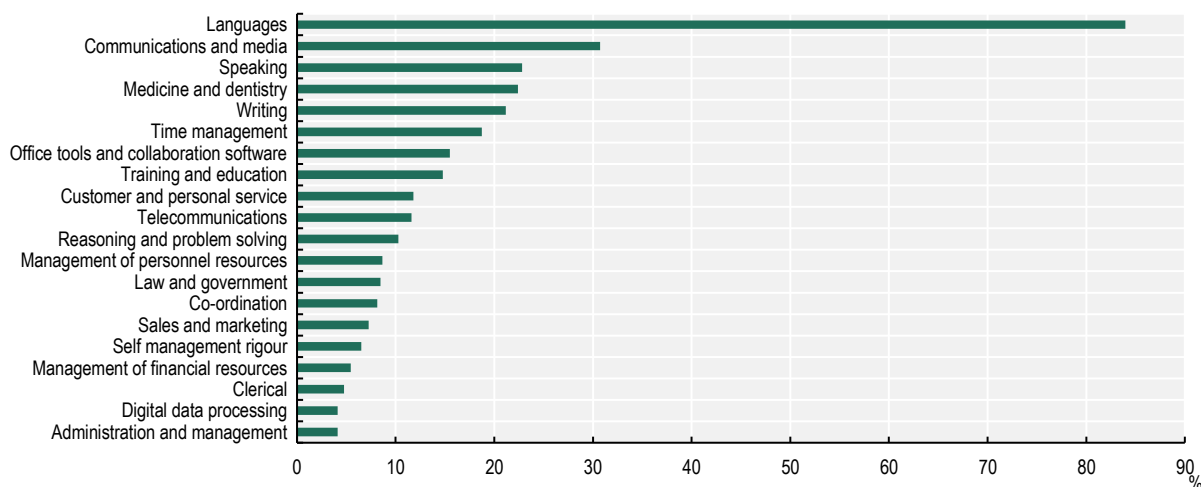
Note: The figure shows the percentage of online job postings mentioning one of the top 20 skills groups. The skill groups are ordered in descending order of the average percentage of online job postings mentioning that skill group between 2015 and 2019. The figure presents the average percentages averaging data from each country – Australia, Canada, New Zealand, the United Kingdom and the United States – over the 2015-19 period.
Source: Calculations based on Lightcast (2022[57]), Lightcast™, https://lightcast.io, (accessed December 2022), in Borgonovi, Hervé and Seitz, (2023[3]), "Not lost in translation: The implications of machine translation technologies for language professionals and for broader society", https://doi.org/10.1787/e1d1d170-en.

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7.5. Conclusions

At both the individual and societal levels, making the most of the opportunities available due to global interconnectedness remains dependent on different economic and social agents being able to understand and communicate with each other. Linguistic diversity is key to the sustainability of communities worldwide, and inter-language communication can favour mutual understanding, global awareness and respect. This chapter has considered the role of developing language skills proficiency and language mediation in societies and labour markets and their implications for education and training systems.

Promoting language acquisition among young people in schools and among adults through participation in language learning brings benefits to individual learners, to labour markets, as well as to broader society. Language is key to intercultural understanding and to being able to access information in different languages. Language also remains an important "intangible" barrier to the movement and allocation of workers. Due to language barriers, some economic sectors may suffer from an oversupply of qualified workers to perform specific tasks. At the same time, other areas may face an undersupply of such workers because workers lack the specific language skills needed to be integrated into another linguistic context.

Across European countries, significant efforts have been made to ensure that individuals will master two other languages in addition to their mother tongue. Most young people start learning a language in either pre-primary or primary school; in many cases, this language is English. A second modern language is introduced for most learners in secondary school, although large differences exist between students who attend general secondary programmes and those who attend vocationally oriented programmes. Students

who take part in vocationally oriented programmes are considerably less likely than other students to attend language learning classes at school. Results indicate that English is the most demanded (and taught) modern language in Europe and the most demanded in labour markets. Although the demand for English language skills is most pronounced in managerial and professional occupations, employers seeking workers in many other sectors also require knowledge of English.

This chapter also considered the role of technological developments in shaping inter-language communication. The introduction of MT tools is reshaping the labour market opportunities of language professionals and the opportunities businesses and individuals have to engage in inter-language communication. There are concerns over the extent to which the introduction of MT technologies and improvements in the capabilities of AI systems may lead to devaluing and deskilling of professionals and lead to lower wages and employment conditions. Many language professionals work as freelancers and initial evidence on the employment outcomes of freelancers on a large online platform following the introduction of the large language model ChatGPT indicates that freelancers experienced reductions in both employment and earnings (Hui, Reshef and Zhou, 2023[58]). The collective agreement reached in Finland in April 2023 establishing minimum rates for self-employed audiovisual (AV) translators represents one effort to reduce the devaluation of the work of language professionals (slator, 2023[59]). Today, language mediation systems are available at one's fingertips: one can request the translation of a text on a smartphone screen and receive immediate and free mediation. An expanded choice set can yield significant societal benefits by broadening access to information produced in multiple languages. At the same time, unless potential users of language mediation systems are educated about the opportunities and limitations of alternative language mediation providers, it is possible that digital mediators will create harm as well as enhance opportunities. In particular, as societies struggle to limit the spread and the deleterious effects of misinformation, disinformation and malinformation, the use of MT technologies could have the unintended effect of making such problems more acute (Caramancion, 2022[60]; Muda et al., 2021[61]). To the extent that un-checked translations of varying levels of accuracy and quality are made available to a larger number of individuals and are accessed by individuals without a critical understanding of the nature of the translation process, MT tools could exacerbate existing problems associated with online content.

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8 The human behind the machine: Skills and attitudes towards the future of artificial intelligence

This chapter considers the role of people and communities in developing and adopting artificial intelligence (AI) technologies. It reveals a significant polarisation of attitudes among adults in OECD countries about the overall impact of AI on people in the next two decades. The demand for professionals with the skills to develop, adapt and maintain AI systems grew between 2019 and 2022 but remained very small overall. Such demand differs across countries and economic sectors. Employers advertising positions for professionals with AI skills generally demand a mix of technical, socio-emotional and foundational skills. Despite increasing ethical concerns over the development and use of AI, virtually no vacancy in 2022 explicitly prioritised ethical aspects or responsible AI development and use. The chapter concludes by considering risk preferences and attitudes towards failure among adults and youth, two attitudes and dispositions which will guide the integration of AI in workplaces and everyday decision making.

Key messages

Artificial intelligence (AI) and robotics have the potential to profoundly impact industries and occupations that rely on data and information, automating a wide range of tasks currently performed by humans. Many of today's political and social tensions arising in response to the automation of tasks revolve around the questions of whether technologies will substitute or complement workers, give rise to better or worse labour market conditions, and ultimately whether they will be associated with an increase or a decrease in labour market opportunities.

This chapter considers the skills humans will need to make the most of technological change. In particular, it explores the demand for workers involved in the development and deployment of AI and the skills demanded of them, including technical skills, socio-emotional and foundational skills, as well as skills related to ethical decision making. The chapter also considers the set of attitudes and dispositions that may shape the readiness of individuals to benefit from large-scale deployment of AI systems.

Key empirical findings include:

- Across OECD countries, 35% of adults in 2021 reported worrying that AI would mostly harm people in the next two decades, whereas 42% believed it would mostly help people.

- Perceptions about the long-term effects of AI on societies differed according to gender, education level and experience with discrimination. For example, on average across OECD countries in 2021, 32% of men but 38% of women indicated that they worried that the long-term impact of AI would be mostly harmful.

- The demand for professionals working in AI development and deployment increased markedly between 2019 and 2022. On average, the share of online vacancies requiring AI skills increased by 33% in 14 countries with available data. In the United States, for example, the country with the highest share of online vacancies requiring AI skills, the increase has been around 22%. However, in a few countries, such as Austria and Sweden, no increase over time has been observed.

- The demand for professionals to fill positions requiring AI-related skills is highly concentrated, both in terms of sectors and in terms of occupations. The majority of job postings in the sample requiring AI skills were for positions referring to Professional Activities (25%), Information and Communications Technology (ICT) (24%), and Manufacturing (13%).

- Employers looking for AI talent require a mix of technical, socio-emotional and foundational skills. Among the top ten AI employers and other AI firms, the skill profiles demanded do not vary substantially, with programming languages accounting for many of the most demanded technical skills, especially Python. This is followed by competencies in Computer and Data Science.

- Only a small minority of firms advertising AI positions mentioned ethics and responsible AI in job adverts for professionals with AI skills. Despite large increases between 2019 and 2022, in 2022, in the majority of countries with available data, less than 1% of AI positions advertised mentioned such keywords.

- Large sections of OECD populations hold negative attitudes towards risk and uncertainty and have high levels of fear of failure. This is more the case among women and girls: for example, 64% of men but 72% of women reported that they associate the word "risk" with danger rather than opportunity. Further, 45% of 15-year-old boys but 61% of girls indicate that failing makes them doubt their plans for the future.

8.1. Introduction

In today's world, data and information are at the core of many economic activities, technological advances, and social exchanges. The increasing reliance on data analytics and the analysis and sharing of information for economic and social decisions, thanks to the development and use of AI, a category of models that make statistical predictions by identifying patterns in existing data, is significantly impacting individuals and societies.

Since AI plays a key role in the use of information and decision making in modern economies and societies, it is crucial to understand the human element behind advances in AI. The continuous evolution of AI systems brings with it different skills needed by AI workers to develop, adapt, and maintain AI applications. Across countries, differences in AI penetration mean that the demand for AI workers and the demand for specific AI-related skills may vary, too. An extensive review of the literature on the skills required in the development, adaptation and maintenance of AI systems and how the demand for professionals with such skills varies across countries, industries and occupations is available in the following technical working paper, which was developed to support the preparation of this report: Borgonovi et al. (2023[1]). Readers interested in the extensive set of analyses and indicators as well as the underlying methodology can consult this working paper.

The emergence of generative AI models has further enhanced the capabilities of AI systems with potentially far-reaching consequences for labour markets and societies more widely. For example, AI could automate tasks previously performed by humans, in particular, outperforming existing workers on tasks that rely on identifying patterns in large data infrastructures, leading to job displacement in certain industries. Early indications suggest that generative AI applications could be positively associated with increases in workers' performance and productivity (OECD, 2023[2]). It could also improve quality of life by enhancing, for example, medical diagnostics and increase efficiency and productivity by automating repetitive tasks, which, however, might also exacerbate existing inequalities.

Over the past few decades, education and training systems have evolved to ensure that individuals can solve non-routine tasks. This transformation was driven by previous waves of technological progress, which emphasised the significance of problem solving alongside technology in the workplace (Autor, Levy and Murnane, 2003[3]; Ikenaga and Kambayashi, 2016[4]; Spitz-Oener, 2006[5]). However, contrary to previous technological advances, AI is a general-purpose technology that has the potential to solve a wide range of non-routine problems, thus posing new demands on education and training systems (Brynjolfsson, Rock and Syverson, 2017[6]). The emergence of AI systems has the potential to significantly reshape the future demand for skills as algorithms and machines become increasingly capable of reliably performing non-routine tasks (Georgieff and Hyee, 2021[7]) and performing at human levels or surpassing human levels in some fields, such as science and reading (OECD, 2023[8]; 2023[9]). On the one hand, technology may obviate the need for humans to perform certain tasks. On the other hand, technologies may complement humans, requiring workers to learn to work effectively with new technologies (Arntz, Gregory and Zierahn, 2016[10]; Georgieff and Hyee, 2021[7]) as some tasks, but not all, will be affected by automation (Bessen, 2016[11]; Lassébie and Quintini, 2022[12]). The way in which AI will affect workers' employment opportunities and job quality will also depend on their occupations. In particular, because AI is a prediction technology in occupations such as managerial occupations in which decisions encompass a judgement-related component, as well as a prediction component, AI adoption might require workers to improve skills complementary to AI, such as managerial decision skills, and skills related to risk management and ethics (Agrawal, Gans and Goldfarb, 2022[13]; OECD, 2023[2]).

Many of today's political and social tensions arising in response to the automation of tasks previously carried out by humans in labour markets revolve around questions of whether digital technologies will substitute or complement workers, whether they will give rise to better or worse labour market conditions, and ultimately whether they will be associated with an increase or a decrease in labour market opportunities. In addition to the direct implications that AI and digital technologies have for productivity and

growth, a crucial aspect of addressing these questions lies in understanding the tasks various technologies can undertake and the skills humans must acquire to effectively harness the benefits of technological advancements (OECD, 2021[14]; Violante, 2008[15]; OECD, forthcoming[16]).

This chapter identifies the human element behind advances in the development and application of AI by analysing skill requirements for individuals engaged in AI development and adaptation across 14 OECD countries – Australia, Austria, Belgium, Canada, France, Germany, Italy, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom and the United States – during the period from 2019 to 2022. Using information derived from vacancies posted on line by prospective employers of AI professionals, the chapter considers differences in the demand for AI professionals – i.e. workers with skills needed to develop, adapt and maintain AI systems – in different sectors, and the range of skills required of AI professionals in general and by large "AI employers" in particular. The chapter also considers to what extent vacancies advertising positions for individuals with AI skills mention aspects related to ethics and responsible use of AI, elements of growing importance given advances in AI adoption and deployment. For the purposes of this Skills Outlook AI skills refer to the skills that are needed to develop, maintain and adapt AI systems and not the broader set of skills that are needed to work with and alongside AI. The chapter further considers some of the attitudes, beliefs and dispositions that may shape how general populations will respond to AI adoption and determine the success of integrating AI systems in labour markets and societies.

8.2. Perceptions about AI differ by country and socio-economic characteristics

AI-powered systems can process large amounts of data, identify patterns and make predictions faster and more accurately than humans, leading to increased efficiency and productivity in various industries. Furthermore, because AI systems can analyse vast amounts of data in a short timeframe and reveal patterns in ways that would be impossible for humans to identify, they can provide valuable insights to support decision-making processes in contexts characterised by large data infrastructures. This could be the case in areas such as healthcare, finance and scientific research, where AI can assist in diagnosing diseases, identifying investment opportunities or accelerating the discovery of new drugs. Finally, AI could provide individualised input to individuals based on their needs and preferences.

On average, across OECD countries, 35% of adults in 2021 reported worrying that artificial intelligence in the next two decades would "mostly harm", and 42% believed it would "mostly help", with the rest having no opinion, declining to answer or indicating that AI would neither help nor harm (Figure 8.1). However, countries differ significantly in terms of perceptions of AI. For example, in Portugal, over 50% of individuals worried that AI would mostly harm people in the next 20 years, whereas in Korea, Japan and Iceland, less than 20% did. Similarly, in Korea, Finland and Japan, over 60% of people reported believing that AI will mostly help people; in Chile, Croatia, Portugal and Colombia, less than 30% did. Across OECD countries, as many as 18% of adults indicated not having an opinion on the likely impact of AI, and in Iceland, as many as 35% of adults reported the same. In contrast, in Korea and Italy, only 9% indicated not having an opinion.

Figure 8.1. Adults' perception of the long-term impact of AI in selected countries, 2021

Percentage of adults who perceive AI in the next 20 years to "mostly help", "mostly harm", had "no opinion" or "neither/refused"
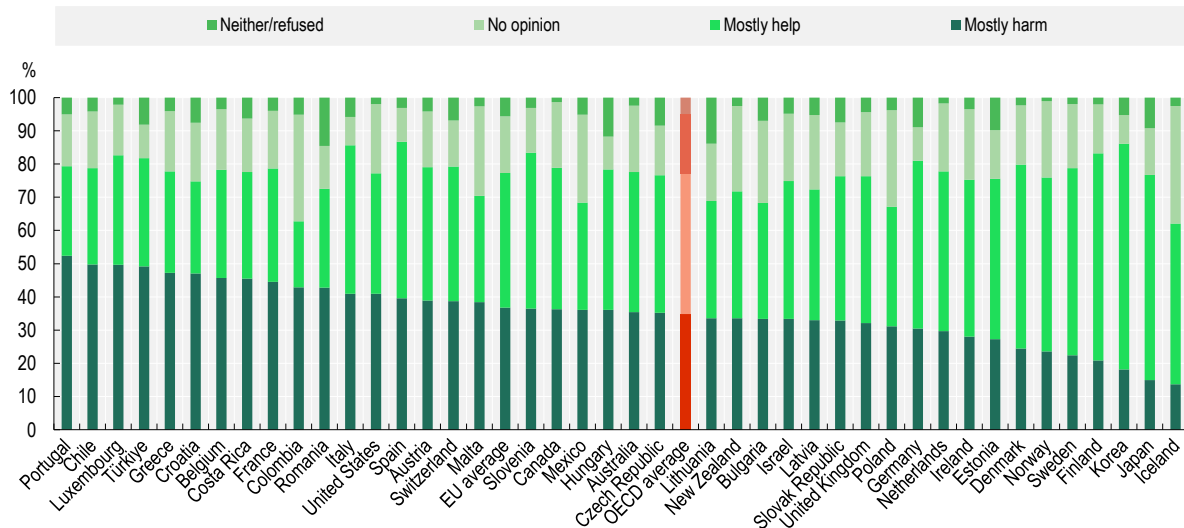
Note: The figure shows the percentage of adults who respond to the following question: "Artificial intelligence will help or harm people in the next 20 years", with "mostly harm", "mostly help", "no opinion", "neither/refused". Countries are sorted in descending order of the percentage of those answering "mostly harm".
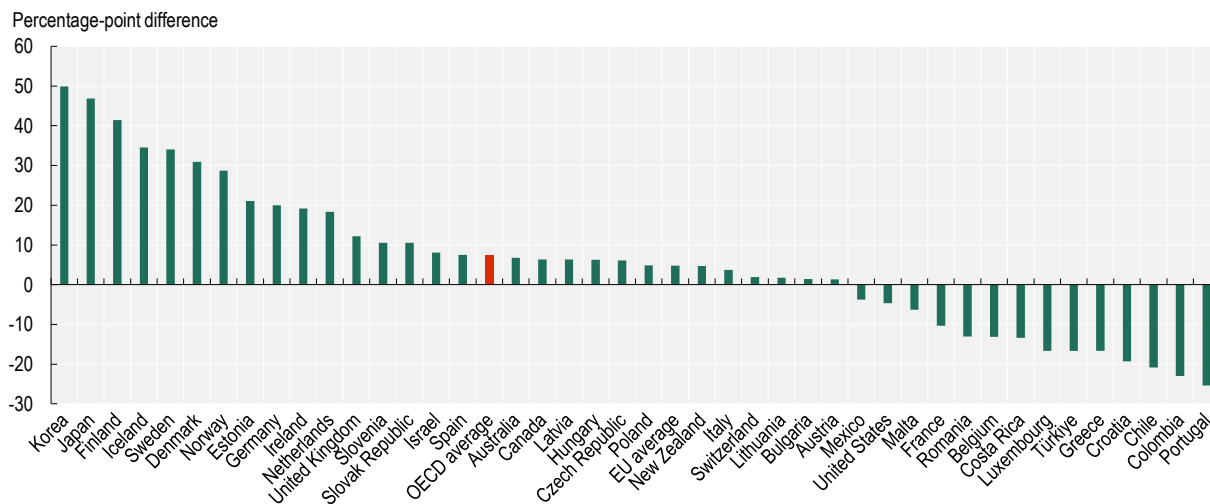Source: World Risk Poll (2021[17]), *World Risk Poll 2021: A Digital World - Perceptions of Risk from AI and Misuse of Personal Data*, https://wrp.lrfoundation.org.uk/data-resources/.

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When considering only individuals expressing an opinion on AI's likely impact on people in the next two decades, on average across OECD countries, the percentage of those who believe that AI would mostly help was 7 percentage points higher than those who worried that AI would mostly harm (Figure 8.2). This suggests that, on average, across OECD countries in the general population in 2021, there were more optimists than pessimists concerning the overall impact of AI. At the same time, countries differed greatly in whether local populations generally had an optimistic or pessimistic view of AI. For example, in Portugal, there was a difference of 25 percentage points in the share of adults reporting that they believed AI would mostly harm and those who thought AI would mostly help people in the next two decades. Similarly, this difference was 23 percentage points in Colombia and 21 percentage points in Chile. By contrast, in Korea, there was a difference of 50 percentage points in the share of adults reporting that they believed AI would mostly help and those reporting that AI would mostly harm people in the next 20 years. In Finland, this difference was 41 percentage points; in Japan, it was 47 percentage points.

Figure 8.2. Difference between positive and negative associations with AI in selected countries, 2021

Percentage-point difference between the share of adults who perceive AI as "mostly helpful" and those who perceive it as "mostly harmful"

Note: The figure shows the percentage-point difference of adults who responded "mostly helpful" and "mostly harmful" to the following question, "Artificial intelligence will help or harm people in the next 20 years?"
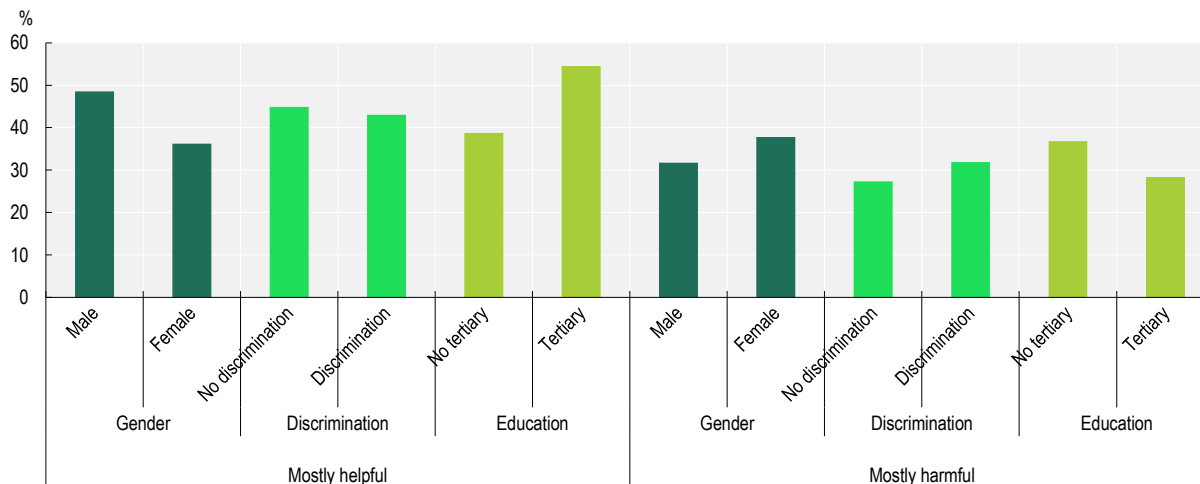Source: World Risk Poll (2021[17]), *World Risk Poll 2021: A Digital World - Perceptions of Risk from AI and Misuse of Personal Data*, https://wrp.lrfoundation.org.uk/data-resources/.

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Perceptions about the long-term effects of AI on societies differ according to individuals' socio-economic profiles and experiences of discrimination. In particular, women, individuals without tertiary qualifications and individuals who had faced discrimination due to the colour of their skin, religion, nationality/ethnic group, gender or disability were more likely to report worrying that AI would have a harmful long-term impact. For example, on average, across OECD countries in 2021, 32% of men but 38% of women indicated that they worried that the long-term impact of AI would be mostly harmful, whereas 49% of men and 36% of women indicated they believe AI would be mostly helpful in the long term (Figure 8.3). Similarly, 28% of tertiary-level graduates and 37% of individuals without tertiary-level qualifications worried that the long-term effects of AI would be mostly harmful, and 55% of tertiary-level graduates and 39% of individuals without tertiary-level qualifications indicated they believed that the effects of AI would be mostly helpful. Finally, whereas a similar number of individuals with and without a past experience of discrimination expected AI to have positive long-term effects, 32% of individuals with and 27% without a past experience of discrimination expected AI to have harmful long-term effects.

Figure 8.3. Adults' perception of the long-term impact of AI, by gender, discrimination and education, 2021

Percentage of adults who perceive the long-term impact of AI as "mostly helpful" or "mostly harmful" by gender, discrimination and education

Note: The figure shows the percentage of adults who perceive the long-term impact of AI as "mostly helpful" or "mostly harmful" by gender, discrimination (individuals who faced discrimination due to the colour of their skin, religion, nationality/ethnic group, gender or a disability) and education (tertiary versus non-tertiary).
Source: World Risk Poll (2021[17]), *World Risk Poll 2021: A Digital World - Perceptions of Risk from AI and Misuse of Personal Data*, https://wrp.lrfoundation.org.uk/data-resources/.

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Data presented on general populations refer to attitudes about the expected overall impact of AI on people. Recent work on the likelihood that employees in manufacturing and finance firms indicated higher levels of optimism about the role of AI in the labour market than those expressed by the general population on the overall expected impact of AI: 19% of workers in finance and 14% in manufacturing said that they were very or extremely worried about job loss in the next ten years, while 46% and 50% were not worried at all (Lane, Williams and Broecke, 2023[18]). To note that the survey was administered before the advent of generative AI and attitudes may have shifted since then, both with respect to the overall impact of AI and the impact of AI on the workplace. In fact, a survey conducted in August 2023 in the United States indicated that over two thirds of adults reported being concerned about AI displacing workers with around a third of respondents reporting being very worried (American Federation of Labor and Congress of Industrial Organizations (AFL-CIO), 2023[19]).

8.3. The demand for and the skills of workers responsible for AI development, adaptation and maintenance

The debate on the consequences of AI development and adoption generally considers machines and humans as separate and conflicting entities, even though AI systems are developed, deployed and used by humans and perform tasks driven by human decision making. For example, the lack of interpretability of the outputs of AI systems does not arise from AI systems acquiring decision-making abilities or free will. Rather, it is a result of the limited information capacity of human cognition in relation to the level of complexity of the steps and processes AI systems engage in to produce output. This complexity is driven

by the interaction between the algorithms AI systems are built on and the amount of data used by the systems to generate predictions. Large language models at the basis of now widely known AI systems such as ChatGPT were developed by humans and only become useful when they are put to use by humans to solve their questions and challenges. What differs whenever AI is used is that decision making is shifted in time and space: decisions over the course of action taken by AI systems are not made when and where such systems encounter a problem to solve but, rather, when and where AI developers defined the parameters in the system.

Because AI systems are the product of humans, appreciating the capabilities and potential of AI for societies and labour markets starts with a better understanding of the role humans play in creating new AI systems or adapting AI systems to the unique needs of different end users. AI professionals, in fact, determine how AI systems collect, store and use data to make predictions ranging from cancer detection (Bi et al., 2019[20]) to providing instantaneous translation between different languages (Borgonovi, Hervé and Seitz, 2023[21]). Yet little is known about the demand for workers with skills to develop and adapt AI systems in different countries, how this demand has changed – and is changing – over time, and whether it differs across sectors and occupations.

Moreover, exploring potential variations in the skill sets required by different employers utilising AI can assist in uncovering the underlying factors contributing to disparities in technology diffusion, productivity and economic growth. Recent evidence has, in fact, documented increasing productivity gaps between the best-performing firms and the rest of the business population (Andrews, Criscuolo and Gal, 2016[22]), reflecting a slowdown in technology diffusion. Skills are key for such diffusion processes, especially in the current stages of digital transformation. Recent OECD work has explored the characteristics of firms that adopt AI (Calvino et al., 2022[23]; Dernis et al., 2023[24]) as well as the connections between AI usage and productivity (Calvino and Fontanelli, 2023[25]). This research has underscored substantial heterogeneity based on factors such as firm size, age and sector. Importantly, it has also highlighted the crucial role of complementary assets, particularly skills, for both AI adoption and the productivity benefits experienced by AI users. In this context, understanding the specific skill sets sought by different types of AI employers can enhance understanding of the foundations on which their performance hinges. This knowledge can inform policies aimed at promoting an inclusive digital transformation.

The existing literature on the AI workforce and its participants is limited and primarily relies on evidence from online job postings by employers. This reliance stems from the lack of dedicated categories in official employment statistics to accurately capture individuals involved in developing and utilising AI systems. Although estimates of the number of people engaged in developing and using AI tools and systems vary (Acemoglu et al., 2022[26]; Alekseeva et al., 2021[27]; Green and Lamby, 2023[28]; Samek, Squicciarini and Cammeraat, 2021[29]), they all suggest that few individuals worldwide are involved in the development and use of AI technologies.

Previous efforts to map the demand for workers that could advance the development and use of AI systems focused on English-speaking countries and exploited different algorithms as well as AI-related keywords to identify AI-related skills and jobs in online job postings (Alekseeva et al., 2020[30]; Babina et al., 2020[31]; Manca, 2023[32]; Samek, Squicciarini and Cammeraat, 2021[29]; Squicciarini and Nachtigall, 2021[33]). More recently, Green and Lamby (2023[28]) widened the scope, providing estimates of the size and characteristics of the AI workforce across OECD countries. In particular, Green and Lamby (2023[28]) highlighted how the AI workforce currently lacks diversity, being disproportionally male and having high levels of educational qualifications.

8.3.1. The demand for AI professionals

Few vacancies posted on line require skills to develop, maintain and adapt AI systems

Figure 8.4 shows how the share of online vacancies advertising positions requiring AI skills changed between 2019 and 2022. On average, across countries in the sample, the share of online vacancies requiring AI skills increased from 0.30% in 2019 to 0.40% in 2022 [estimates are in line with other related studies, such as Green and Lamby (2023[28])]. These results represent trends up to 2022 before the generative AI chatbot ChatGPT was first introduced. However, evidence from the United States indicates that despite a very large growth of generative AI between December 2022 and September 2023, generative AI remains small in proportion to the whole AI market. In 2022, there were 519 job postings calling for generative AI. Between December 2022 and September 2023 there were 10 113 generative AI postings in the United States, an increase of 1.848%. However generative AI postings represented only 0.026% of all AI postings advertised between December 2022 and September 2023 (Lightcast, 2023[34]).

Figure 8.4. Share of online vacancies requiring AI skills in selected countries, 2019 and 2022

Percentage of online vacancies advertising positions requiring AI skills, by country
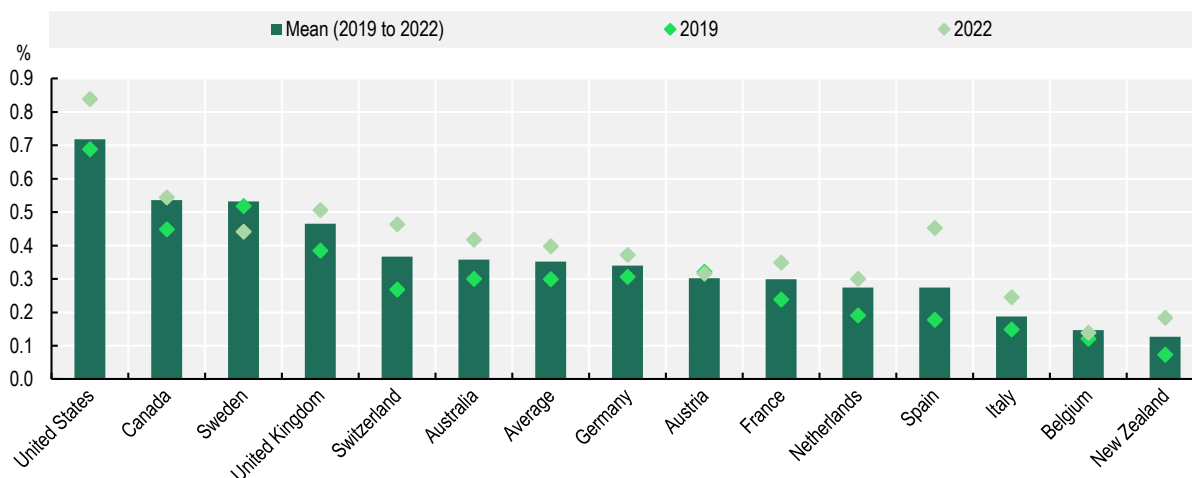
Note: The figure shows the percentage of online vacancies advertising positions requiring AI skills by country. This corresponds to the total number of online vacancies requiring AI skills relative to all vacancies advertised in a country. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Borgonovi et al. (2023[1]) on generic and specific skills). Countries are sorted in descending order by the highest average share across 2019 to 2022 of vacancies requiring AI skills. Average refers to the average across countries with available data.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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The share of online vacancies that require AI-related skills and their evolution over time vary across the 14 OECD countries with available data. In 2019, the share of positions requiring AI skills ranged between 0.07% in New Zealand to 0.69% in the United States, while in 2022, the share of positions requiring AI skills ranged between 0.14% in Belgium to 0.84% in the United States. While initial levels differed across countries, in most countries, the share of overall vacancies requiring AI-related skills increased between 2019 and 2022, except for Austria and Sweden. At the same time, the share of all online vacancies requiring AI skills did not exceed 1%, not even in the most recent year under analysis. These estimates do not shed light on the actual stock of workers with AI-related skills in the labour market but, rather, the

evolution of the demand for workers who would be required to use AI skills in their jobs. As such, they suggest that only a few occupations require the specialised skills necessary to develop and use AI systems.

Over time, the diffusion of AI skills, measured as the increase in the share of online vacancies requiring AI skills, varied across countries. On average, across countries in the sample, the share of online vacancies requiring AI skills increased by 33%. In some countries, the diffusion of AI skills is well beyond this average increase. For example, in Spain and New Zealand, countries with initially relatively low shares of online vacancies requiring AI skills, shares increased by 155% and 150%, respectively, between 2019 and 2022. Spain ranked 11th out of 14 countries when considering the share of positions requiring AI skills in 2019 but ranked 5th by 2022. New Zealand ranked last in 2019 and second to last in 2022. The increase over time has been more modest for countries that started with relatively high shares of online vacancies requiring AI skills in 2019. In the United States, for example, the country with the highest share of online vacancies requiring AI skills, the increase has been around 22%. In a few countries, such as Sweden and Austria, no increase over time has been observed.

Figure 8.5. Top three sectors in which online vacancies requiring AI skills are advertised in selected countries, 2019-22

Percentage of online vacancies advertising positions requiring AI skills in specific sectors and averaged between 2019 and 2022, by country
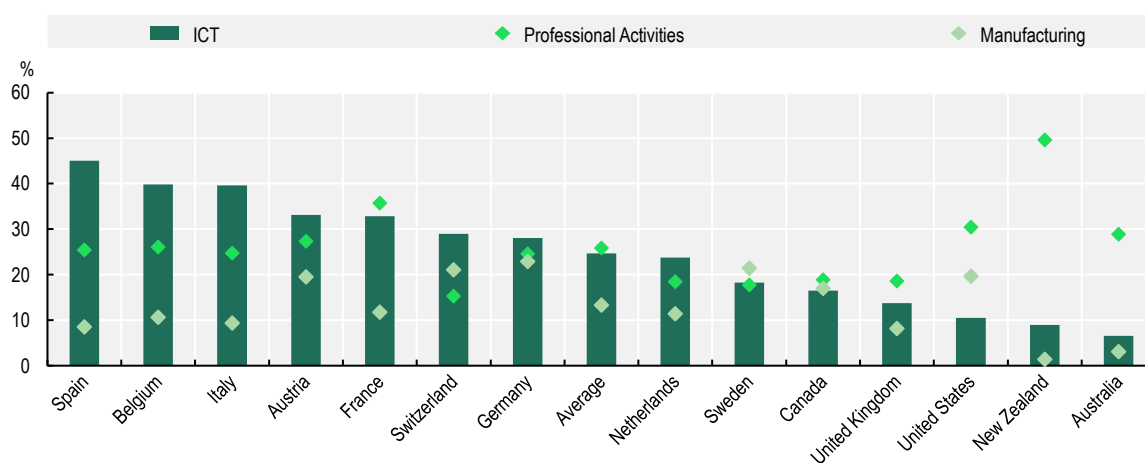
Note: The figure shows the percentage of online vacancies advertising positions requiring AI skills (reported in this figure for the top three industries). This corresponds to the total number of online vacancies advertising positions requiring AI skills in a given industry sector in a country relative to all positions requiring AI skills across all industries in a given country. Countries are sorted in descending order of the highest average share of vacancies requiring AI skills in ICT. The top three industries are based on the highest share of positions requiring AI skills across countries and years. Positions requiring AI skills are positions in which at least two generic AI skills or at least one AI-specific skill were required (see Borgonovi et al. (2023[1]) on generic and specific skills). Borgonovi et al. (2023[1]) detail how the harmonisation of sectoral information across European countries and English-speaking countries was conducted, given differences in the taxonomies used by Lightcast in the compilation of data for English-speaking and countries in Europe. Average refers to the average across countries with available data.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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The share of online vacancies that require AI-related skills and their evolution over time also vary across sectors of the economy. In particular, the share of postings requiring AI skills over the 2019-22 period was considerably higher in "Professional Activities", "ICT" and "Manufacturing" than in other sectors, such as "Accommodation and Food", "Agriculture", and "Transportation", where virtually no postings required AI skills (Borgonovi et al., 2023[1]). Moreover, sectors with very low shares of AI-related job postings in 2019

exhibited little change over time. In contrast, sectors such as Manufacturing, ICT and Professional Activities, for which the shares were already comparatively high in 2019, exhibited substantial increases over time. Figure 8.5 indicates the share of online vacancies for positions requiring AI skills posted in ICT, Manufacturing, and Professional Activities, the three industry sectors that rank highest in demand across all countries and years over the 2019-22 period.

The average share of positions requiring AI skills across English-speaking and European countries in the sample was 25% for Professional Activities, 24% for ICT and 13% for Manufacturing. The country with the highest share of vacancies requiring AI skills in Professional Activities was New Zealand (50%), followed by France (36%) and the United States (30%). Among postings requiring AI skills in the ICT sector, shares were highest in Spain (45%), Belgium (40%) and Italy (40%). For Manufacturing, shares were highest in Germany (23%), Sweden (21%) and Switzerland (21%). Within countries, the relative share of positions requiring AI skills can differ substantially between sectors, likely reflecting specialisation differences.

The skills most requested in online vacancies for AI professionals

While the previous analyses focused on the distribution of positions requiring AI skills across countries, sectors and occupations, this section focuses on the type of skills required by employers when looking for AI talent to hire. To categorise positions into those that require AI skills versus those that do not, a list of 211 pre-defined AI keywords was used. In order to meaningfully describe the skills required in AI-related postings, these skills were further condensed into meaningful clusters of skills. These clusters were determined based on industry expert assessment of skills common in these topic areas or implementations of AI. Skills were grouped into the following seven skill clusters: "Artificial Intelligence", "Autonomous Driving", "Machine Learning", "Natural Language Processing", "Neural Networks", "Robotics" and "Visual Image Recognition" (Table 8.1 provides some examples of the set of skills in each of the seven skill clusters).

Table 8.1. Examples of skill sets in the seven AI-related skill clusters

Artificial Intelligence	Autonomous Driving	Machine Learning	Natural Language Processing	Neural Networks	Robotics	Visual Image Recognition
Baidu	Advanced Driver Assistance Systems	Supervised Learning	Text Mining	TensorFlow	Cognitive Robotics	3D Reconstruction
Intelligent Control	Autonomous System	Test Datasets	Tokenization	Pybrain	Motion Planning	Activity Recognition
Weka	Path Finding	Training Datasets	Voice Interaction	Long Short-Term Memory (LSTM)	Robot Framework	Computer Vision
OpenAI Gym	Remote Sensing	Vowpal Wabbit	Voice User Interface	Keras (Neural Network Library)	Nvidia Jetson	Machine Vision
Watson Studio	OpenCV	Xgboost	Word2Vec Models	Long Short-Term Memory (LSTM)	Servomotor	Eye Tracking

Note: The table provides a selected list of skills for each of the seven skill groups.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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Figure 8.6 shows the evolution of online vacancies advertising positions requiring AI skills by skill cluster between 2019 and 2022. In 2022, the skill cluster mentioned most frequently in postings was Machine Learning. Machine Learning was required in more than 0.25% of all vacancies posted on line. Among postings requiring AI skills, which account for around 0.35% of total online vacancies in 2022 (Figure 8.4),

almost 35% require Machine Learning skills (Figure 8.7). Artificial Intelligence is the second most frequently requested skill cluster, with around 0.16% of postings requesting such skills in 2022, almost 21% of postings among those requiring AI skills (Figure 8.7). The remaining skill clusters are demanded in less than 0.1% of all vacancies posted on line, with Robotics and Autonomous Driving being the skills clusters requested least frequently (0.04% and 0.06%). One reason these skills may be the least in demand is that they are highly industry- and country-specific.

Figure 8.6. Trend in the demand for AI workers by skill cluster, 2019-22

Percentage of online vacancies requiring AI skills, by skill cluster and year
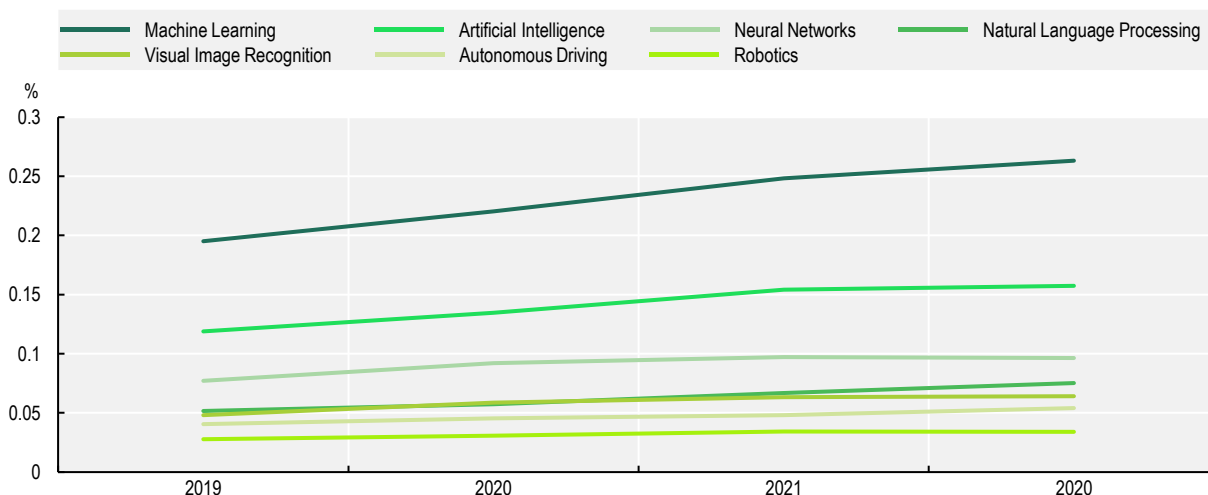
Note: The figure shows the percentage of online vacancies requiring AI skills relative to all postings, by skill cluster and year, which is the total number of online vacancies requiring AI skills relative to all online vacancies. Examples of skills assigned to the different skill clusters are provided in Table 8.1, while a full overview of which AI skills are assigned to which cluster is provided in Borgonovi et al. (2023[1]). Positions requiring AI skills are positions in which at least two generic AI skills or at least one AI-specific skill were required [see Borgonovi et al. (2023[1]) on generic and specific skills].
Source: Calculations based on Lightcast (2022[35]), Ligthcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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Figure 8.7 shows the relative demand for the top three of seven skill clusters mentioned in postings requiring AI skills in each country between 2019 and 2022. On average, over the period and across the 14 countries with available data, 34% of online vacancies requiring AI skills required skills from the Machine Learning cluster, followed by 21% requiring skills related to the AI cluster and 14% requiring skills related to the Neural Networks cluster.

Across all countries, the Machine Learning skill cluster ranked highest, ranging from 39% in the United States to 29% in France. In 11 out of 14 countries, skills related to the AI cluster were the second most frequently requested skill cluster, with the highest shares observed in New Zealand (27%) and the lowest in Sweden (14%). In Switzerland, Germany, and France, the share of AI-related postings requiring AI skills is smaller than the share requiring Neural Networks. However, France and Germany lead the distribution of postings requiring Neural Networks skills, with 18% and 17%, respectively.

Figure 8.7. Top three skill clusters demanded in postings requiring AI skills, selected countries, 2019-22

Percentage of online vacancies requiring AI skills averaged across 2019-22, by skill cluster and country
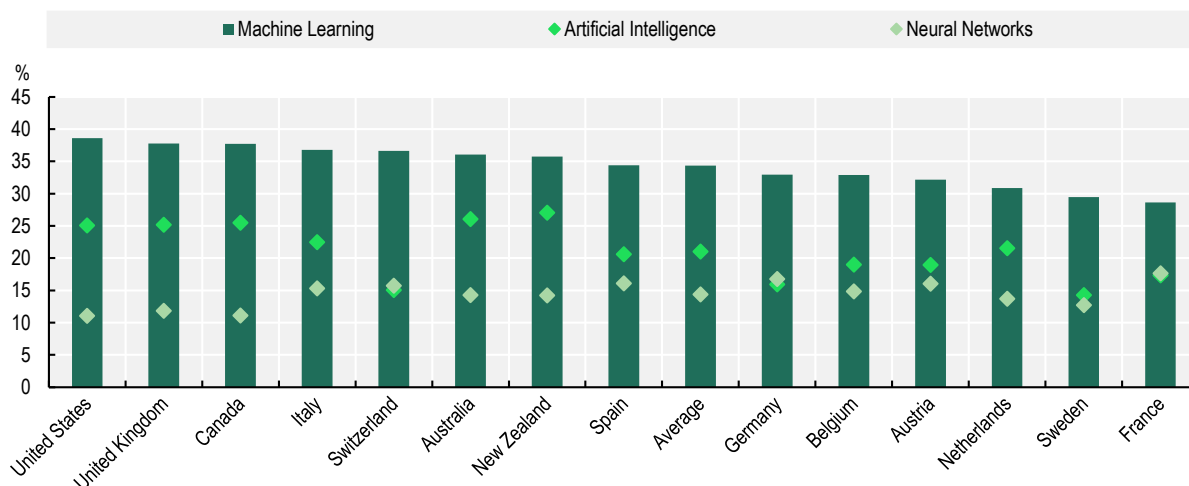
Note: The figure shows the percentage of online vacancies requiring AI skills for specific skill clusters, for the top three skill clusters, by country, which is the total number of online vacancies requiring specific skill clusters relative to the total number of online vacancies requiring AI skills. Examples of skills assigned to the different skill clusters are provided in Table 8.1, while a full overview of which AI skills are assigned to which cluster is provided in Borgonovi et al. (2023[1]). Positions requiring AI skills are positions in which at least two generic AI skills or at least one AI-specific skill were required [see Borgonovi et al. (2023[1]) on generic and specific skills]. Countries are sorted in descending order by percentage of postings requiring Machine Learning skills. Average refers to the average across countries with available data.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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Examining the type of skills required in online postings advertising positions requiring AI skills indicates that two skill clusters are especially prevalent over the 2019-22 time period (Figure 8.6) and across countries (Figure 8.7): Machine Learning and AI. Nonetheless, Figure 8.8 suggests that when other skill clusters are considered, countries vary with respect to the relative demand for skills in the less-demanded clusters. In particular, whereas Figure 8.6 showed that two skill clusters have, compared to all other clusters, relatively low shares on average across countries in 2022 (Autonomous Driving [0.05%] and Robotics [0.03%]), Figure 8.8 indicates that the share of postings requiring skills related to the Autonomous Driving cluster was comparatively high in France (where 19% of online vacancies advertising positions requiring AI skills require skills in this cluster) and Sweden (where 17% of online vacancies advertising positions requiring AI skills require skills in this cluster). This was very low in New Zealand (where only 3.7% of online vacancies advertising positions requiring AI skills require skills in this cluster). For the Robotics cluster, demand was comparatively strong in the Netherlands (13%), followed by Sweden (9%), and lowest in New Zealand and Spain (1.5%).

Figure 8.8. AI skill cluster distribution, by country, 2019-22

Percentage of online vacancies requiring AI skills averaged across 2019-22, by skill cluster and country
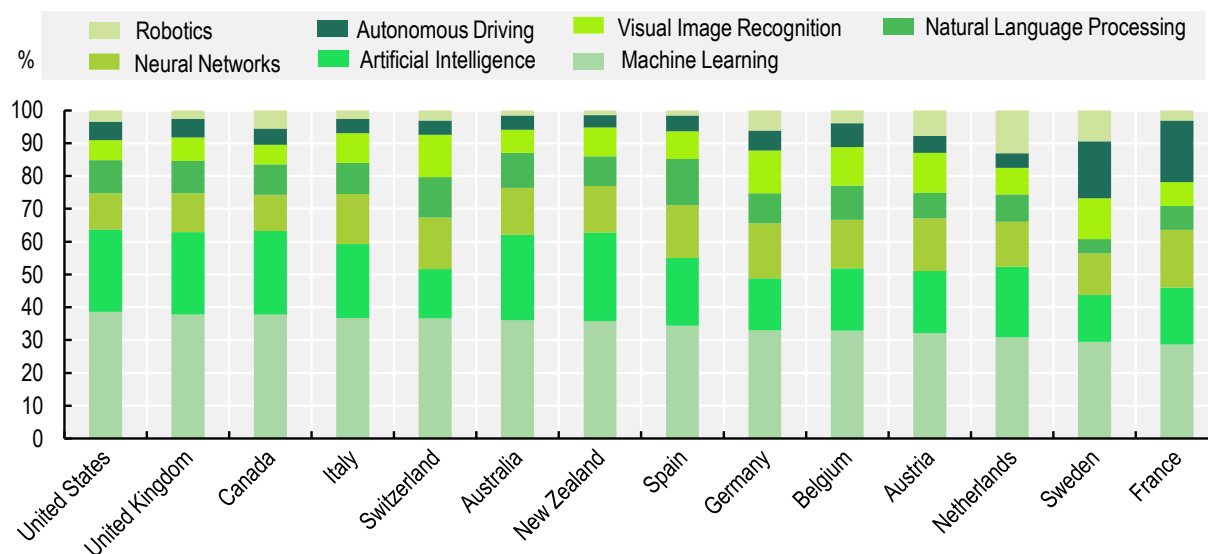
Note: The figure shows the percentage of positions requiring specific skill clusters relative to the total number of AI jobs averaged across 2019-22, by country. Examples of skills assigned to the different skill clusters are provided in Table 8.1, while a full overview of which AI skills are assigned to which cluster is provided in Borgonovi et al. (2023[1]). Positions requiring AI skills are positions in which at least two generic AI skills or at least one AI-specific skill were required [see Borgonovi et al. (2023[1]) on generic and specific skills]. Countries are sorted in descending order by percentage of postings requiring Machine Learning skills.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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8.3.2. AI job postings rarely mention ethical decision making

AI systems have the potential to support and improve decision making and perform complex analytical tasks, but at the same time, they pose unique ethical challenges. The *Recommendation on Artificial Intelligence* – the first intergovernmental standard on AI – was adopted by the OECD Council at the Ministerial level on 22 May 2019 (OECD, 2019[36]). The Recommendation aims to foster innovation and trust in AI by promoting the responsible stewardship of trustworthy AI while ensuring respect for human rights and democratic values. Complementing existing OECD standards in areas such as privacy, digital security risk management and responsible business conduct, the Recommendation focuses on AI-specific issues and sets a standard that is implementable and sufficiently flexible to stand the test of time in this rapidly evolving field. In June 2019, at the Osaka Summit, Group of Twenty (G20) Leaders welcomed the G20 AI Principles drawn from the OECD Recommendation (OECD, 2019[36]).

The Recommendation identifies five complementary values-based principles for the responsible stewardship of trustworthy AI and calls on AI actors to promote and implement them: 1) inclusive growth, sustainable development and well-being; 2) human-centred values and fairness; 3) transparency and explainability; 4) robustness, security and safety; and 5) accountability.

Alongside strong regulatory frameworks, ensuring the implementation of the OECD AI Principles requires AI developers and users to embed ethical considerations into the design, development, adaptation and ultimate use of AI systems.

Despite the adoption of the OECD AI Principles and growing concerns about the importance of the ethical risks associated with AI development and use when prospective employers advertise positions for people to develop and adapt AI systems in their work, they only rarely mention ethical decision making.

Figure 8.9 shows the share of online AI job postings for positions involving tasks related to developing and utilising AI systems. It specifically focuses on the presence of keywords associated with AI ethics, trustworthy AI, responsible AI or ethical AI. Results indicate that in the majority of countries, less than 1% of all vacancies mentioned keywords associated with AI ethics, trustworthy AI, responsible AI or ethical AI. However, between 2019 and 2022, the share of positions mentioning keywords related to ethics in AI increased sharply in the majority of countries.

For example, in the United States in 2019, only 0.1% of all online job postings for AI professionals mentioned any keyword associated with ethics in AI in vacancies requiring prospective workers to possess skills related to AI development and use. This increased to 0.5% in 2022. Similarly, in Germany, the share of AI positions advertised requiring ethics in AI increased from less than 0.05% in 2019 to 0.4% in 2022; in the United Kingdom, this increased from around 0.1% in 2019 to 0.4% in 2022 and in Spain, it increased from less than 0.1% in 2019 to 0.3% in 2022.

Figure 8.9. AI job postings mentioning keywords related to ethics, 2019-22

Percentage of online AI job postings mentioning keywords related to ethics
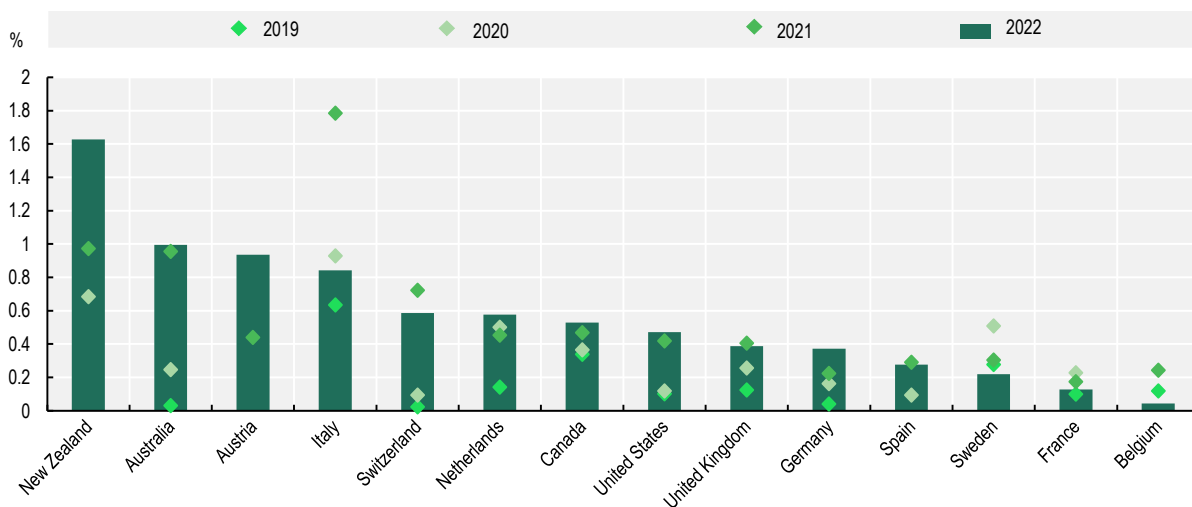
Note: The figure shows the percentage of AI job postings mentioning AI ethics-related keywords. The AI keywords used were "ethical artificial intelligence", "ethical ai", "ai ethics", "ethics of artificial intelligence", "responsible ai", "responsible artificial intelligence", "trustworthy AI" and "trustworthy artificial intelligence" as well as similar terms in the official languages spoken in the different countries.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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8.3.3. The demand for AI professionals among large employers of AI talent (top AI employers)

This section focuses on a subset of AI employers in the United States, the country with the highest demand for AI talent in online job postings among countries with available data. More specifically, the section considers the demand for workers with AI skills among the top ten employers within each industry, which make up around 43% of all AI postings (just under 315 000) in the United States in 2022. Similar to the previous analyses, this section explores differences in the number of vacancies for positions requiring AI

skills across sectors, occupations and skills. However, here, the hiring patterns are further distinguished by employer type.

In particular, AI online vacancies posted by the top ten AI employers (hereafter, "top AI") are compared to the remaining AI postings posted by other AI employers (hereafter, "other AI"). The top ten AI employers are the ten employers in each industry that posted the largest share of vacancies on line for workers with the skills needed to perform AI tasks. To put any potential differences into perspective, the analyses also extend to postings not mentioning any AI-related skills, i.e. not looking for any AI talent (hereafter, "non-AI"), hence postings stemming from top AI, other AI or non-AI employers.

Levels of concentration of AI job postings by top AI employers across industries

ICT, Professional Services, Manufacturing, and Finance and Insurance are among the industries with the highest share of AI vacancies posted by the top ten AI employers, as shown in Figure 8.10 in the United States. Figure 8.10 shows that the share of postings requiring AI skills by top employers relative to postings by other AI employers is higher among industries where overall AI vacancy shares are comparatively low. For example, although around 3% of vacancies in the US Information industry require AI skills, only around 46% of those are posted by the top ten AI employers. Instead, in Agriculture, around 1.4% of postings require AI skills, but almost 90% are posted by the top ten AI employers.

Figure 8.10. Share of AI vacancies posted by US top AI and other AI employers, by industry, 2022

Percentage of online vacancies requiring AI skills posted by top ten AI and other AI employers, by industry, United States
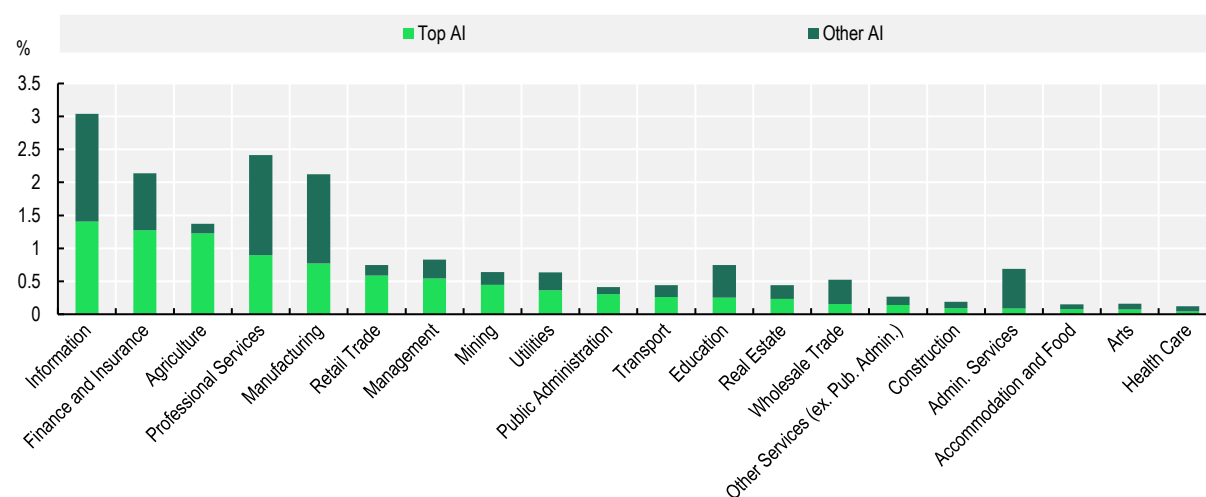
Note: The figure shows the percentage of online vacancies requiring AI skills that are posted by the top ten AI (light green) and other AI (dark green) employers, by industry in the United States, which is the total number of online vacancies requiring AI skills posted by the top ten AI employers vis-à-vis other AI employers relative to online vacancies posted by all employers in the respective industry. The top ten AI employers are the ten employers in each industry that posted the largest share of vacancies on line for workers with the skills needed to perform AI tasks. Positions requiring AI skills are positions in which at least two generic AI skills or at least one AI-specific skill were required [see Borgonovi et al. (2023[1]) on generic and specific skills]. Industries are sorted in descending order by the percentage of positions requiring AI skills posted by the top ten AI employers.
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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Top AI employers demand a mix of technical, socio-emotional and foundational skills

Figure 8.11 focusses on the technical, socio-emotional and foundational skills required by the different AI employer types in the United States. More specifically, Figure 8.11 shows the share of AI online vacancies posted by the top ten AI and other AI employer firms that mention a specific technical (Panel A) or socio-emotional and foundational (Panel B) skill in their job description, focusing on the 20 skills most frequently demanded in AI job postings by the top ten AI employers. The skill profiles demanded by the top ten AI and other AI employers do not vary substantially, with programming languages accounting for many of the most demanded technical skills, especially Python. This is followed by competencies related to Computer and Data Science, as well as skills associated with the widely adopted cloud and computing service Amazon Web Services (AWS).[1]

Figure 8.11. Top 20 skills in AI job postings by US top AI employers, 2022

Percentage of AI online vacancies by top AI vs other AI employers and percentage of non-AI online vacancies requiring specific skills, United States
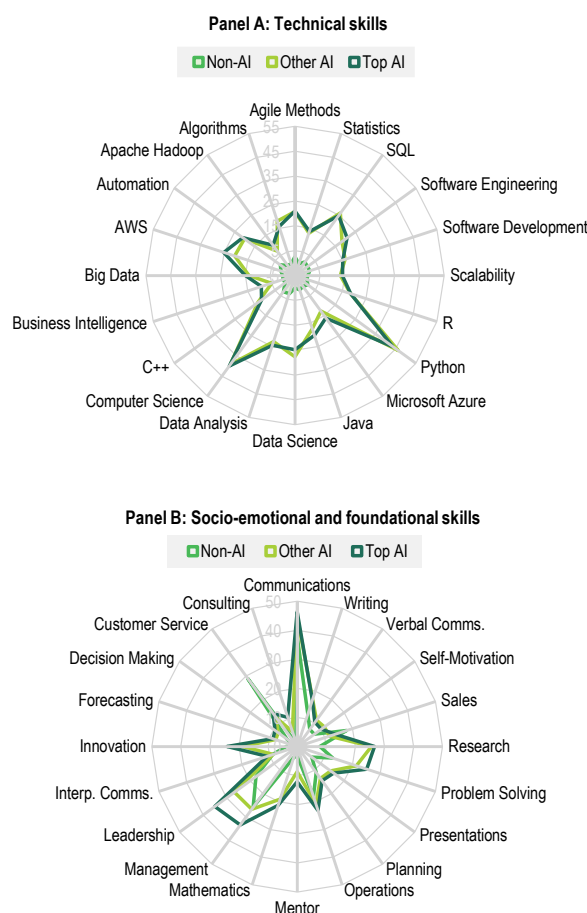
Note: The figure shows the percentage of AI online vacancies for the United States, mentioning a specific technical (Panel A) or socio-emotional and foundational (Panel B) skill, distinguishing vacancies posted by the top ten AI and other AI employers. It also presents the percentage of the remaining non-AI online vacancies. The top ten AI employers are the ten firms in each industry that posted the largest share of vacancies online for workers with the skills needed to perform AI tasks. Therefore, for both the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies; hence, the shares across all skills can exceed 100%. The figure displays only the top 20 skills in each panel based on the share of AI jobs posted by the top ten AI employers. The underlying data to the figure for technical and soft skills is provided in Borgonovi et al. (2023[1]). Positions requiring AI skills are positions in which at least two generic AI skills or at least one AI-specific skill were required [see Borgonovi et al. (2023[1]) on generic and specific skills].
Source: Calculations based on Lightcast (2022[35]), Lightcast™, https://lightcast.io/ (accessed December 2022), in Borgonovi et al. (2023[1]), "Emerging trends in AI skill demand across 14 OECD countries", https://doi.org/10.1787/7c691b9a-en.

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Compared to other AI firms, a larger share of the top AI employers requires skills related to AWS, Business Intelligence, Microsoft Azure, Apache Hadoop, Java, Software Engineering, Data Analysis, and Big Data. Unsurprisingly, none of these skills is particularly evident in non-AI online vacancies, i.e. vacancies not requiring any AI-related skills.

By contrast, the frequency with which socio-emotional and foundational skills appear in AI and non-AI online vacancies is more similar. In particular, Communication skills are very common in postings across the board. However, more AI-related online vacancies, compared to non-AI postings, demand Leadership and Management skills, as well as Innovation, Research, Problem Solving and Mentorship, reflecting the need for AI workers to be endowed with a broad skill mix, including technical as well as socio-emotional and creativity-related skills. In fact, except for Customer Service and skills related to Sales, employers demand either of the remaining socio-emotional and foundational skills presented in Figure 8.11 more frequently in AI than non-AI postings.

In particular, top ten AI employers put relatively more emphasis on Leadership, Mentorship and Management skills – as well as Innovation and Problem-Solving skills – than other AI employers. Compared to other AI firms, the top ten firms also more frequently request competencies related to Customer Service, Forecasting, Operations, Planning or Maths. Interestingly, although different types of Communication skills are highly demanded across all online vacancies, top AI employers demand Interpersonal Communication and Presentation skills more often.

8.4. Attitudes and dispositions needed to make the most of generative AI systems

The previous section details the set of skills that are required of workers engaged in the development, maintenance and adoption of AI technologies. However, the impact of AI on economies and societies will also depend on the set of skills, attitudes and dispositions of broader populations who may use products and technologies enabled and supported by AI. The French writer François Gaston, duc de Lévis, suggested that people should be judged by the quality of their questions rather than the quality of their answers (duc de Lévis, 1810[37]). Generative AI systems reduce the time and effort required to generate output based on existing knowledge, i.e. to produce answers. However, the quality of the outputs produced by generative AI systems depends on the quality of the prompts humans develop, the problems they prioritise and how such problems are framed. Furthermore, how the outputs produced by AI are used depends on how humans interpret them. In other words, at least in the near term, realising the potential of generative AI will depend on individuals being able to generate high-quality prompts – i.e. asking good questions – and being able to evaluate the quality of the answers and interpret them in ways that make them applicable to real-life problems and situations. Finally, responsible use of AI requires human users to be ready to discard the output of AI systems and take an alternative course of action.

Decision making over the if, when, and how outputs of AI systems are used to perform different tasks clearly requires individuals to possess the content knowledge needed to evaluate AI's output. At the same time, strong content knowledge must be accompanied by the belief in the superiority of one's own knowledge and skills over those of the AI being used, a prerequisite for individuals to assume responsibility for making decisions over the use of AI's outputs. This belief requires people to have a high level of confidence and self-efficacy in their abilities in general and their preferred course of action in specific contexts. It also requires them to be willing to make mistakes when choosing to discard input provided by AI systems which, *ex post*, might have proved right. At the same time, the attitudes and behaviours of managerial structures in firms will also require new accountability practices with the aim of fostering the empowerment of workers in relation to the use of AI.

A potential paradox arises from certain attributes that define tasks where AI systems are unable to replace humans in the foreseeable future. This paradox stems from the discomfort experienced by many individuals and organisations when operating in situations where their comparative advantage lies,

i.e. situations with only little prior evidence and that reflect cultural and contextual nuances. Rather than seeing such uncertain situations as opportunities, individuals currently view them as threats. Psychological research suggests that for many people, the toll associated with the experience of losses is larger than the benefit associated with the experience of gains, and, as a result, faced with the prospect of failure, they are more likely to settle for a suboptimal course of action from a "rational perspective" to avoid experiencing losses (Kahneman and Tversky, 1979[38]).

8.4.1. Most people in OECD countries consider the term "risk" more as danger than opportunity

In statistics, the term "risk" refers to the probability that an event will occur. Therefore, risk refers to the known level of uncertainty that certain events will occur and is neutral, i.e. does not have positive or negative connotations. Nonetheless, Figure 8.12 suggests that, except for Latvia, more than one in two adults in OECD countries perceive the term "risk" as denoting danger. In Mexico, Colombia, Spain and Costa Rica, over 80% of adults perceived "risk" to indicate danger, whereas in Croatia, Slovenia, Lithuania, Bulgaria, Germany, Estonia, Poland, Austria, Hungary and Greece, between 50% and 60% did.

Figure 8.12. Perception of "risk" as a threat or an opportunity in selected countries, 2019

Percentage of adults who perceive risk as "opportunity, "danger", "both" or "neither"
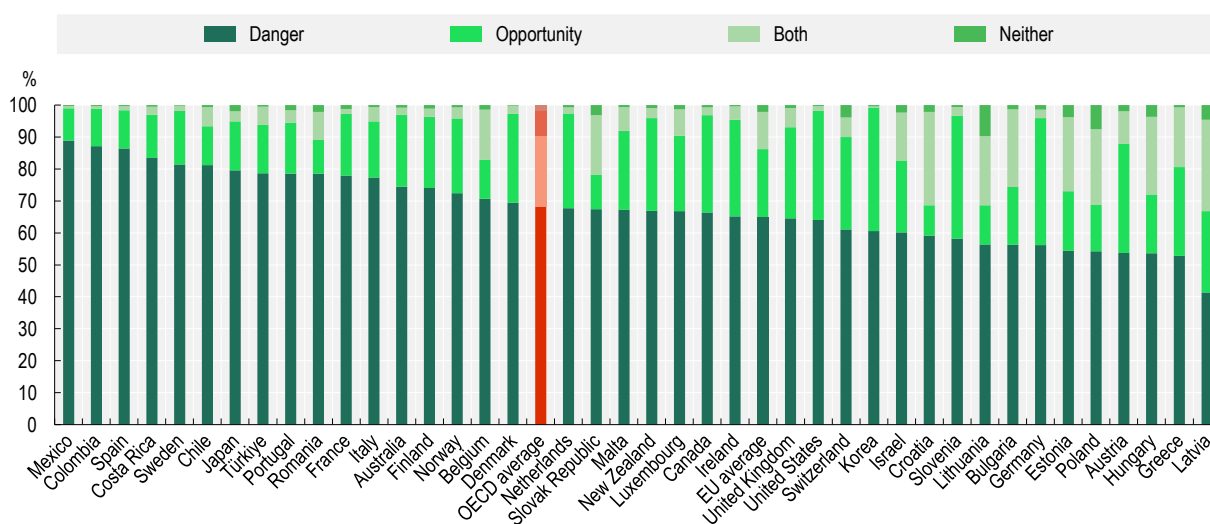
Note: The figure shows the percentage of adults who respond "opportunity, "danger", "both", or "neither" to the following question, "When you hear the word 'risk', do you think more about opportunity or danger?". Countries are sorted in descending order by the percentage of adults reporting perceiving risk as a danger.
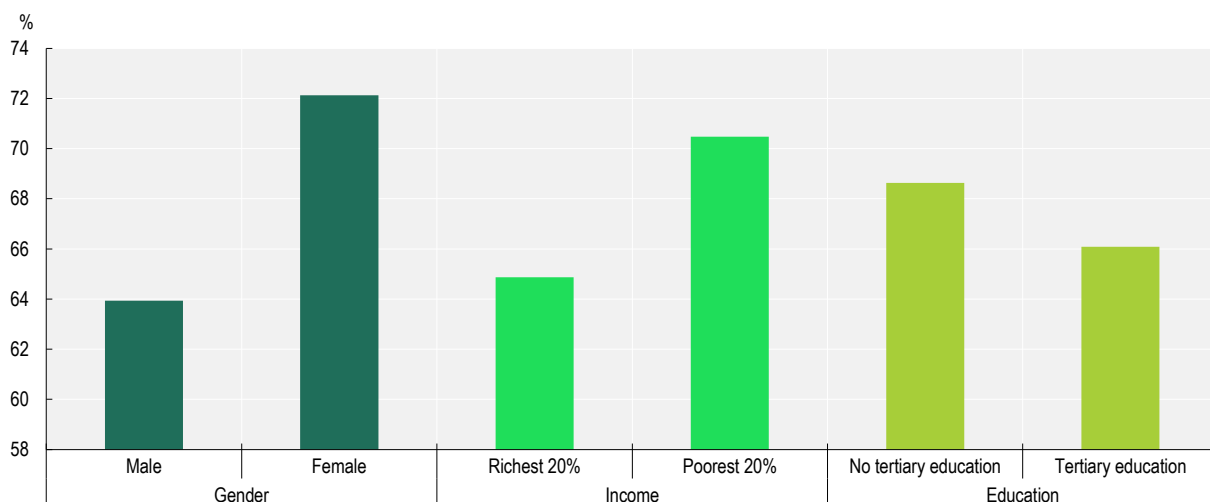Source: World Risk Poll (2019[39]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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Individuals' perception of the word "risk" as associated with danger differs across socio-economic characteristics. In particular, on average, across OECD countries, 64% of men but 72% of women reported that they associate the word "risk" with danger rather than opportunity, a difference of 8 percentage points (Figure 8.13). Similarly, across OECD countries, perceptions of risk as reflecting danger were more prevalent among lower-income than higher-income groups. For example, among the poorest 20% of the population in each country, 70% reported that the word "risk" indicates danger, whereas 65% of the 20% richest did. By contrast, differences in perceptions of risk as reflecting danger were less pronounced across levels of educational attainment: on average, 69% of individuals without a tertiary qualification reported that the word risk indicates danger rather than opportunity, while among those with a tertiary-level qualification, 66% did.

Figure 8.13. Perceptions of risk as a danger, by gender, income and educational attainment, OECD average, 2019

Percentage of adults who perceive risk as danger, by gender, income and educational attainment

Note: The figure shows the percentage of adults who respond "danger" to the following question, "When you hear the word 'risk', do you think more about opportunity or danger?", by gender, income and educational attainment.
Source: World Risk Poll (2019[39]), *The Lloyd's Register Foundation World Risk Poll Report 2019*, https://wrp.lrfoundation.org.uk/.

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8.4.2. Many young people fear failure, and a fear of failure is especially strong among girls

Fear of failure characterises the tendency of individuals to avoid making mistakes when performing a task or an activity because failure is perceived as shameful (Borgonovi and Han, 2020[40]; McGregor and Elliot, 2005[41]). The level of fear is determined by the perceived level of risk of failing (i.e. how hard a task is) and by the costs associated with failure (which can include the missed opportunity of benefiting from success as well as social stigma and judgement and other negative consequences that can arise from failure (Lazarus, 1991[42]; Warr, 2000[43]). Failure avoidance can lead individuals to limit their choices and take fewer risks than optimal given their abilities. The literature indicates that fear of failure is higher among women than among men (McGregor and Elliot, 2005[41]) and that women are more likely to experience negative outcomes when they fear failure (Wach et al., 2015[44]). These findings are consistent with research indicating that women respond less positively to competitive environments (Croson and Gneezy, 2009[45]; Niederle and Vesterlund, 2010[46]), tend to be more risk-averse (Fisk, 2018[47]) and have lower levels of self-efficacy and self-concept than males with similar levels of achievement (Goldman and Penner, 2014[48]).

To the extent that organisations responding to advances in AI and robotics will require individuals to perform a larger number of tasks that entail a high degree of uncertainty, managers will have to develop metrics of success that reflect the inherent uncertainty in outcomes despite the level of effort and the proficiency of workers. At the same time, as a precondition of success, workers will have to develop an appreciation of failure and failing that is free from stigma and grow accustomed to engaging with harder and less predictable tasks and situations.

Figure 8.14 suggests that, on average, across OECD countries, 73% of 15-year-old students report that failure makes them doubt their talent. In Japan, 87% of 15-year-old students indicated that failure made

them doubt their talent; in the Slovak Republic, this figure was 84%; in Korea, 83%; in Ireland and Denmark, 82%. By contrast, 56% of 15-year-old students in the Netherlands and Austria indicated that failure made them doubt their talent; this figure was 50% in Germany.

Figure 8.14. Students' fear of failure in selected countries, 2018

Mean index of students' general fear of failure and percentage of students who agree and strongly agree with the statement, "When I am failing, I am afraid that I might not have enough talent"
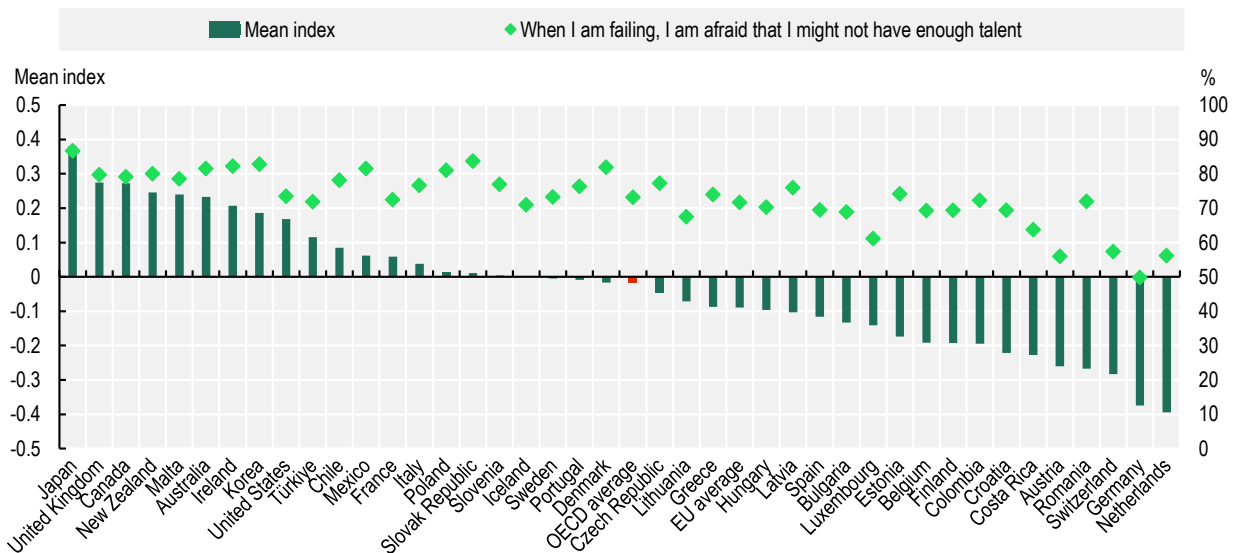
Note: The figure shows the mean of students' general fear of failure, which consists of three items: "When I am failing, I worry about what others think of me", "When I am failing, I am afraid that I might not have enough talent", and "When I am failing, this makes me doubt my plans for the future" (left y-axis). The percentage of students who agree and strongly agree with the statement, "When I am failing, this makes me doubt my plans for the future", is provided on the right y-axis. Countries are sorted in descending order by the mean index of students' general fear of failure.
Source: OECD (2018[49]), *PISA database 2018*, https://www.oecd.org/pisa/data/2018database/.

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In line with previous empirical evidence on adult populations, Figure 8.15 reveals that girls are considerably more likely than boys to express a fear of failure. For example, on average across OECD countries, 67% of boys, but 77% of girls, indicate that when failing, they worry about what others will think of them; 65% of boys, but 81% of girls, indicate that when failing, they worry that they might not have enough talent; and 45% of boys, but 61% of girls, indicate that failing makes them doubt their plans for the future. By contrast, there are no differences in fear of failure across students with and without at least one parent with a tertiary-level qualification. For example, on average across OECD countries, 73% of 15-year-old students with, and 72% of students without, a tertiary-educated parent indicate that when failing, they worry about what others will think of them; 73% indicate that when failing, they worry that they might not have enough talent; and 54% and 53% indicate that failing makes them doubt their plans for the future.

Figure 8.15. Students' fear of failure in selected countries, by gender and parental education, 2018

Percentage of students who "agree" or "strongly agree" to the following statements, by gender and parental education
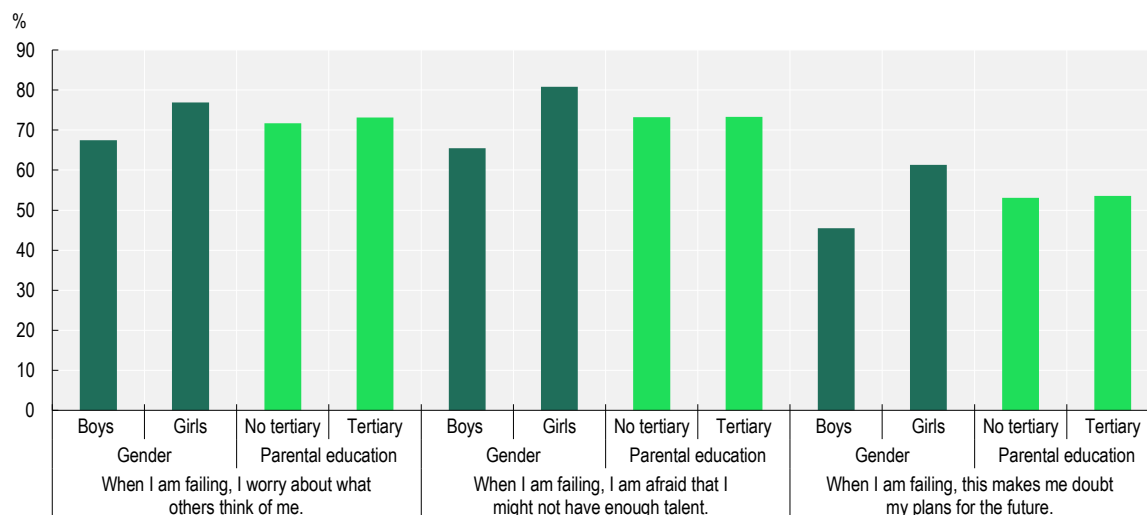
Note: The figure shows the percentage of students who "agree" or "strongly agree" with the statements, "When I am failing, I worry about what others think of me", "When I am failing, I am afraid that I might not have enough talent", and "When I am failing, this makes me doubt my plans for the future", by gender and parental education.
Source: OECD (2018[49]), *PISA database 2018*, https://www.oecd.org/pisa/data/2018database/.

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8.5. Conclusions

Humans tend to anthropomorphise, i.e. to "ascribe" human traits to non-human entities and to engage with them as if these were human (Festerling and Siraj, 2021[50]). Despite this tendency, robotics and AI systems, including large language models such as GPT4, should be recognised for what they are: tools created by humans that, at their core, combine in complex ways, work previously developed by other humans (Lanier, 2023[51]). This means that whereas machines excel at summarising and identifying patterns in the work previously conducted by other humans, they are instruments in support of human decision making and do not yet have an independent level of autonomy.

Evaluating the role of skills policies in supporting responsible AI development and deployment and developing effective policies as a result rests on a better understanding of: 1) the demand for workers involved in the development and deployment of AI, 2) the skills demanded of them, 3) the attitudes and dispositions that shape human decision making, and 4) the attitudes which may be affected by large-scale deployment of generative AI. As highlighted by the findings regarding the hopes and concerns expressed by populations regarding the potential impact of AI on people's opportunities, it is essential to ensure that the talent engaged in AI development and deployment possesses not only the technical skills required for their work but also the ability to foster the development of responsible and ethical AI systems.

Results presented in this chapter indicate that, even following a marked increase in the demand for professionals with AI skills, AI-related online vacancies represent only a small share of all job vacancies that were posted on line in the 14 countries analysed in 2019 to 2022. In particular, the share of AI-related online job vacancies was highest in the United States in 2022, where AI-related vacancies represented 0.84% of all vacancies posted on line. On average, across the countries in the sample, shares of online vacancies requiring AI skills were 0.30% in 2019 and 0.40% in 2022. The fact that only a small share of new positions advertised on line required individuals involved in the development and deployment of AI,

coupled with the major impact AI systems can have, suggests that a relatively small number of people have the potential to exert a profound impact on the global economy and human societies.

Some skills – notably those related to Machine Learning – appear particularly pervasive among AI-related job postings. Indeed, across all countries, between 29% (in France) and 39% (in the United States) of all AI job postings require skills related to Machine Learning. Skills related to Autonomous Driving and Robotics appear, on average, less demanded, possibly reflecting their more industry-specific nature. They also exhibit a high degree of cross-country variation, possibly reflecting the relative importance of different sectors in different countries and their likely evolution, given industry-specific trends and industrial investment decisions.

A set of analyses examined differences in skills requirements among different firms in the United States, where the AI sector has been comparatively large for the longest. Results reveal that top AI firms tend to demand some technical skills more intensively and require Leadership and Management skills more frequently, as well as Innovation and Problem-Solving skills. This reflects the importance such companies place on their employees having a broad skill mix. The hiring decisions of top ten AI firms may anticipate trends in skills requirements in the broader economy as AI permeates a broader set of firms.

Despite a growing awareness of the importance of ethical considerations in the development of AI, only a very small minority of firms advertising positions requesting prospective employees to possess AI skills mentioned ethics and responsible AI in online vacancies. By 2022, only 0.3% of AI positions advertised in Canada, 0.5% in the United Kingdom and 0.4% in the United States requested skills related to ethics in AI. This suggests that despite strong commitments on the part of countries and stated intentions on the part of AI development firms, ethics in AI is not yet prioritised in hiring decisions. These considerations should be prioritised alongside considerations over the lack of diversity of the AI workforce and the implications this has for the AI systems that are being developed.

A final set of analyses illustrated variations across countries and by socio-economic groups in the attitudes adults and youngsters have with respect to risk and failure. Attitudes and dispositions related to decision making under uncertainty are likely to shape how AI will be adopted by people and organisations worldwide; their ability to adopt AI as a useful instrument and aid in independent decision making; and willingness to engage in tasks in which humans are at a comparative advantage over AI systems, i.e. situations that are data poor and marred with a high degree of uncertainty. Results reveal that large sections of OECD populations hold negative attitudes towards risk and uncertainty and have high levels of fear of failure, especially women and girls. These results are concerning because they may be an early signal that women might be less ready to engage in tasks in which AI tools perform poorly and to override AI algorithms in their decision-making processes as AI outputs improve in quality and AI systems become widely adopted. These findings should be considered alongside results indicating a lack of representativeness among AI workers (Green and Lamby, 2023[28]) and findings highlighted in Chapter 5 of this report on boys' higher levels of overconfidence. They should also be considered in relation to societal perceptions that boys/men are more likely than girls/women to be endowed with exceptional talent (Leslie et al., 2015[52]; Zhao et al., 2022[53]) and the fact that such perceptions allow boys and men to experience failure as a possible precursor of success rather than evidence of underlying (lack of) potential.

Analysing the human element behind advances in AI makes it possible to assess the scale and diversity of the demand for AI jobs and skills. Such analysis may help in designing interventions to promote the diffusion of AI throughout the economy, particularly among employers and sectors that have yet to fully benefit from its potential. The adoption of AI encompasses both the utilisation of AI services, such as ChatGPT or Amazon (widely used services in OECD countries), which leverage AI in their service provision, as well as the active integration and customisation of AI algorithms in production and service delivery, as seen, for example, in the development of an online dating app. Such analyses are also a useful reminder that humans drive technical developments in AI diffusion and adoption and, as such, AI developments can ultimately be the subject of human decision making.

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Note

[1] AWS stands as a comprehensive suite of services offered by Amazon and provides businesses with the digital infrastructure to manage data, execute applications, and perform a myriad of other tasks via the internet, bypassing the need for physical servers.

OECD Skills Outlook 2023

SKILLS FOR A RESILIENT GREEN AND DIGITAL TRANSITION

Skills are vital for building resilient economies and societies. By helping individuals develop a diverse range of skills and empowering them to apply these skills effectively, skills policies play a crucial role in responding to emerging threats, such as environmental degradation and harmful applications of technologies used to collect, generate, and exchange information. This edition of the *Skills Outlook* highlights the importance of supporting individuals in acquiring a wide range of skills, at varying levels of proficiency, to promote economic and social resilience. Additionally, the report acknowledges the role of attitudes and dispositions in enabling skills development and effective skills use. It also emphasises the need for policy makers to monitor the costs associated with policies aimed at promoting the green and digital transition, and how the transition affects inequalities. Training opportunities that respond to emerging labour market needs and efforts to facilitate their uptake can promote a just and inclusive green and digital transition. In turn, education systems that equip young people not only with skills but attitudes to manage change can ensure that the green and digital transition is sustainable in the longer term.