

New Economy Skills: Skills for the Maker Economy

WHITE PAPER

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Executive summary

The race to build the future physical economy is becoming a race for maker skills.

“Maker skills” are defined as the practical, hands-on capabilities that power the physical economy. They enable people to construct and install infrastructure, operate equipment and machinery, and handle and process material resources across key sectors, including manufacturing, energy, logistics, food production and AI infrastructure.

Demand is accelerating

These skills underpin large parts of the global economy. People whose jobs rely heavily on these skills – “makers” – account for more than 60% of employment on average in Southern Asia, South-East Asia and Sub-Saharan Africa. In the United States, nearly one in four job postings mention maker skills. This proportion rises to 72% in the supply chain and transportation sector, 67% in manufacturing, 64% in infrastructure and 60% in automotive and aerospace.

Demand is set to grow even further. Trillions of dollars in investment in AI infrastructure, clean energy, and industrial expansion will increase demand for workers who can build, operate and maintain the physical economy. Of the 28 skills analysed in this report, the three maker skills are among those most strongly linked to occupations expected to grow by 2030: constructing and installing ranks first, operating equipment and machinery fourth, and handling and processing material resources eighth. Strengthening maker skills is becoming a strategic priority for economic growth, competitiveness and resilience.

Maker skills are increasingly combining physical and digital skills

Automation may be increasing the value of strong maker skills as they depend on two foundational abilities: (1) manual dexterity, endurance and precision, and (2) sensory-processing abilities, which are both linked to higher wages. A 10 percentage-point increase in proficiency in these abilities is associated with an estimated annual wage gain of about \$2,500. Meanwhile, predicted automation risk is 38% for occupations with the lowest levels of proficiency in these abilities, compared with 19% for those with the highest.

At the same time, digitalization is reshaping maker work. AI, robotics and intelligent systems are becoming embedded in physical work environments. This increases demand for workers who combine maker skills with digital skills. Across countries analysed for this report, 57% of makers report needing stronger AI skills to remain relevant, and a 10 percentage-point increase

in digital skills proficiency is associated with an estimated wage gain of about \$3,500 across maker occupations.

Talent supply is not keeping pace

The maker talent pipeline is not keeping pace with demand. The maker workforce is ageing faster than the workforce overall. In Asia, Europe and Northern America, those aged 55 and above make up 20–35% of makers. At the same time, too few young people are preparing to replace them: only 13% of boys and 4% of girls expect to work in maker occupations, despite these jobs accounting for 45.6% of total global employment. The pipeline is further limited by who enters these roles. Women represent only 30% of makers on average across regions, compared with 49% of other workers. Many economies have also relied on migration to recruit workers with maker skills. As some countries tighten migration policies, this source of labour is becoming less available.

The maker pipeline faces early constraints in the education system. On average across OECD countries, practical and vocational learning accounts for only 4.5% of compulsory instruction time in primary and lower secondary education, despite growing evidence that the motor and sensory abilities underpinning maker skills are developed in childhood. Vocational pathways also struggle to meet employer needs, with business leaders rating vocational education above tertiary education in only 15% of countries.

Building the future maker skills pipeline

Meeting future demand therefore requires rebuilding the maker skills architecture across the entire talent pipeline, from childhood through vocational education, apprenticeships and lifelong learning.

This report identifies five priorities for action:

- Build vocational pathways for the industries of tomorrow
- Embrace AI and digital skills in maker curricula
- Start building maker skills earlier
- Expand high-quality apprenticeships and work-based learning
- Ensure maker skills are visible and portable

Introduction

A transforming economy needs people with maker skills.

Maker skills power the physical economy. They are the hands-on capabilities required to produce, operate, maintain and repair infrastructure, equipment and products. They help build the homes we live in, maintain the roads and energy systems we use, produce the goods we buy and grow and process the food we eat.

Across economies, the need to strengthen maker skills is becoming critical. China's ambition to maintain its manufacturing edge, the United States' rapid AI infrastructure buildout, and Europe's efforts to strengthen defence and energy systems all depend on people with the skills to build, operate, maintain and repair. Meanwhile, over the next decade, about 400 million jobs are expected to be created in emerging economies. The World Bank identifies infrastructure and energy, agriculture, tourism, healthcare and manufacturing as key sectors for job creation — sectors that rely heavily on maker skills.¹ This demand is already visible in hiring patterns: in many economies, demand for workers with maker skills is outpacing demand for traditional white-collar workers.²

However, the systems that develop maker skills are not yet prepared for the scale, pace or complexity of this demand. Pathways into maker careers face structural problems at every stage.

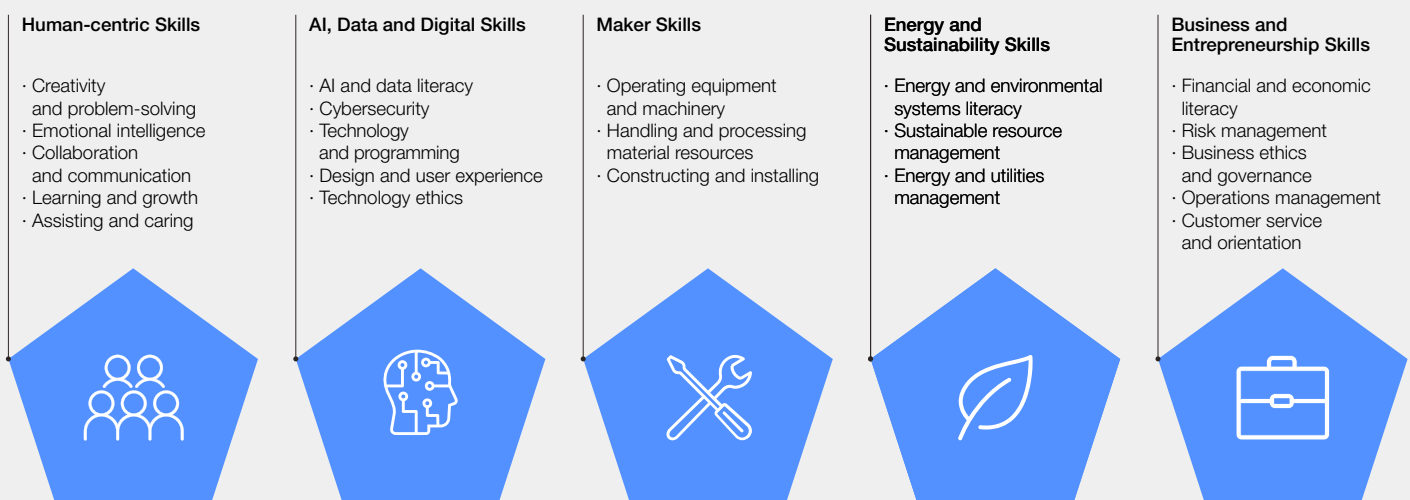
In childhood and adolescence, education often fails to fully develop the foundational motor and sensory abilities that support hands-on skills, as practical and vocational training receives limited attention. When young people make career choices, they are also much less likely to consider jobs that rely on maker skills. On average, these jobs account for 45.6% of employment but only 8.5% of students' expected career choices.³ For those who do enter this type of training, learning pathways remain uneven in quality and recognition, while digitalization is changing skill requirements faster than many programmes can adapt. And for workers, practical skills are often difficult to signal to employers.

This calls for a shift in how skills are developed, assessed and credentialled so that economies can build the workforce needed to deliver the AI buildout, the energy transition, and infrastructure renewal, while strengthening employment opportunities and competitiveness.

This report is the third instalment in the World Economic Forum's *New Economy Skills Series* (Figure 1). It explores the capabilities that enable individuals, organizations and economies to adapt to change and power sustainable growth, innovation and competitiveness. This report explores why maker skills are becoming increasingly important, how their requirements are evolving, and how to strengthen their development.

FIGURE 1

New Economy Skills



1

Maker skills are becoming a strategic advantage

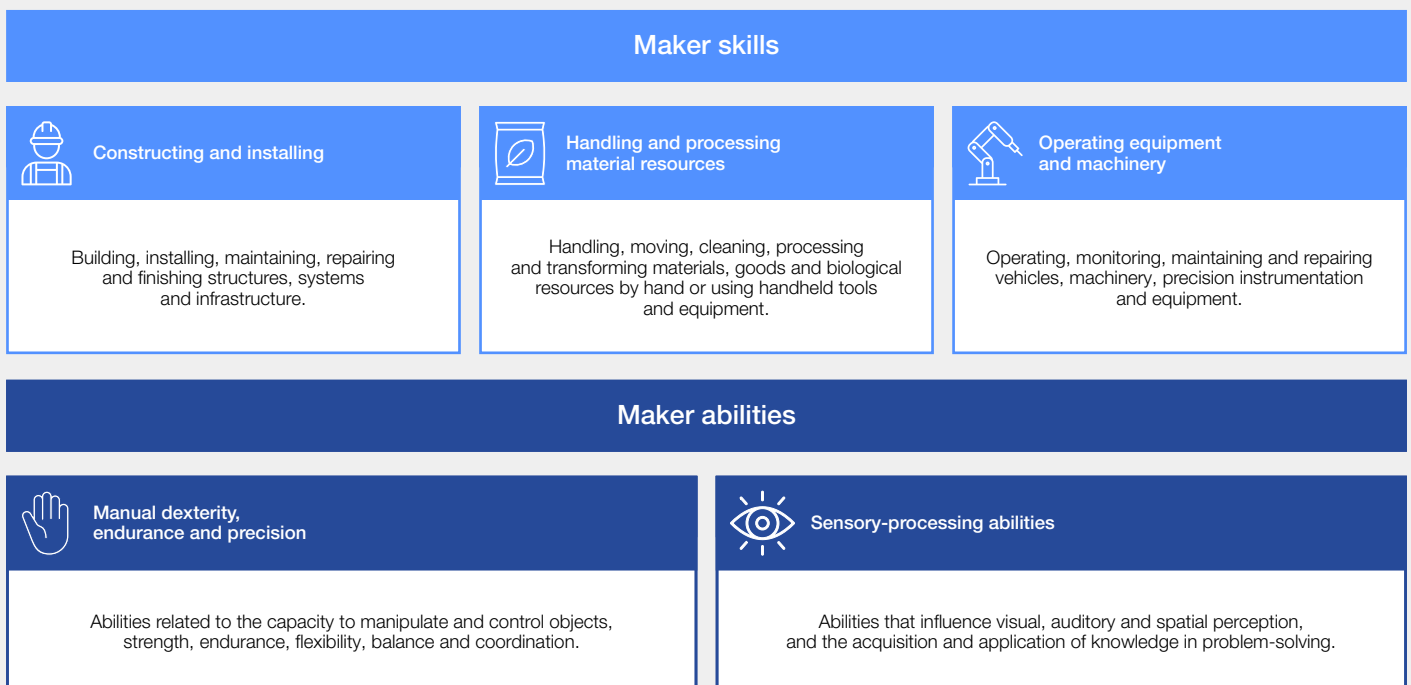
Demand for maker skills is rising faster than supply.

What are maker skills?

Maker skills are the practical, hands-on capabilities used to build, operate and maintain the physical economy. They fall into three broad skill areas: (1) constructing and installing, (2) operating equipment and machinery, and (3) handling and processing material resources (Figure 2).

Two foundational abilities underpin these three maker skills: 1) manual dexterity, endurance and precision, and 2) sensory-processing abilities. Together, these motor and sensory abilities support the practical tasks at the core of maker work. The first enables workers to manipulate tools, materials and machinery accurately, while the second enables them to interpret the physical environment through sight, sound and spatial awareness.

FIGURE 2 The three maker skills and the two foundational abilities



These three maker skills are required at different levels across occupations. People whose jobs rely heavily on maker skills are referred to in this report as “makers”. They are mainly found in four broad occupational groups:⁴

1. Skilled agricultural, forestry and fishery workers, including farmers, hunters, fishery workers, gardeners and forest rangers

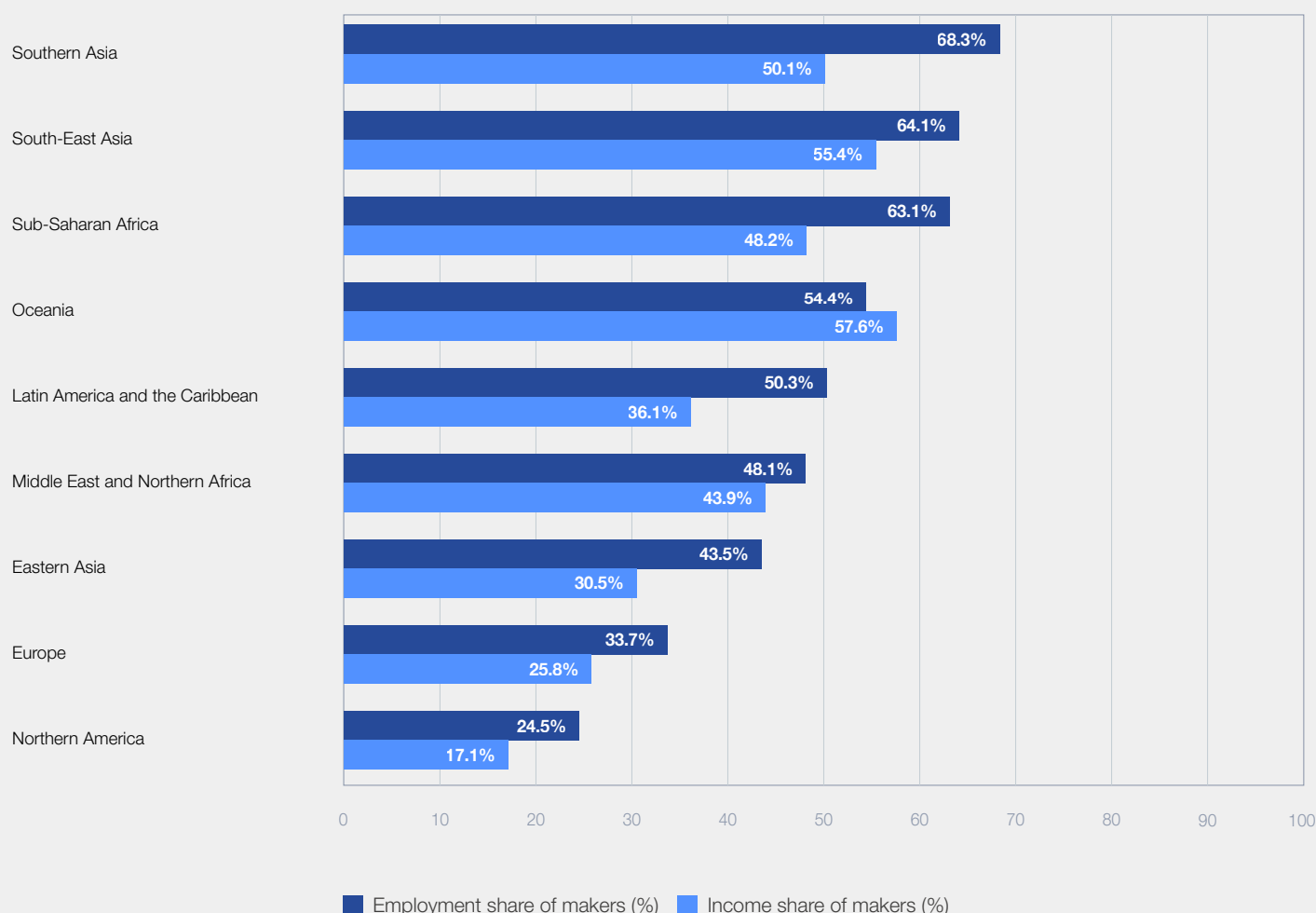
2. Craft and trade workers, including electricians, butchers, tailors, welders, clock and watchmakers, heating, ventilation and air-conditioning (HVAC) service engineers, toolmakers and metalworkers
3. Plant and machine operators and assemblers, including heavy equipment operators, industrial machine operators, crane drivers and manufacturing assemblers
4. Elementary occupations, including cleaners, forestry labourers, food preparation assistants and refuse workers

Every industry depends on maker skills

The four maker groups play a central role in labour markets (Figure 3). In many parts of the world, they account for more than half of employment and labour income. In South and South-East Asia and Sub-Saharan Africa, makers make up well over 60% of total employment in the average country.

Even in Europe and Northern America, where their share is lowest, they still represent roughly 35% and 25% of the workforce, respectively. Their economic importance is also reflected in labour income, where they generate approximately half of total earnings across many regions.

FIGURE 3 Employment and income shares of makers, by region



Note: The figure shows the average regional share of total employment and total labour income accounted for by makers. Country-level shares are calculated using the latest available International Labour Organization (ILO) data from 2021 onwards. Regional values are unweighted averages across countries in each region.

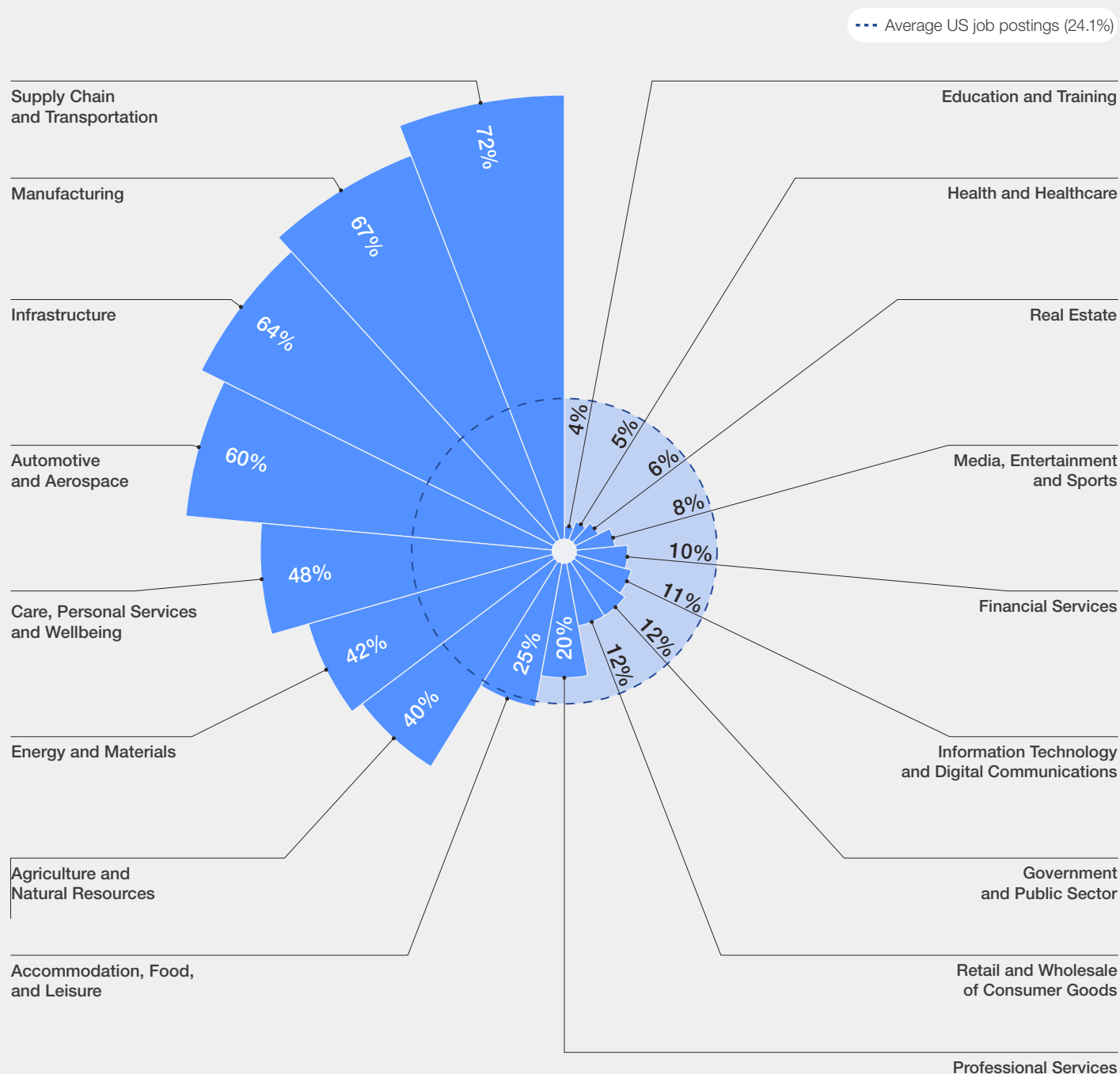
Source: ILOSTAT.

The importance of maker skills is also visible in job postings. An analysis by Indeed finds that almost one quarter of US job postings mention maker skills (Figure 4). It is highest in sectors built around moving goods, making products and maintaining infrastructure: maker skills appear in 72% of supply chain and transportation postings, 67% of manufacturing postings, 64% of infrastructure postings, 60% of automotive and aerospace postings, 48% of care, personal services and wellbeing postings, 42% of energy and materials postings, 40% of agriculture and natural resources postings, 25% of accommodation, food, and leisure postings, 20% of education and training postings, 12% of health and healthcare postings, 12% of real estate postings, 11% of media, entertainment and sports postings, 10% of financial services postings, 8% of information technology and digital communications postings, 6% of government and public sector postings, 5% of retail and wholesale of consumer goods postings, 4% of professional services postings.

of manufacturing postings, 64% of infrastructure postings and 60% of automotive and aerospace postings. Yet demand is not limited to these sectors. Maker skills appear in at least 10% of job postings in 13 out of 17 sectors analysed.

FIGURE 4

Share of US job postings mentioning maker skills, by sector



Note: Share of US job postings mentioning maker skills from May 2024 to April 2025, by sector. The data consist of nearly 2,900 granular work skills, classified according to the World Economic Forum's Global Skills Taxonomy and mentioned in US job postings.

Source: Indeed analysis; World Economic Forum, Global Skills Taxonomy.

The future economy is driving growing demand for maker skills

Today's largest economic investments depend on people with maker skills:

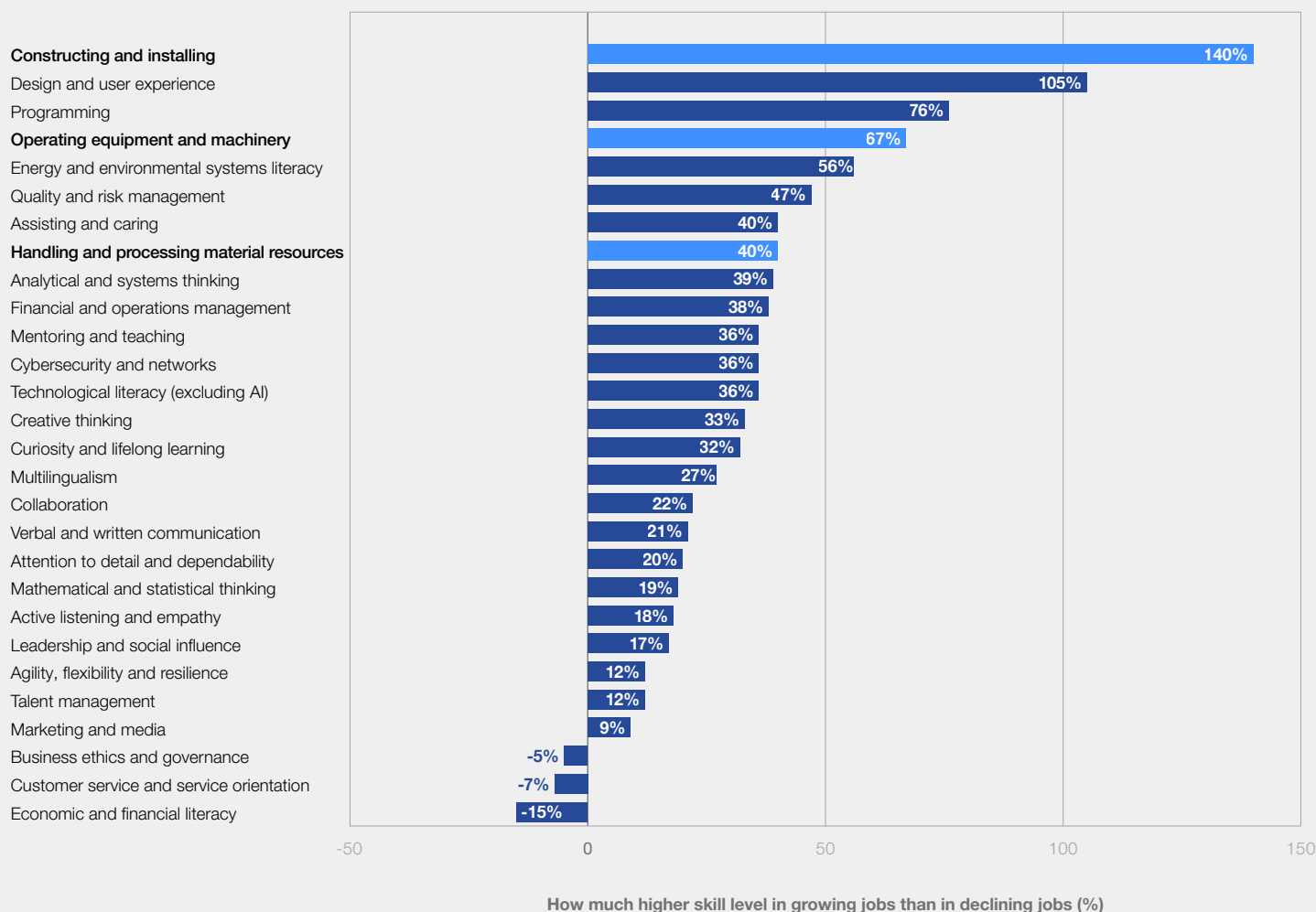
- The AI and digital transition: The rapid expansion of AI is driving large-scale investment in data centres and power infrastructure. Nearly \$7 trillion in global data-centre investment may be needed through 2030.⁵ This makes expertise in electrical installation, high-voltage systems, and advanced cooling increasingly critical (Box 1). In the United States, where more than 40% of this investment is expected to take place, even

conservative scenarios indicate demand shocks that the current maker workforce cannot absorb.⁶

- The transformation of food systems: Population growth, urbanization and climate pressures are increasing the need to produce more food more sustainably. This creates growing demand for skills in food production. The World Economic Forum projects that farmworker jobs will grow by 35 million globally by 2030, the largest absolute increase of any job category.⁷

FIGURE 5

Percentage differences in skill proficiency requirements between growing and declining jobs



Note: The figure shows the percentage difference in average required skill proficiency between jobs expected to grow and jobs expected to decline, based on Future of Jobs Survey net growth classifications matched to O*NET-SOC skill data. Positive values indicate skills required at higher levels in growing jobs; negative values indicate skills required at higher levels in declining jobs. The three maker skills are highlighted.

Source: World Economic Forum analysis, based on Future of Jobs Survey 2024, the World Economic Forum's Global Skills Taxonomy and O*NET skill proficiency level data.

- The green transition: Clean energy is creating a new wave of technical work. Investments in renewable energy, grid upgrades, and building renovations are creating a need for skills in solar and wind installation, electrical upgrades, heat pumps, insulation, and industrial retrofitting. The International Energy Agency (IEA) expects global energy investment to reach \$3.4 trillion in 2026, with clean energy investment rising to \$2.2 trillion.⁸
- The push to reshore production: As many governments adopt policies to strengthen domestic manufacturing and strategic industries, employers are seeking expertise in production. This industrial push is visible in public spending: industrial subsidies reached \$108 billion in 2024, their highest level since the global financial crisis.⁹
- The expansion and renewal of infrastructure: Across advanced economies, infrastructure needs replacement and upgrades. In emerging economies, urbanization and population growth are driving expansion. A cumulative \$106 trillion in global infrastructure investment is estimated to be needed through 2040.¹⁰ This creates strong demand for constructing and installing skills.

These trends place maker skills at the forefront of job growth. Figure 5 compares the skill proficiency requirements of growing and declining jobs across 28 skills, using projections from the World Economic Forum's Future of Jobs Survey. Constructing and installing exhibits the biggest difference: growing jobs require this skill at a level 140% higher than declining jobs do. Operating equipment and machinery ranks fourth, at 67% higher, while handling and processing material resources ranks eighth, at 40% higher.

BOX 1 Fast-tracking maker skills for the AI buildout

The rapid AI infrastructure buildout is creating urgent demand for maker skills. However, data centre operators report difficulties attracting qualified workers.¹¹ This has prompted massive efforts to build faster, more attractive skilling pathways into jobs such as electricians, HVAC technicians, plumbers and ironworkers, primarily in the United States:

1	Meta's America's Workforce Academy Backed by an initial \$115 million investment, the academy aims to train thousands of makers. Meta covers tuition and participant support, including travel, lodging and a daily stipend. It then connects graduates to guaranteed jobs. Participants receive verified, industry-standard credentials.
2	Google.org's Skilled Trades Initiative Google.org's \$50 million commitment aims to train more than 300,000 workers across more than 20 US states by funding unions, trade associations and training intermediaries. The model strengthens existing programmes, which give workers access to established training routes, the accreditation they need to pursue a skilled trades career across employers, regions and sectors.
3	BlackRock Future Builders This \$100 million initiative aims to reach 50,000 workers over five years by supporting non-profits and workforce-development partners. It funds pre-apprenticeship access, skilled-trades training, programme completion and licensure, supporting workers from initial training through qualification and employment.

Employers cannot find enough workers with maker skills

Growing demand for maker skills is exposing weaknesses in the maker talent pipeline. Employers across sectors increasingly struggle to recruit workers with maker skills, raising concerns that labour shortages could delay investment, slow productivity growth and constrain competitiveness.

Shortages of maker skills have long been widely recognized. For many years, skilled trades have ranked at the top of employer shortage surveys.¹² In contrast, shortages in other maker occupations have received less attention, particularly in advanced economies, where the narrative has centred on

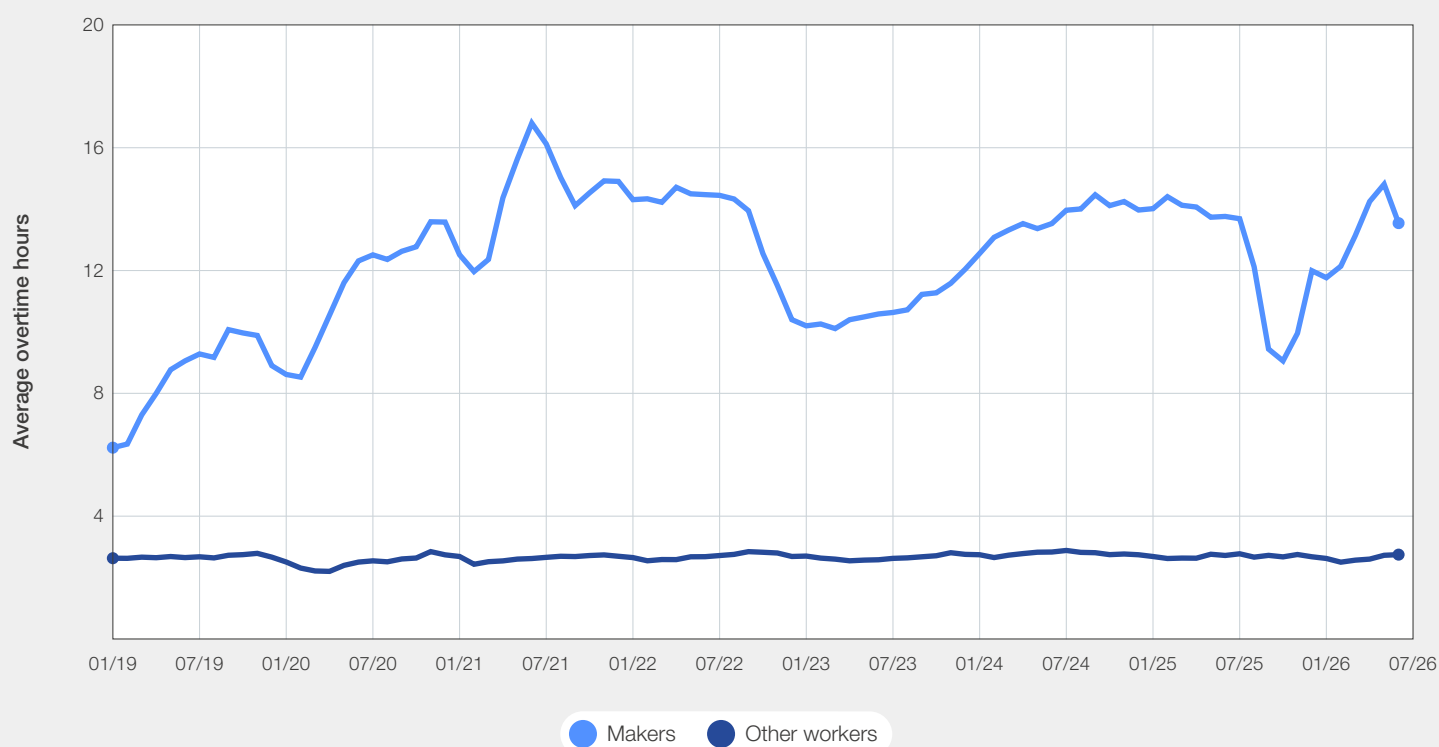
automation and offshoring. This is changing. In the United States, manufacturers report difficulties in filling vacancies,¹³ and recent European data find that manufacturing occupations now account for the largest share of severe skills shortages.¹⁴ Labour and skills shortages are also a major concern in the agro-food sector¹⁵ and across hospitality, where shortages of food workers and other essential staff are still slowing the post-pandemic recovery.¹⁶

High worker overtime levels are another signal of a maker skills pipeline under strain. ADP Research data for the United States (Box 2) reveal that makers record substantially higher overtime levels than workers in other occupations. While overtime can increase when workloads spike, it also indicates that employers stretch existing workforce capacity to meet demand for maker skills. This pattern risks becoming unsustainable.

BOX 2 Persistent reliance on overtime

Overtime patterns provide insight into labour-market conditions. ADP data (Figure 6) compare average weekly overtime hours among hourly makers in the United States with those of hourly workers in other occupations. Throughout the period, makers consistently record higher overtime levels. Although overtime levels fluctuate over time, they began increasing markedly before the COVID-19 pandemic and have remained persistently elevated since, reaching more than 6.5 times the level of other workers at their peak and five times the level in the latest period.

FIGURE 6 Average weekly overtime hours among hourly workers (3-month moving average)



Note: Data is based on US payroll records from ADP Research and covers the period January 2019 to August 2026. Overtime is measured as hours worked beyond a standard 40-hour work week. The figure shows the QCEW-weighted mean weekly overtime hours for hourly workers only. Estimates are seasonally adjusted and smoothed using a centred three-month moving average.

Source: ADP Research.

How future-ready maker skills are built

Developing strong maker skills starts with human abilities and increasingly requires digital skills.

Maker skills go hand in hand with other capabilities

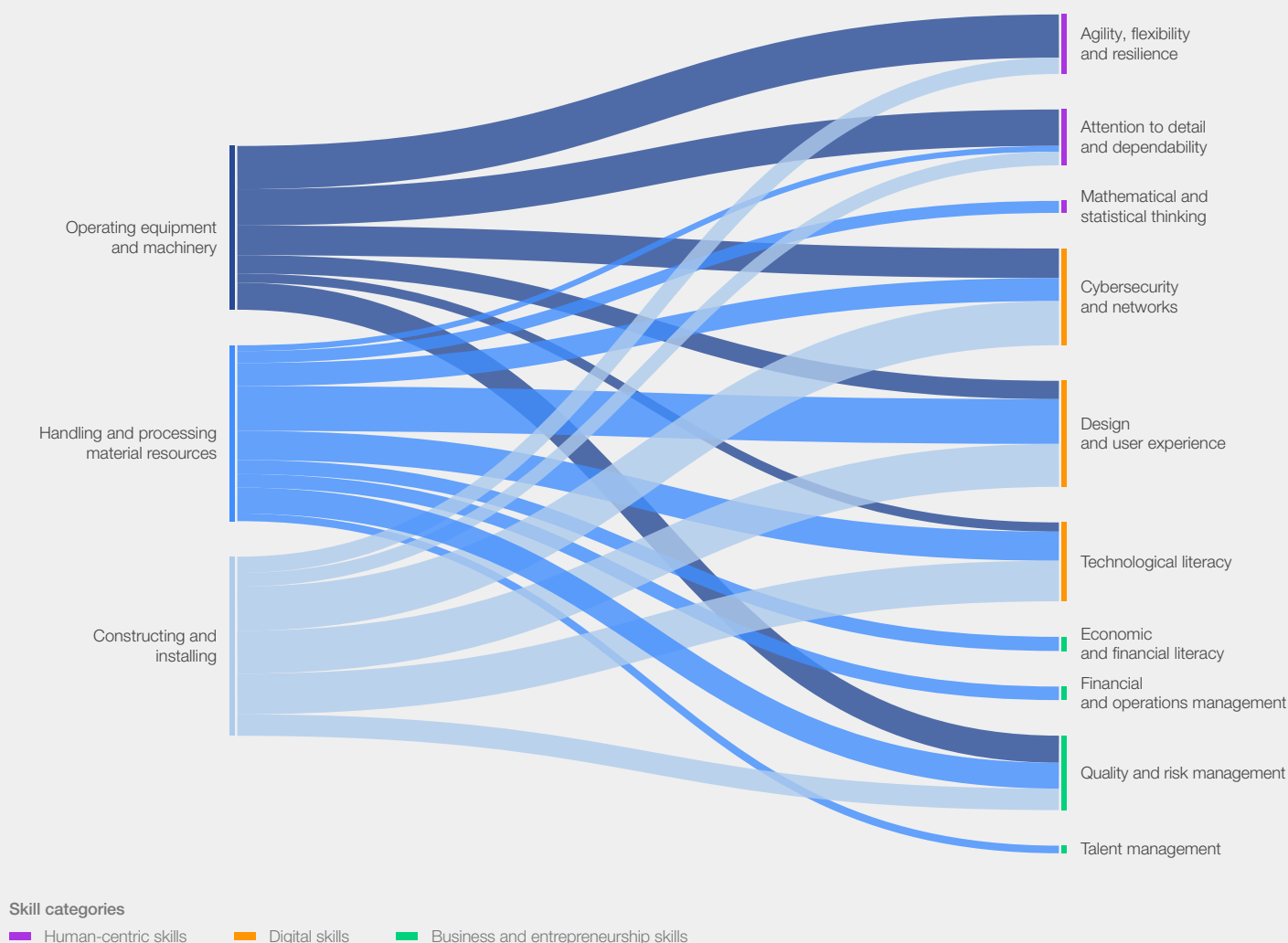
Maker skills are not standalone. This begins with their foundations: manual dexterity, endurance and precision, and sensory-processing abilities. These maker abilities support the acquisition and application of maker skills.¹⁷ Accordingly, to build expertise in maker skills, workers first need strong motor and sensory abilities. Higher requirements for maker skills therefore tend to go hand in hand with higher requirements for these abilities.¹⁸

Maker skills are also intertwined with other skills. Figure 7 shows the skills whose proficiency levels rise and fall with those of maker skills. Even though

only 10 of the 25 skills exhibit positive co-variation with maker skills, one clear pattern is the strong association with digital skills. As digitalization is reshaping the world of production, work requiring maker skills increasingly involves selecting, operating and securing digital tools, working with digitally enabled systems, and using digital design methods to improve functionality, usability and performance. The association between maker skills and cybersecurity and networks, design and user experience, and technological literacy reflects this increasing digitalization of production and manufacturing environments.



FIGURE 7 | Skills that go hand in hand with maker skills



Note: The figure displays positive pairwise correlations between maker skills and other skills. Correlations are calculated using proficiency scores across all occupations.

Source: World Economic Forum analysis, based on the World Economic Forum's Global Skills Taxonomy and O*NET skill proficiency level data for each occupation.

Employers are overlooking maker abilities

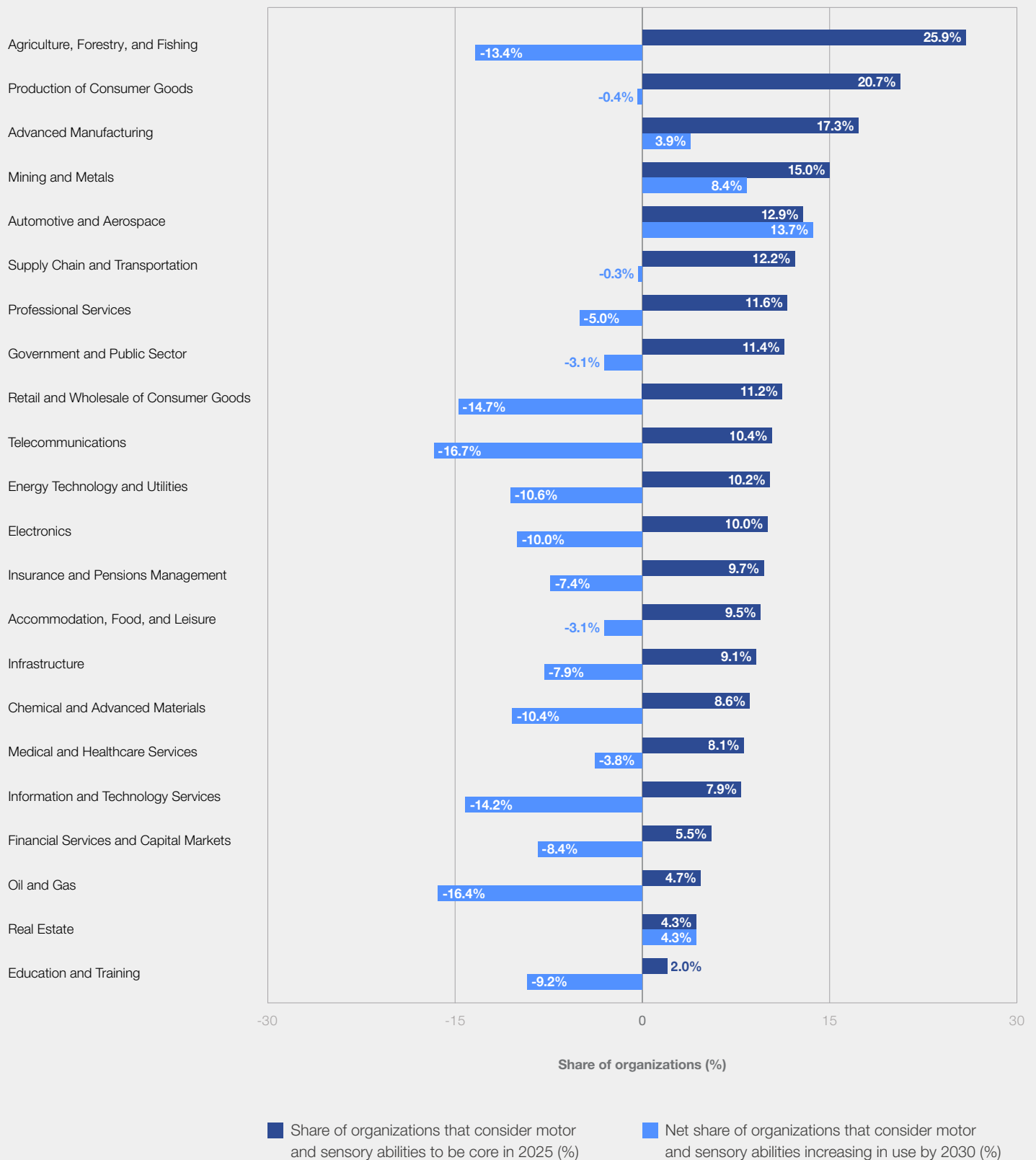
Motor and sensory abilities underpin maker skills, yet employers rarely recognize them as core workforce competencies. Although a significant share of job postings mention maker skills (Figure 4), Figure 8 shows that the share of employers identifying motor and sensory abilities as strategically important is low across industries. This disconnect is particularly evident in some sectors.

For example, in infrastructure, where maker skills are mentioned in 64% of job postings, fewer than 10% of employers identify motor and sensory abilities as core. If anything, this gap widens when considering future workforce needs: only four industries – advanced manufacturing, mining and metals, automotive and aerospace, and real

estate – expect the importance of these abilities to increase by 2030. This contrasts with the evidence that maker skills are among the strongest differentiators between growing and declining occupations (Figure 5).

A similar pattern appears across geographies. In all regions, only a small share of employers see motor and sensory abilities as core (Figure 9), even though makers account for more than half of employment in many regions (Figure 3). The outlook points in the same direction: in most regions, employers expect the importance of these maker abilities to decline rather than increase. Only employers in Sub-Saharan Africa report a net increase above 10 percentage points (+17%).

FIGURE 8 Maker abilities: current importance and expected growth by industry



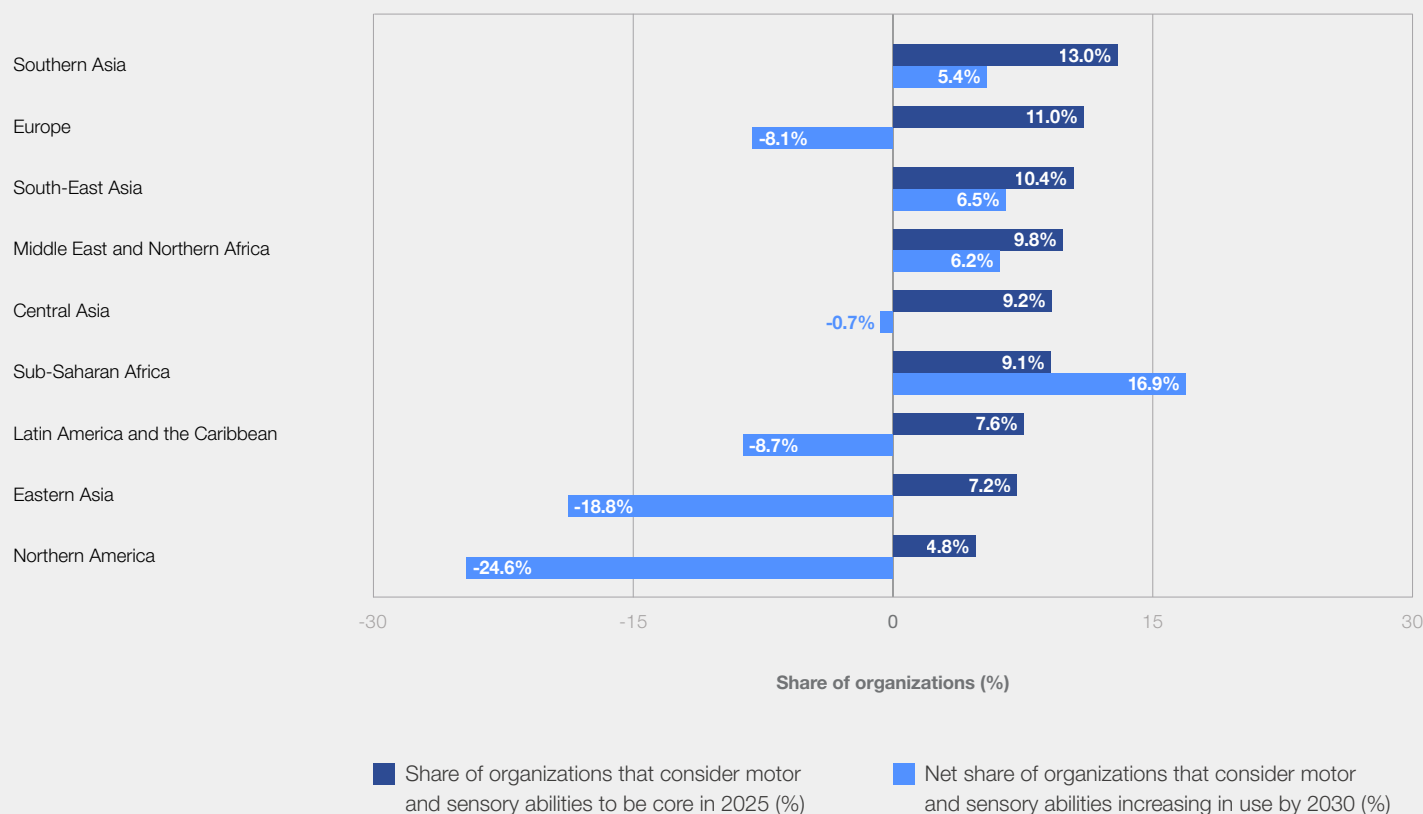
Note: The figure shows, for each industry, the share of organizations that identify manual dexterity, endurance and precision and sensory-processing abilities as core competencies in 2025, alongside the average net share expecting these abilities to become more important by 2030. The net share is calculated as the percentage expecting increased importance minus the percentage expecting decreased importance.

Source: World Economic Forum, Future of Jobs Survey 2024.

This disconnect matters because employer priorities shape both workplace training and education systems. Capabilities that are not recognized as strategically important are less likely to be developed, measured or prioritized, despite their growing value in the labour market. Box 3 describes an OECD initiative designed to support policymakers in linking vocational training with real-world workplace application.

Yet the labour market places a clear value on maker abilities. Figure 10 shows that US maker occupations requiring stronger motor and sensory abilities tend to pay more. A 10 percentage-point increase in motor and sensory abilities' scores is associated with an estimated wage gain of about \$2,500, even without improvements in other skill areas. This association suggests that motor and sensory abilities continue to play an important role in labour-market outcomes.

FIGURE 9 **Maker abilities: current importance and expected growth by region**



Note: The figure shows, for each region, the average of the country shares within that region that identify manual dexterity, endurance and precision and sensory-processing abilities as core competencies in 2025, alongside the average net share expecting these abilities to become more important by 2030. The net share is calculated as the percentage expecting increased importance minus the percentage expecting decreased importance.

Source: World Economic Forum, Future of Jobs Survey 2024.

BOX 3 **OECD – Building trusted signals of applied vocational competence through PISA-VET**

Read the full case study:
[click here.](#)

The OECD's PISA-VET initiative is developing an international assessment model to make vocational competence more visible, comparable and actionable. Inspired by the Program for International Student Assessment (PISA), the programme measures how vocational education and training (VET) students apply occupation-specific skills to real workplace challenges, combining knowledge-based questions, interactive digital simulations and practical demonstration tasks assessed with expert support. By linking performance with learner, institutional and labour-market context, PISA-VET aims from 2030 onward to generate evidence that policymakers, educators and employers can use to strengthen the quality, relevance and trustworthiness of VET systems.

FIGURE 10

US median annual wage by maker abilities,
accounting for differences in other skill areas¹⁹

Higher maker abilities are associated with higher wages

Median annual wage by motor and sensory ability level among selected makers

Lower ability level



\$33,530

Bartenders

Moderate ability level



\$52,310

Hoist and Winch Operators

Higher ability level

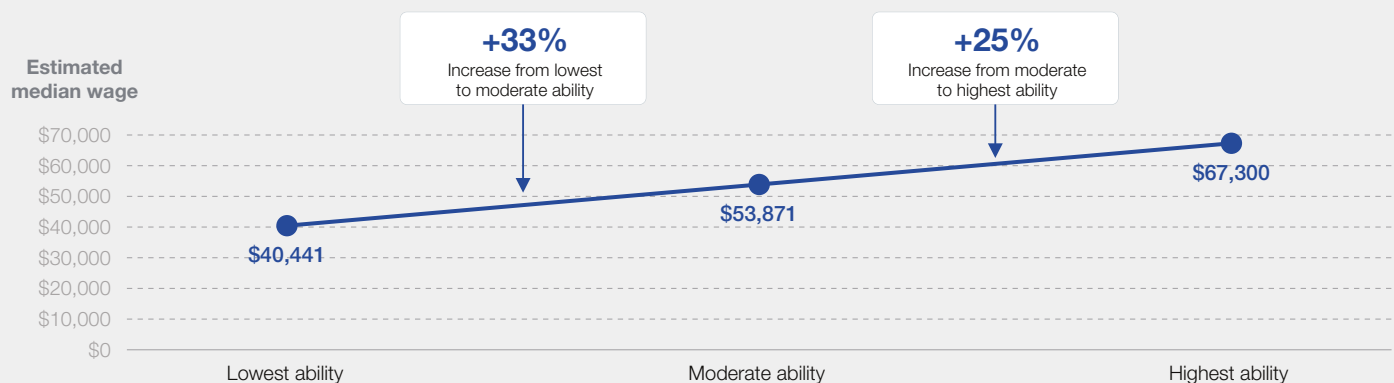


\$62,970

Plumbers and Pipefitters



Even with other skills held constant, increases in maker abilities among makers are associated with **higher wages**.



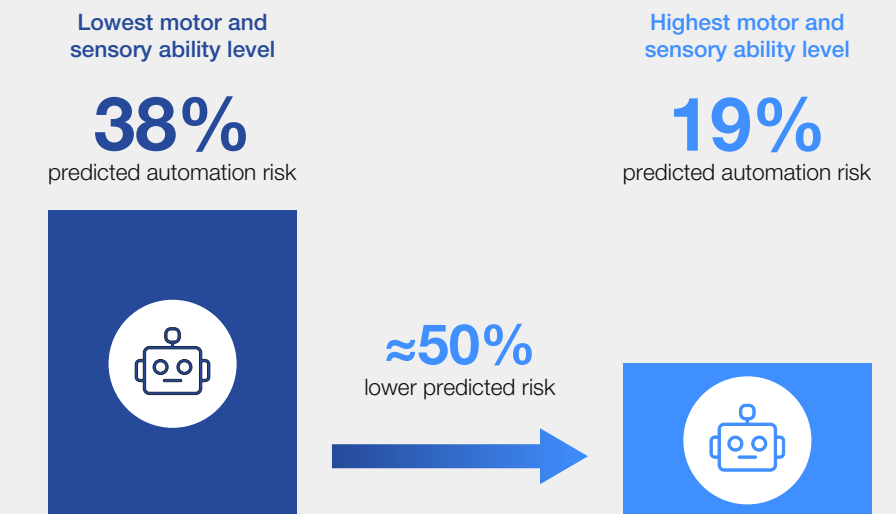
Source: World Economic Forum analysis based on U.S. Bureau of Labor Statistics and O*NET data.

Motor and sensory abilities also strengthen the human advantage in maker work. Today's rapidly scalable AI tools mainly work with text, images, code and other digital information, rather than physically sensing, handling and adapting to the material world.²⁰ Roles that depend on motor and sensory abilities are therefore likely to gain a stronger relative labour-market advantage as generative AI (genAI) adoption expands.²¹

Beyond genAI, occupations requiring higher levels of maker abilities tend to have lower exposure to automation. Advanced motor and sensory abilities help workers deal with the variability of the physical world, where objects, materials,

tools, spaces and conditions often differ from one situation to the next. These demands are harder to automate than routine tasks performed in standardized and predictable settings, even as robots and autonomous systems are becoming more advanced.²² Figure 11 is consistent with this explanation: occupations at the top of the motor and sensory abilities distribution have half the automation risk of occupations at the bottom, even after differences in other skill areas are considered. In short, robotics and autonomous systems are likely to reduce the need for human labour in some occupations and tasks, but occupations that rely more heavily on dexterity and sensory judgement are likely to remain less exposed.

Higher maker abilities are associated with lower automation risk



With other skills held constant, the model predicts automation risk falls from **38%** to **19%** as motor and sensory abilities rise from the lowest to highest level.

Source: World Economic Forum analysis based on O*NET data.

Digital technologies and AI augment maker work

Digital technologies are reshaping how work is performed. In some cases, they replace tasks previously performed by people. In many others, they augment work by complementing and enhancing what people can do rather than replacing them entirely.²⁴

This shift changes how maker work is performed. On construction sites, welders work with programmable robotic arms. In factories, technicians monitor and work with real-time

machine data. In agriculture, workers increasingly operate drones and manage virtual field systems to monitor soil health, water use and crop conditions in real time. Even in commercial kitchens, workers are supervising and calibrating automated food-preparation systems rather than performing every task manually. As a result, technology is increasingly augmenting maker work, combining manual expertise with digital capabilities (Box 4).²⁵ This is reflected in the association between maker and digital skill proficiency requirements (Figure 7).

BOX 4

HP and Homeboy Electronics Recycling – Building digital and circular-economy maker skills

Read the full case study: [click here](#).

HP Inc. and Homeboy Electronics Recycling show how digital technologies and the circular economy can create new pathways into maker careers. Homeboy provides paid, hands-on training for people who have faced barriers to employment, including those who are formerly incarcerated or formerly gang-involved, building practical skills in device refurbishment and electronics recycling that improve material recoverability. HP's partnership adds employer-relevant tools, equipment and workflows used in PC refurbishment, helping participants develop digital literacy alongside technical know-how. The model shows how digitalization can widen access to maker careers by turning electronic waste recovery into training for repair, reuse and remanufacturing roles, while keeping materials out of landfills and returning them to productive use.

Another sign of this augmentation is the growing use of AI across physical work environments. While public attention has focused on AI's impact on knowledge work, AI is increasingly embedded in warehouses, construction sites, factories and farms, where it supports workflow management, process optimization, predictive maintenance and quality control.²⁶

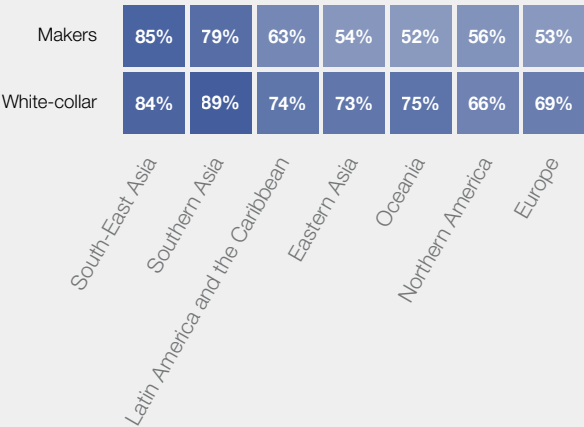
This makes AI literacy increasingly relevant for makers. The shift is already visible in workers' own expectations: across all regions, makers report a strong need to acquire AI-related skills to remain relevant in the labour market, almost matching the levels reported by white-collar workers (Box 5). AI upskilling should therefore not only be a priority for workers who process text, numbers and code, but also for those who build, operate, maintain and repair.

BOX 5 **Makers report a strong need for AI upskilling**

The Randstad Workmonitor²⁷ surveyed over 27,000 workers and 1,225 employers in 35 countries on workplace practices, attitudes, ambitions and expectations.

Most makers across all regions report a need to strengthen their AI skills to remain relevant in the labour market (Figure 12). On average across countries, 57% report this, with the highest shares in Asian countries, many of which are at the forefront of advanced manufacturing, logistics automation and digitally enabled production. On the one hand, the perceived need for AI upskilling is generally lower among makers than among white-collar workers. On the other hand, the differences between the two groups are relatively small.

FIGURE 12 **Perceived need for AI upskilling**



Note: The indicators reflect the share of respondents who agree or somewhat agree that they need to adapt their AI skills to remain relevant in the labour market, for white-collar workers and makers.²⁸ Values represent averages across countries within each region. The sample includes respondents aged 18–69.

Source: World Economic Forum analysis, based on Randstad Workmonitor survey data.

The workforce has yet to catch up with the growing convergence of digital and maker skills. Skills gaps are emerging as employers seek workers who can combine the two. In the United Kingdom, half of skilled-trade vacancies are hard to fill because applicants lack the required skills, qualifications or experience. A lack of digital skills contributes to more than a quarter of these shortages.²⁹ Similarly, only 7% of construction employers in the United States report that nearly all new hires are prepared to work with digital technologies.³⁰

Manufacturing stands out, where digital skills shortages limit firms' ability to adopt new technologies and improve productivity.³¹

As with motor and sensory abilities, maker occupations requiring stronger digital skills tend to pay more. Figure 13 displays a positive relationship between digital skills proficiency and wages across maker occupations, even after accounting for differences in other skill areas.

FIGURE 13

Median annual wage by digital skills proficiency across maker occupations, accounting for differences in other skill areas³²

Higher digital skills are associated with higher wages

Median annual wage by digital skill level among makers

Lower skill level



\$34,220

Food Preparation Workers

Moderate skill level



\$45,160

Printing Press Operators

Higher skill level

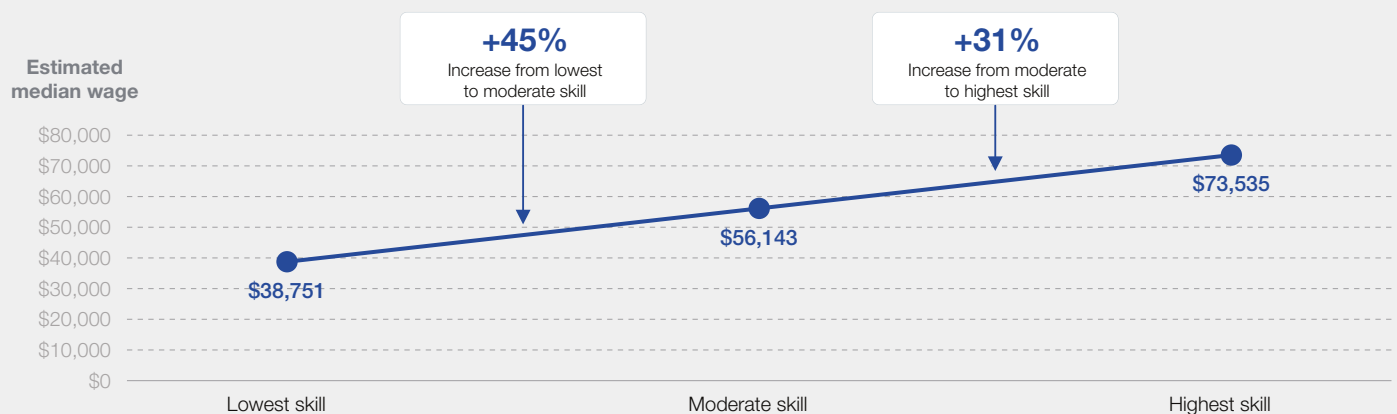


\$63,760

Industrial Machinery Mechanics



Even with other skills held constant, increases in digital skills among makers are associated with **higher wages**.



Source: World Economic Forum analysis based on U.S. Bureau of Labor Statistics and O*NET data.

A 10 percentage-point increase in digital skills proficiency is associated with an estimated wage gain of about \$3,500, compared with less than \$2,000 among other workers. The model predicts that maker occupations at the top of the digital skills distribution earn roughly twice as much as those at the bottom.

Taken together, these findings suggest that digitalization has the potential to strengthen the long-term outlook for maker careers.

As practical expertise becomes increasingly combined with AI and digital technologies, maker skills remain deeply human at their foundations, but new technologies reshape how they are applied. Building the future maker skills will require developing both these foundations and the digital capabilities that increasingly complement them.

3

Strengthening the maker skills pipeline

Building maker skills requires stronger pathways, better training and more attractive careers.

The foundations of maker skills begin to develop long before vocational education

The motor and sensory abilities that underpin maker skills are developed through early childhood experiences that involve movement, play, drawing, making and other forms of hands-on learning. However, evidence suggests that these abilities are weakening among children,³³ with experts pointing to reduced opportunities for hands-on play and increasing exposure to screens as contributing factors.³⁴

As children progress through school, practical subjects such as woodwork, metalwork and sewing can help students develop more advanced motor and sensory abilities alongside practical problem-solving skills. Yet these subjects often receive

limited attention in many education systems (Figure 14). On average across OECD countries, they account for less than 5% of compulsory instruction time. This reflects a strong hierarchy in which abstract academic subjects are valued more highly than practical and vocational learning.³⁵

This matters beyond preparing students for work. Hands-on activities build coordination, precision and spatial reasoning while supporting broader cognitive, physical and social development.³⁶ As education systems seek to prepare learners for an increasingly technology-enabled economy, maintaining opportunities for practical, experiential learning from an early age becomes increasingly important.³⁷

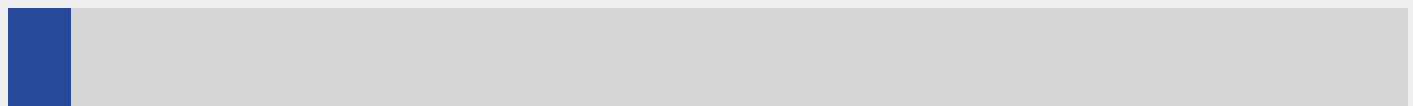
FIGURE 14

Allocation of compulsory instruction time in primary and lower secondary education (OECD countries)³⁸

The 5% Problem

Practical and vocational learning receives less than 5% of compulsory instruction time

95.5% Other compulsory subjects



4.5% Practical & vocational skills

Source: World Economic Forum analysis based on OECD data.

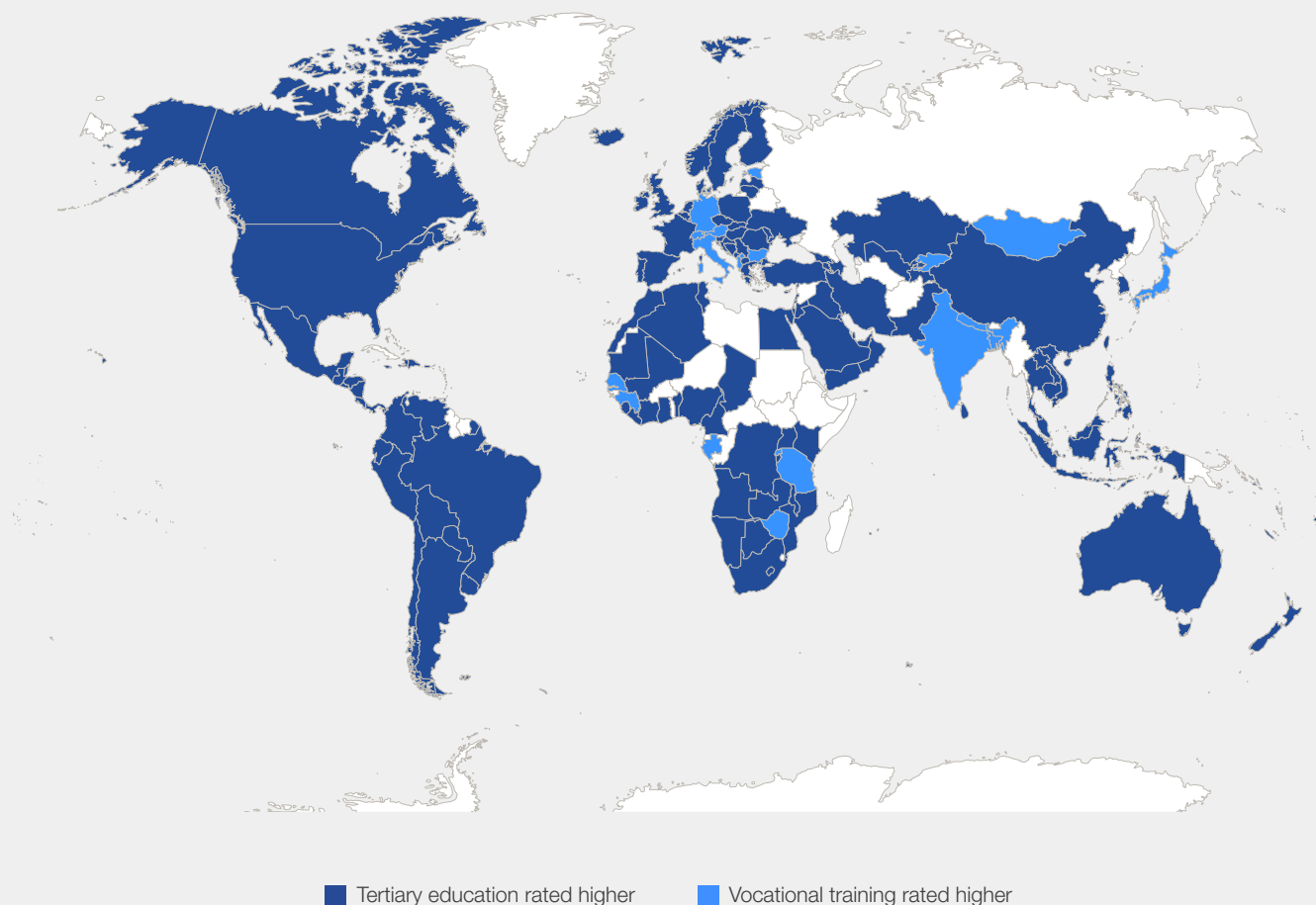
Vocational education needs modernization

As learners move beyond these early foundations, vocational education and training (VET) becomes a primary pathway for developing job-specific maker skills. Half of makers in the European Union, for example, have a vocational qualification as their highest level of education.³⁹

Despite its importance, employers often view vocational education as less effective than tertiary education in meeting the needs of a competitive economy. As shown in Figure 15, business leaders rate vocational training more highly than tertiary education in only 15% of countries.

FIGURE 15

Perceived quality: vocational training versus tertiary education



Note: Country values reflect business leaders' annual assessments of how well tertiary and vocational education meet the needs of a competitive economy. For each country, scores are averaged across years from 2020 onward, and vocational training is compared with tertiary education.

Source: World Economic Forum Executive Opinion Survey 2025.

These perceptions reflect well-documented challenges in vocational training systems. A key problem is that employer involvement in designing curricula and training programmes is often limited.⁴⁰ As a result, curricula and delivery models can become outdated and there is a shortage of high-quality apprenticeships, which are critical for developing maker skills.⁴¹ Scaling maker skills also presents a distinct challenge:

unlike classroom-based or digital learning, practical training requires access to equipment, workplaces and experienced instructors. This makes sustained funding particularly important. Without it, vocational programmes struggle to invest in modern equipment, attract instructors with current industry expertise and keep pace with evolving workplace technologies.⁴²

Read the full case study:
[click here.](#)

In Türkiye, a partnership between Rönesans Holding, UNICEF's "From Learning to Earning for Youth" programme, and the Ministry of National Education turns Gaziantep City Hospital into a workplace-based vocational learning laboratory. Each year, 120 vocational high school students rotate through high-demand technical occupations four days a week, including industrial automation technologies, plumbing and industrial maintenance and repair. By training Rönesans employees as certified master trainers and pairing live workplace tasks with safety, inclusion and curriculum standards, the model shows how apprenticeships can become value-creating partnerships: students gain job-ready competencies, while employers build stronger talent pipelines and internal training capabilities.

Vocational training systems also struggle with assessing and credentialing maker skills. Because these skills are often learned and demonstrated through practice (see Box 6), they can be difficult and costly to assess in a reliable and standardized way. Therefore, even when credentials exist, they may not always serve as strong signals of job-ready competence. Many employers instead rely on practical assessments, workplace experience, informal networks, and in-house evaluations when hiring and promoting makers.⁴³

These challenges are even greater in countries where formal vocational training systems are limited and maker skills are acquired primarily through informal learning. In many emerging economies, workers may learn through family businesses, informal apprenticeships and on-the-job experience. In Lesotho, Nigeria and Tanzania, for example, between half and nearly three-quarters of surveyed apprentices were in informal apprenticeships.⁴⁴ While these pathways often develop valuable skills, they rarely provide learners with recognized credentials.

Untapped talent pools for maker skills

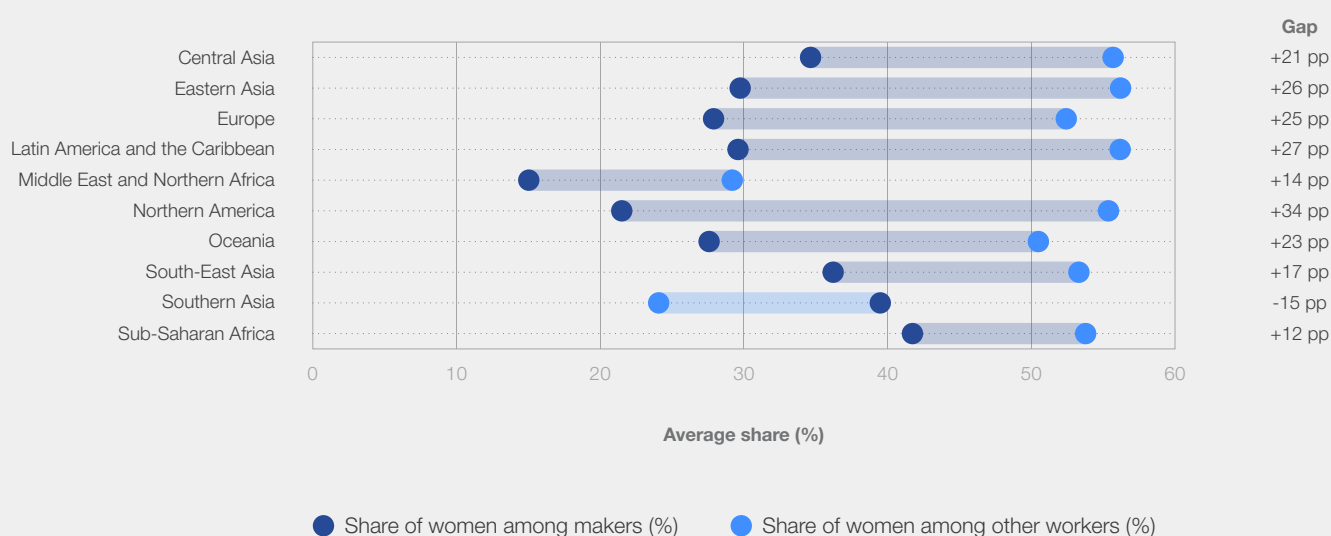
The maker skills pipeline is constrained not only by how skills are built and recognized, but also by a narrow talent base. One problem is the underrepresentation of women. As Figure 16 shows, women account for a smaller share of makers than men in every region. Their share ranges from 15% in the Middle East and Northern Africa to 42% in Sub-Saharan Africa, with a regional average of 30%.

By comparison, women account for 49% of other workers on average across regions.⁴⁵ This gender gap means that a significant share of the potential maker talent pool is untapped.

Makers are also older (Figure 17). This is especially true in Asia, Europe and Northern America, where workers aged 55 and above account for between

FIGURE 16

Share of women among makers and other workers

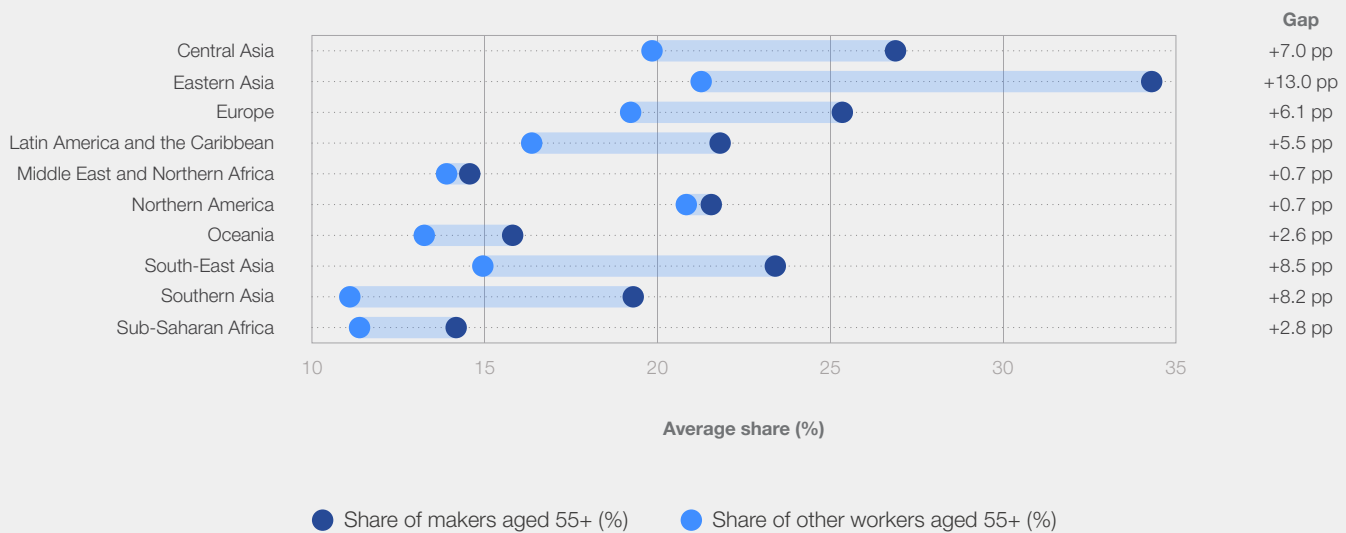


Note: The figure shows women's share of employment among makers and other workers. Values represent averages across countries within each region.

Source: World Economic Forum analysis, based on ILOSTAT data.

FIGURE 17

Share of workers aged 55 and above



Note: The share of makers and other workers aged 55 or older, expressed as a percentage of total employment within each respective group. Values represent averages across countries within each region.

Source: World Economic Forum analysis, based on *ILOSTAT* data.

20% and 35% of makers. Africa is the main exception, with less than 15% of makers aged 55 or above. In every region, makers are also more likely than other workers to be aged 55 or above, and makers are ageing faster than the workforce overall.⁴⁶ The gap is especially large in Asia, where older workers are between 1.4 and 1.7 times more common among makers than among other workers. This means that the risk of workforce exits is higher among makers than among the wider workforce.

This trend is especially problematic because the pipeline of new maker talent is already constrained. Cross-border recruitment is one important source of workers with maker skills. However, its ability to ease shortages is becoming increasingly limited as demand for maker skills rises across countries and visa restrictions, administrative barriers and difficulties recognizing qualifications hinder labour mobility.⁴⁷

This makes it even more important to strengthen the domestic supply of maker skills (Box 7). Doing so will be challenging in many countries, where declining working-age populations coincide with low levels of interest in maker skills among young people. In fact, across regions, only 13% of boys and 4% of girls expect to become makers.⁴⁸ This is well below makers' share of employment, which ranges from 25% in Northern America to 68% in Southern Asia (Figure 3). This points to a major recruitment challenge at a time when demand for maker skills is already high and expected to grow. As experienced makers retire and interest in maker careers among young people remains low, shortages could constrain productivity, slow the adoption of advanced manufacturing technologies, weaken supply-chain resilience and erode industrial competitiveness.

BOX 7

Anglo American – Building local maker skills pipelines for regional growth

Read the full case study:
[click here.](#)

Anglo American's Kumba Iron Ore demonstrates how employers can play a direct role in expanding maker skills pipelines. Through accredited training centres located in local communities and on-site operations, the company equips people with practical trade, artisan and mining skills that are portable and valuable both within and beyond the mining sector. The training has helped address regional unemployment while creating a stronger local pipeline of skilled workers for future industrial growth.

The low attractiveness of maker careers is notable given the benefits these jobs offer. They typically avoid the burden of large student debt, as vocational pathways are shorter, more affordable and often include paid apprenticeships that allow learners to earn while they learn. For example, the average tuition and fees for a four-year college degree in the United States are \$79,200, compared with an average of \$15,200 for a trade school certificate, which can take from less than one year to two years to complete.⁴⁹ Vocational graduates are also more likely to find employment than university graduates, an advantage that may become even greater with the advent of genAI.⁵⁰

Despite these advantages, maker occupations fall short on key factors that shape their attractiveness. One factor is the physical demands. Often, the work of makers involves repetitive movements, heavy lifting and exposure to strenuous conditions. These demands can make the work difficult to sustain over a full career. As a result, these workers are more likely to retire early.⁵¹ Another factor is

wage progression. Even in countries with strong vocational training systems, such as Germany, the early wage advantage diminishes over time.⁵²

The strengthening link between maker skills and digital skills has the potential to address these issues. First, being able to work with new tools and technologies may allow workers to reduce exposure to the most physically demanding and hazardous tasks, such as heavy lifting, repetitive work and dangerous activities.⁵³ Second, maker occupations requiring stronger digital skills tend to pay more (Figure 13). Third, the digital shift taps into young people's interest in technology and can serve as a gateway into these careers.⁵⁴

Consistent with this, Figure 18 shows that occupations combining strong maker and digital skill proficiency requirements are associated with greater expected career interest among young people, even after accounting statistically for wages and other occupational characteristics.

FIGURE 18 Expected career choice by maker skills, digital skills and gender⁵⁵

Jobs requiring both high maker and high digital skills are associated with stronger career interest among young people

Skill mix	Boys' career expectations	Girls' career expectations
 Low digital, Low maker	↑	↑
 High digital, Low maker	↑	↓
 Low digital, High maker	↓	↓
 High digital, High maker	↑	↑

 Higher than average career expectation

 Lower than average career expectation

 These patterns hold even after accounting for other skill demands and wages.

Source: World Economic Forum analysis based on OECD and O*NET data.

Calls to action: five priorities to strengthen maker skills

Strengthening maker skills requires coordinated action across the education and workforce ecosystem.

Economic transformation depends on maker skills. Yet the pipeline of maker talent is not keeping pace with demand for these skills. As this report has shown, three challenges stand out: training systems that are not adapting quickly enough to changing skill requirements, limited inflows of new talent, and weak systems for recognizing and credentialing practical skills.

Addressing these challenges requires coordinated action across employers, education and training providers, and governments. The priorities outlined below provide a roadmap for expanding the maker talent pipeline to support long-term growth.

Build vocational pathways for the industries of tomorrow

High-quality vocational education should lead to the same prestige, progression and long-term opportunities as academic education.

Vocational education remains undervalued in many countries. Despite growing demand for maker skills and the rising cost and uncertainty of traditional university pathways, many families are still steering young people towards academic education.⁵⁶ As countries invest in advanced manufacturing, clean energy, AI infrastructure and other strategic industries, vocational education should be a cornerstone of economic competitiveness rather than an alternative to university.

Changing perceptions requires changing reality. Vocational education must consistently deliver skills that employers value, and therefore employers must play a central role in designing curricula and qualifications. Doing so requires sustained collaboration between employers, education providers, and governments, often at the local or regional level, to ensure that programmes evolve alongside changing technologies and local labour-market needs. Large employers can engage directly, while sector bodies, chambers and local intermediaries can represent the skills needs of small and medium enterprises (SMEs) with more limited capacity. Systems that perform well have institutionalized such involvement.⁵⁷ In Germany, Austria and Switzerland, where employers rate vocational training higher than tertiary education

(Figure 15), industry associations define training standards, while public authorities and social partners ensure quality and accessibility.

Vocational programmes also need modern equipment, instructors with up-to-date industry expertise and clear progression into higher education.⁵⁸ This enables learners to receive high-quality training and move seamlessly between vocational and academic pathways throughout their careers. Vocational education can then become a flexible pathway for lifelong learning rather than a separate track. By supporting continuous skill-building, vocational education can also open more routes into higher-wage roles, supervisory positions and entrepreneurship (Box 8). This can help address the limited career and wage progression opportunities often associated with maker occupations.

Career guidance should also evolve. Young people and their families need a better understanding of how maker careers are changing, including the growing role of digital technologies, opportunities for career progression and the critical role these jobs play in building the future economy.⁵⁹ Changing these perceptions requires employers, educators and governments to actively promote maker careers in schools and local communities.

Read the full case study:
[click here.](#)

There is a widening labour shortage in the skilled trades in the United States. The challenge is not only to bring more workers into the field, but also to help them progress into higher-wage roles, supervisory positions and business ownership. Many tradespeople receive strong technical training but have fewer opportunities to build the business, financial and operational skills needed to lead teams, manage projects or launch successful enterprises. The collaboration connects The Home Depot's Path to Pro Program with Georgia Tech's Lifetime Learning content, combining foundational technical training with business and professional skills, financial literacy, entrepreneurship readiness and technology enablement, including AI-enabled workflows. At scale, the partnership aims to equip entry-level and experienced tradespeople with the capabilities to enter high-demand roles, improve jobsite and business operations, prepare for small-business ownership and build longer-term economic mobility.

- **Education and training providers:** Build vocational programmes that connect to higher qualifications, strengthen employer partnerships and provide clear progression pathways throughout a learner's career.
- **Employers:** Co-design curricula, directly or through sector associations and local employer networks, share labour-market intelligence and provide clear pathways from education into employment to ensure vocational programmes reflect evolving industry needs.
- **Governments:** Strengthen progression between vocational and academic pathways, communicate the long-term opportunities offered by maker careers and support campaigns that reach students, parents and local communities to shift public perceptions of how maker occupations are changing.

Embrace AI and digital skills in maker curricula

[As technology reshapes maker work, modern curricula should integrate digital and AI skills and offer shorter, targeted programmes for high-demand roles.](#)

To keep training aligned with evolving skill requirements, educators, employers and governments should fully embrace AI and digital skills as essential complements to maker skills. A stronger emphasis on digital skills not only has the potential to increase interest in acquiring maker skills; it can also help raise productivity and prepare for increasingly automated production and manufacturing environments. This will become increasingly important as working-age populations decline and recruitment becomes more difficult. Direct involvement from employers can help shape curricula that more closely reflect the increasingly augmented nature of tomorrow's maker skills.

The World Economic Forum's SmartStart initiative⁶⁰ shows how to put this approach into practice. It aims to prepare 1 million young people for careers in manufacturing and supply chains by 2035. At the core of the initiative is the ambition to better connect training with digital skills requirements in these roles and increase the attractiveness of these careers.

Modernizing maker curricula also means recognizing the pace at which new skills are needed. Shorter, targeted programmes are needed to create faster pathways into high-demand maker occupations. When well designed, these programmes can provide more immediate routes into employment while also opening maker careers to a broader talent pool.

- **Education and training providers:** Work with employers to identify digital skills gaps for makers, understand the combination of digital and maker skills needed for employment and create short-term training programmes that directly meet those talent needs.
- **Employers:** Share information and data on how technologies are changing maker skills and the combinations of maker and digital skills required in the workforce.
- **Governments:** Invest in modern training facilities, equipment, and the recruitment and continuous development of instructors.

Start building maker skills earlier

The foundations of maker skills are built in childhood, long before young people choose a career. Early practical learning builds the motor, sensory and problem-solving abilities on which maker skills depend.

Early childhood education and primary education help develop the motor and sensory abilities that underpin later technical skills, while practical learning also strengthens problem-solving, confidence and creativity. Yet hands-on learning receives limited attention, which leaves fewer opportunities for children to develop these capabilities or discover an interest in making and building. Reversing this trend is becoming increasingly important as experienced makers retire and demand for maker skills grows across advanced manufacturing, infrastructure, energy and other sectors. Just as every child learns to read, write and calculate, every child should also have opportunities to design, build, repair and create. Expanding the future talent pipeline requires investing much earlier and building these capabilities in the classroom.

- **Education and training providers:** Embed hands-on learning throughout early childhood education by protecting activities that develop fine motor skills, spatial reasoning and practical problem-solving, including drawing, making, building, and crafting.
- **Employers:** Partner with schools to ensure maker careers are visible from an early age through classroom projects, workplace visits, maker challenges, mentoring, and hands-on demonstrations that connect learning to real industries.
- **Governments:** Treat practical learning as foundational rather than optional by strengthening its place in national curricula, investing in teacher capability and modern equipment, and ensuring every child has sustained opportunities to develop maker skills from an early age.

Expand high-quality apprenticeships and work-based learning

Maker skills are learned by doing. High-quality apprenticeships and workplace learning build job-ready and future-ready capability.

Practical workplace experience is essential for developing maker skills. Offering learners these opportunities requires employers, education providers, and governments to work together. The World Economic Forum's First Mile Sandbox builds on this principle by bringing these partners together to develop, test and scale learn-to-earn models, including apprenticeships, that strengthen pathways from education into employment.⁶¹

Such close collaboration is a common feature of high-performing apprenticeship systems. In Germany, for example, whose vocational training system is often recognized as a global leader, apprenticeships are jointly governed by industry, trade unions and government, with tripartite bodies developing and updating standards in line with labour-market needs.

Engaging SMEs in this is particularly important because they employ a large share of the workforce but often lack the time, staff and resources to offer apprenticeships on their own. Governments can help by reducing administrative burdens, providing co-funding and supporting local intermediaries, while sector bodies and training providers can help SMEs share apprenticeships across firms.⁶² Where they have the capacity, large employers can also support this by opening training facilities, apprenticeship programmes and technical expertise to SMEs, helping extend high-quality workplace learning beyond their own workforce.

Apprenticeships should also be recognized as a source of immediate value for firms and not only as a long-term investment. Apprentices can bring the latest digital skills, while experienced workers transfer practical expertise, judgement and problem-solving.⁶³ This two-way exchange strengthens workforce capability across generations while building a sustainable pipeline of future talent.

The two-way exchange between apprentices and experienced workers should itself be part of a broader culture of continuous workplace learning. As technologies and skill requirements evolve, learning cannot stop once workers become experienced. Yet time constraints, limited access to learning opportunities and the operational demands of front-line environments often make continuous skill development more difficult than for office-based workers. Workplace learning therefore needs to be practical, accessible and embedded in everyday work.

- **Education and training providers:** Integrate high-quality workplace learning into vocational programmes and work with employers to define learning outcomes that reflect industry needs.
- **Employers:** Expand apprenticeship opportunities directly or through shared consortia, protect time for front-line learning, and treat apprenticeships and work-based learning as two-way models in which experienced workers transfer practical know-how and apprentices bring digital fluency and

new perspectives into the workplace. Where they have the capacity, large companies can support SMEs by sharing training facilities, workplace learning programmes and technical expertise.

- **Governments:** Make apprenticeships and work-based learning easier for employers

to offer by reducing administrative barriers, providing predictable co-funding or wage support, simplifying access to public schemes, and supporting local intermediaries and shared training facilities, particularly for SMEs and sectors where the vocational ecosystem is still developing.

Ensure maker skills are visible and portable

Workers need reliable ways to prove what they can do, regardless of where or how they developed their skills.

Maker skills are acquired and demonstrated through practice, which makes them difficult to assess using traditional academic methods. New technologies can help make assessment more scalable and closer to real-world work, including through digital simulations and interactive environments. In automotive repair, for example, a virtual garage can assess whether learners inspect the right components, select appropriate tools and follow correct procedures before working on a real vehicle.⁶⁴ Employers should play a central role in defining standards so assessments measure the capabilities that matter on the job.

Assessment alone, however, is not enough. Maker skills continue to develop throughout a career, but much of this learning remains invisible because it happens through work experience rather than formal education. Modular credentials, microcredentials and Recognition of Prior Learning (RPL) can make these capabilities visible by recognizing skills gained through work, short courses and informal learning. By breaking skills into smaller, verifiable units, they allow learners to build skills progressively and accumulate them over time. Their flexible design also allows faster alignment with evolving industry needs and supports continuous upskilling. To become trusted signals of capability, these credentials must be recognized across employers, education providers and qualification systems.

Even when skills are visible, workers may still struggle to have them recognized elsewhere. In the United States, for example, HVAC contractors often face different licensing requirements from one state to another, which can prevent them from taking jobs across state borders. Greater recognition of equivalent licences and credentials would make it easier for qualified workers to move where demand is highest.⁶⁵

- **Education and training providers:** Develop assessments, in partnership with employers, that reflect real workplace tasks and expand the use of modular credentials that recognize skills acquired throughout a learner's career.
- **Employers:** Co-design assessment standards and recognize modular credentials and RPL in recruitment, promotion and pay.
- **Governments:** Build skills recognition systems that make maker skills portable across employers, sectors and regions by establishing common assessment standards, qualifications frameworks and RPL.

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19. The x-axis ranks maker occupations by a combined motor and sensory abilities score, calculated as the average proficiency of sensory-processing abilities and manual dexterity, endurance, and precision. The blue line is the predicted wage from a regression model that controls for other skill proficiencies, with all controls held at their sample means. The analysis is based on the World Economic Forum's Global Skills Taxonomy, O*NET skill proficiency level data and Bureau of Labor Statistics salary data for each occupation.
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