MAKING FOR TOMORROW: SKILLING ACROSS THE AGES

Manufacturing skills for the Middle East and Africa

KnowledgePoint
Where learning lives

Summary

Economies across the Middle East and Africa (MEA) are transforming, adapting to the rapid technological advances of the Fourth Industrial Revolution.

Each industrial revolution marked a milestone in human progress – shaping economies, societies and the very nature of work. As in the past, where steam power, electrification and digital computing each revolutionised their respective eras, today's world faces a new wave of transformation. Automation, robotics, artificial intelligence, and 3D printing are reshaping the manufacturing sector, a vital driver of economic development and diversification in the region.

Yet, as in previous revolutions, this era of change brings disruption alongside opportunity.

The creation of new roles and the redundancy of others has led to an unprecedented shift in the skills required for success. Transformation reveals a widening gap between the skills that workers possess and those demanded by employers.

This report takes you on a journey through the "four ages" of learning – school, university, work and beyond. We explore the skills the manufacturing sector in the region needs to develop not only to meet today's demands but to build a future-ready workforce.

Rather than focusing too much on specific jobs or career paths which may appear or disappear, we emphasise the need to cultivate skills. Across and for all ages. This means equipping individuals with knowledge in science, technology, engineering and mathematics (STEM) as well as critical, adaptable skills that can keep pace with evolving technology. This will include addressing some deep-rooted structural and societal barriers which prevent access to education and learning opportunities.

As the future of work emerges at the intersection of human potential and technological innovation, this report serves as both a call to action and a guide for the region.

> "The path of human progress is marked by milestones created when a relevant technology arrives at the right time to meet or drive forward a compelling collective need.[1]

The adoption of new technology will also create new job opportunities and potentially enhance productivity. However, the specific type of jobs created, and the benefits to society from the future of work, will depend to an important extent on the availability of the skills needed to meet upcoming demand.[2]

Setting the scene

In the two hundred and fifty years since the First Industrial Revolution, the world has undergone tremendous transformation.

In this time, manufacturing has been one of the key drivers in advancing technology, changing society and productivity – and the nature of work. Jump forward to today, when we're in the throes of the Fourth Industrial Revolution which is accelerating change all around us.

"4IR is a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries…" Klaus Schwab, Founder and Executive Chairman of the World Economic Forum[3]

A sector characterised by growth and change

As it has in the three previous industrial revolutions, the global manufacturing industry continues to evolve, shaped by technological advances, shifting economic policies and evolving consumer demands. On the whole, manufacturing has been – and continues to be – a driver of economic growth around the world. In more recent years, the sector has seen some resurgence after the pandemic-related disruptions of 2020 and 2021. According to UNIDO, global manufacturing output rose by approximately 3% in that period.[4] Asia, particularly China and India, continues to lead as the global manufacturing hub.

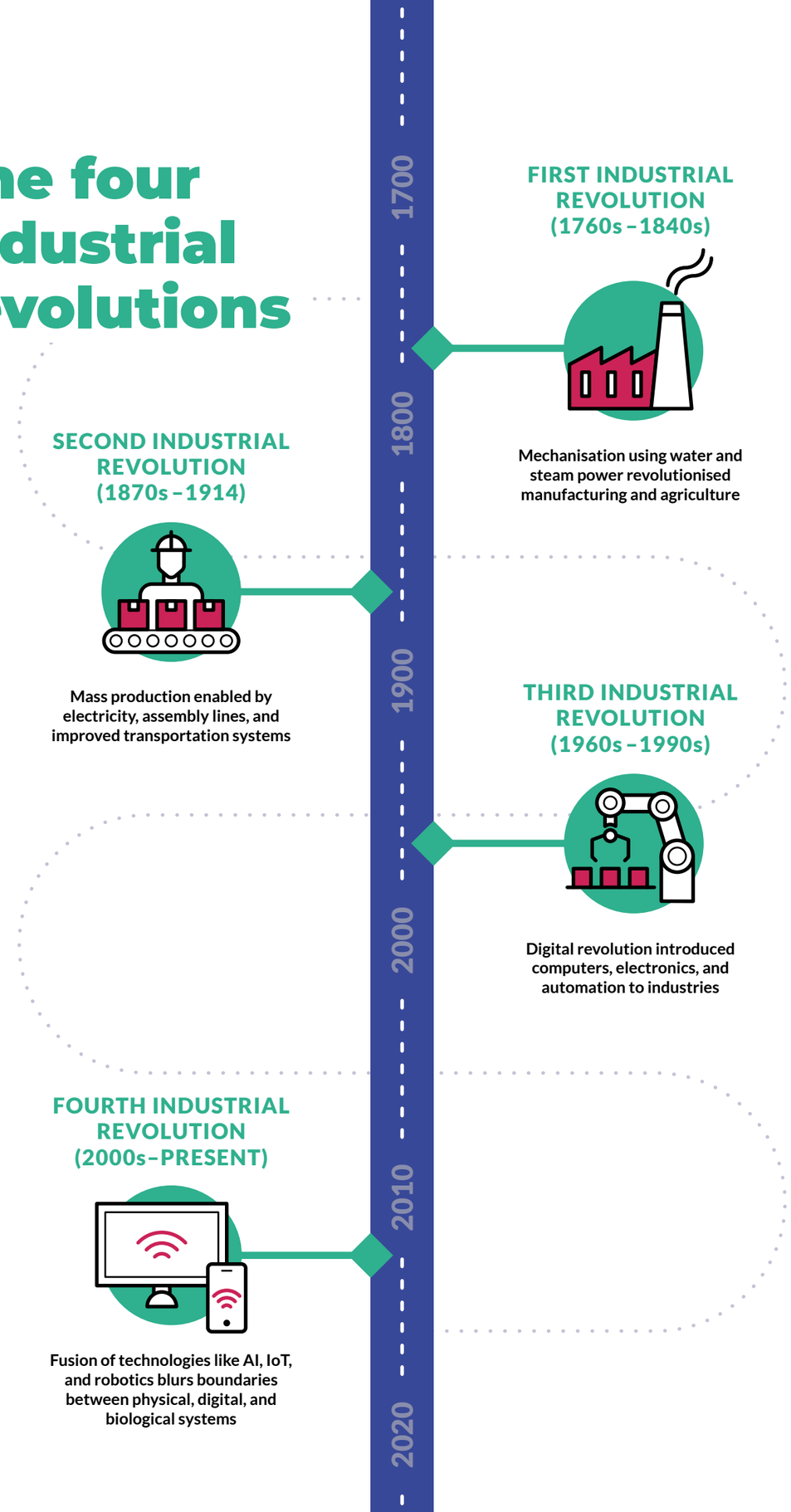
In MEA, the manufacturing sector features in economic diversification strategies, particularly in oil-reliant Gulf states. Saudi Arabia's Vision 2030[5] and the UAE's Operation 300bn[6] target increasing the contribution of manufacturing to GDP through non-oil industries such as green energy, chemicals and pharmaceuticals. The Qatar Manufacturing Strategy[7] was launched to support the nation in meeting its growth aspirations in the sector; within its key pillars for enabling growth is a reference to "encouraging and financially supporting innovation and developing local talent".

In Sub-Saharan Africa, countries like Kenya[8] and Ethiopia[9] are positioning themselves as emerging manufacturing hubs, focusing on textiles, agro-processing and automotive production. Similarly, increasing industrial competitiveness through manufacturing is a key focus for North African countries including Egypt[10] and Tunisia[11].

Despite these ambitions, regional manufacturing output remains lower than global competitors. Across MEA, manufacturing contribution to GDP remains around 10%, compared to a global average of 16%.[12, 13]

Closing this gap requires investment in both technology and human capital.

The four industrial revolutions



The advance of digital technology

Innovations such as automation, artificial intelligence (AI) and the Internet of Things (IoT) are transforming the manufacturing landscape around the world. Adopting new technologies such as additive manufacturing, advanced robotics and digital twins can enhance manufacturing operations. The shift towards smart factories involves the integration of such digital tools with traditional production methods, to boost efficiency and reduce waste through data-driven decision-making.

The role of technology is not limited to production processes but also extends to supply chain optimisation and sustainability efforts, which require manufacturing businesses to invest in modernising their practices. Digital design is proven to improve visibility, leading to more efficient and effective processes. This in turn reduces lead times in development and gets products to market faster. Data has become a critical component for unlocking success in manufacturing; it can increase collaboration and boost productivity.

Technology adoption is clearly on the roadmap for economic growth, but the uptake varies significantly across the region. Some countries are moving rapidly, while other areas are struggling due to high technology costs and a lack of infrastructure.

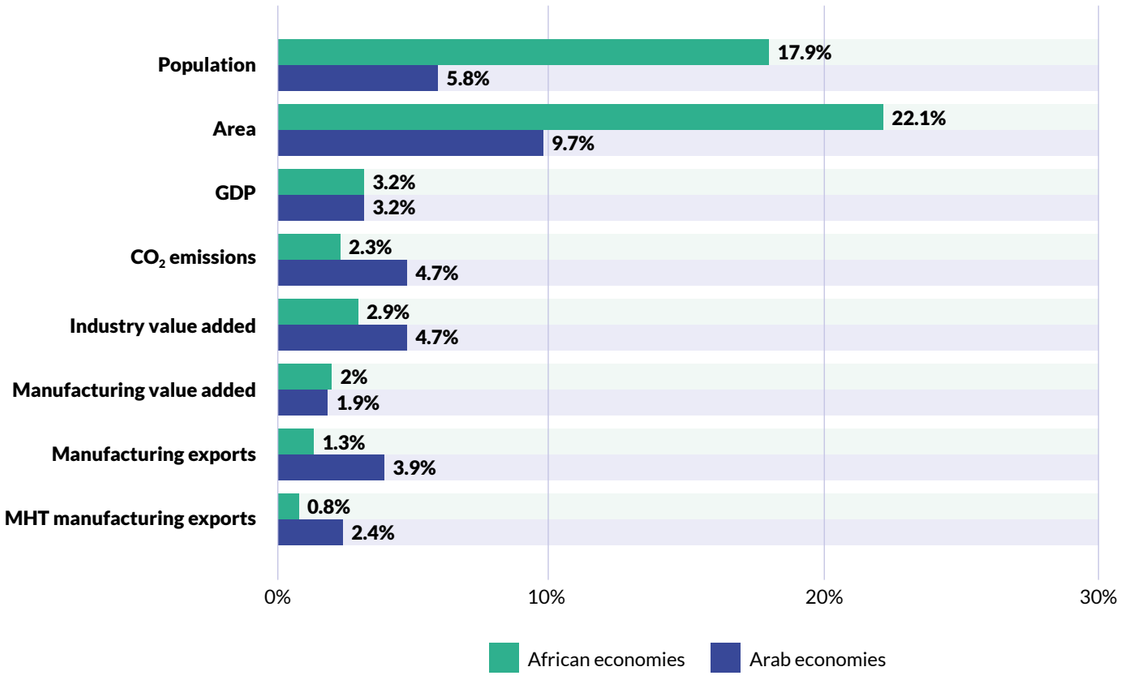
The World Economic Forum[14] recently highlighted data which showed that 80%[15] of companies in the wider MENA region are adopting digital technologies, and investment in digital transformation is predicted to rise rapidly, reaching $298.2 billion by 2032 from $38.4 billion in 2022[16].

Examples of investment include the Saudi Advanced Manufacturing Hub strategy which, in partnership with the World Economic Forum, has identified more than 800 investment opportunities totalling $273 billion to diversify the industrial economy. By 2035, it aims to increase the number of factories to 36,000. Nearly 4,000 factories in the KSA will be heavily reliant on automated equipment and technologies.[17]

Through the Make it in the Emirates campaign, the UAE is attracting some of the world's leading technology and industrial companies to work within its manufacturing ecosystem.[17]

> The manufacturing industry in the Arab region is diverse, marked by varying levels of development, specialization and integration. Lower technology industries, such as food, beverages and refined petroleum products, constitute nearly two-thirds of manufacturing value added (MVA). The share of higher technology industries, such as electronics and machinery, remains relatively low and concentrated in a few countries, such as Oman, Morocco, Qatar, Saudi Arabia and the United Arab Emirates.[13]

Share of Africa and Arab economies in the world economy, 2022[12,13]



Source: UNIDO calculations.
Note: Figures for CO_2 emissions are for 2020. CO_2 = carbon dioxide; MHT = medium-high and high technology industries.

Demographic factors at play

The global population reached a significant milestone in November 2022 – 8 billion! The latest projections by the United Nations suggest the world's population could grow to around 8.5 billion in 2030 and 9.7 billion in 2050; it is projected to reach a peak of around 10.4 billion people during the 2080s and to remain at that level until 2100.[18]

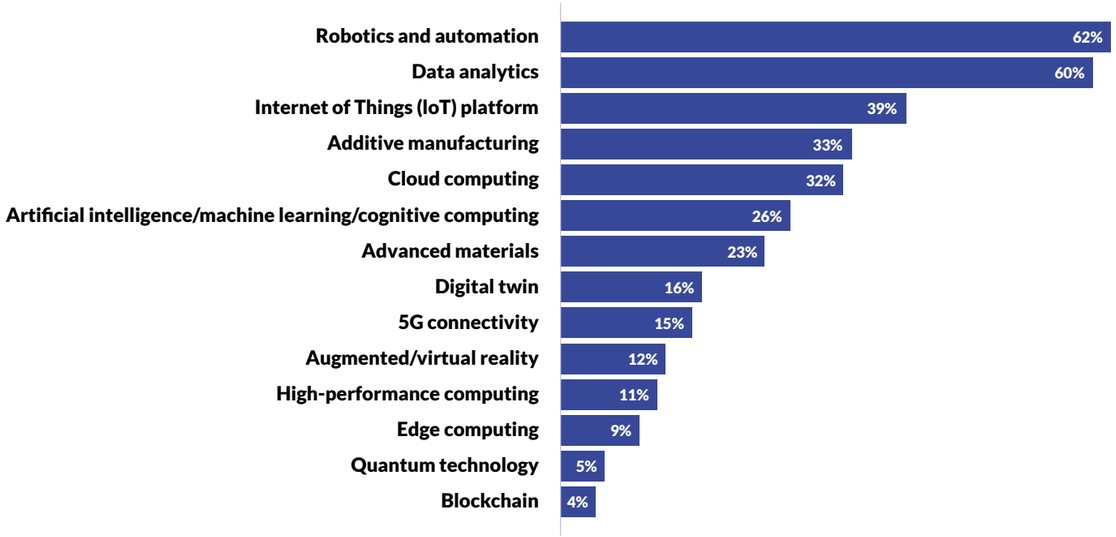
Growing numbers of youth in Africa are both a challenge and an opportunity. Africa has the youngest population in the world. By 2050, one in every four people on earth and more than a third of the world's young people aged 15-24 are expected to be African.[19]

As such, the ability of Africa to convert its youth dividend – with a projected 362 million young people between 15-24 years by 2050 – into a highly skilled STEM workforce can be a game changer.[20] Currently, millions of young African men and women enter the job market annually, most commonly in the agriculture and retail trade sectors, and not necessarily in ICT and STEM-related occupations. The occupational structure of employment is driven not only by the supply-side factor (i.e. the availability of skilled workforce) but also by demand-side factor (i.e. the availability of job opportunities).[21]

The global incidence of youth not in employment, education, or training (NEET) has seen only a modest decline since 2015, falling from 21.3% to 20.4% in 2024. The Arab States region has the highest incidence of youth NEET, at 33.3%, followed by Africa (23.3%).[22]

> Africa today is a $2.5 trillion economy. It's over 1.3 billion people. But it is spread across 54 countries. People tend to think of it as a monolithic grouping, but they are very different.
>
> Acha Leke, McKinsey[25]

Surveyed manufacturers plan to focus on a range of technologies to increase operational efficiencies over next 12 months[26]



The importance of skills

Worker profiles, job roles and the skills required in manufacturing are rapidly evolving. Traditional skills, once sufficient to operate machinery or manage production lines, are no longer enough. The modern manufacturing worker needs to be proficient in digital literacy, data analytics and machine programming.

In the MEA region, this need for new skills is even more pressing as countries push to modernise their industrial sectors. This is even more true in a fast-changing world, where having the right skills at the right time is the key to workers' relevance and longevity. Engineers and technicians are now expected to manage complex, automated systems, while shop-floor workers must adapt to interfacing with digital tools and robotics. This shift underlines the need for educational reform and continuous professional development which is in step with technological advances.

For transformation to happen, technology, skills and employment must be in step. As a recent report from the International Labour Organisation puts it: "Increasing automation in manufacturing – a sector that has acted as the engine of economic and employment growth in the classical pathway of structural transformation – may limit the developmental impact of new technologies if productivity growth is not accompanied by employment growth at a sufficiently high level to absorb new entrants to the labour force."[23]

As technology continues to reshape the manufacturing industry, there is an urgent need to align education systems with industry demands – both to bring people into the sector and to up or re-skill those in the sector. An estimated 41% of all work activities in Kuwait are susceptible to automation, as are 46% in Bahrain and Saudi Arabia, 47% in the United Arab Emirates, 49% in Egypt, 50% in Morocco, and 52% in Qatar.[24] In addition, according to UNIDO, increasing numbers are employed in the manufacturing sector across Africa. Moreover, the growth of female employment has generally outpaced that of males.[12] Conversely, many Arab States are seeing stagnation.[13]

> Steam propelled the original Industrial Revolution; electricity powered the second; preliminary automation and machinery engineered the third; and cyberphysical systems – or intelligent computers – are shaping the Fourth Industrial Revolution.
>
> McKinsey[27]

From early education to technical training, students must be exposed to the skills that will prepare them for future careers in manufacturing. Increasing emphasis on STEM education is required to cultivate the next generation of engineers, designers and technicians.

Formal education is only part of the solution. Continuous upskilling and reskilling of the existing workforce is essential. Many current manufacturing workers lack the advanced technical knowledge needed to thrive in a modern, digitised manufacturing environment. Lifelong learning, on-the-job training, and public-private partnerships will play crucial roles in bridging this skills gap. Concerted focus on reskilling and upskilling could significantly boost productivity and position the region as a competitive player in global markets.

As Mayowa Kuyoro from McKinsey puts it: "We need to make sure we are developing our talent. The absolute imperative for all the stakeholders is how do we make sure there is a match between the skills Africa's talent has and the skills Africa and the world's employers need."[25]

In terms of manufacturing industries in Africa, the largest by value added are food products, other non-metallic mineral products and beverages. Conversely, the contribution from industries such as computer, electronic and optical products as well as other transport equipment is limited. Expectations are high for motor vehicles and electrical equipment, two medium-high and high technology (MHT) industries that achieved high growth rates in 2021.[12]

Creating the foundations: the school age

The foundation of a strong manufacturing workforce in MEA begins in the early years of education. As the global economy leans towards advanced manufacturing and technological innovation, developing basic STEM skills in the school setting has become critical.

Across the MEA region, equipping students with these skills at school is essential not only for their future work ambitions, but also for the broader economic development of the region. Beyond the core STEM disciplines, STEM education develops critical thinking, problem-solving skills, communication, collaboration and digital skills. All these skills are critical to young people in building their resilience and navigating transitions in their lives, in particular preparation for future roles in the manufacturing sector.

While there are significant challenges which could undermine these ambitions, particularly in terms of infrastructure, teacher training and gender disparities, there are also promising initiatives and strategies that can be scaled up. Data released by The Economist Intelligence Unit revealed that connecting schools is "key to improved learning outcomes and more prosperous economies, finding that a 10% increase in school connectivity can increase the effective years of schooling for children by 0.6%, and GDP per capita by 1.1%."[1]

By investing in quality education, updating curricula, and addressing socio-economic barriers, the region can better prepare its youth for the demands of the manufacturing industry which has a critical role to play in regional growth.

Skills for the **school age**

1.

Basic STEM proficiency

- Foundational skills in **mathematics and science** are critical. These subjects help students develop problem-solving abilities, logical reasoning and an understanding of physical principles that are directly applicable to manufacturing processes.
- As manufacturing increasingly integrates with digital technology, **digital literacy** is becoming a crucial skill. Students need early exposure to computers, coding and basic digital tools to be prepared for more advanced technological training later on.
- The ability to **think critically and solve complex problems** is fundamental in manufacturing, where troubleshooting and optimisation are daily tasks.

2.

Exposure to manufacturing technologies

- Introducing students to technologies like **3D printing and robotics** can spark interest in manufacturing careers and provide practical skills that will be beneficial in advanced education and future employment.

3.

Soft skills

- Manufacturing is often a collaborative process that requires **strong communication and teamwork skills.** Encouraging group projects and teamwork from an early age can help develop these abilities.
- Encouraging **creativity** in problem-solving can lead to **innovative** approaches in manufacturing. Integrating arts with STEM (STEAM education) can enhance creativity while still focusing on technical skills.

Challenges for the school age

Access to quality STEM education remains patchy, with significant disparities between urban and rural areas, and between boys and girls. In many parts of the MEA region, particularly in rural and underserved areas, schools lack the necessary infrastructure and trained teachers to deliver quality and effective STEM education.

Many African schools lack the basic infrastructure and materials necessary for effective STEM education, such as laboratories, modern equipment, and up-to-date textbooks. This scarcity of resources hinders practical, hands-on learning, which is crucial for understanding complex scientific and mathematical concepts.[28]

Exposure to digital literacy and the emerging technologies so important in manufacturing are also curtailed by the lack of internet access – both at home and in school. Data suggest 12% of school age children in Eastern & Southern Africa have access to the internet at home.[29] Evidence from South Africa shows that just 20% of schools have internet connectivity for teaching and learning.[30]

There is a shortage of well-trained teachers capable of delivering STEM education effectively. According to UNESCO, there is a shortfall of STEM teachers in some countries with insufficient numbers receiving adequate training.[31] This shortage is particularly acute in sub-Saharan Africa. Reportedly, only around 30% of the region's short-cycle tertiary enrolment is in STEM subjects (25% of female and 34% of male enrolments).[32] According to estimates, sub-Saharan Africa is the only region where its small number of STEM graduates is insufficient to provide an adequate number of STEM teachers to meet Sustainable Development Goal (SDG) 4 needs by 2030, even if every single STEM graduate could be recruited into teaching.[31]

In some markets, the shortage of teachers may also be exacerbated by the perception of teaching as a career choice. In Ethiopia, careers in teaching have been perceived as a 'last resort' due to teachers' low social status and pay compared to other professions.[33] Retention can be an issue too; teachers are pulled away from teaching by roles in other fields that offer higher pay or more room for professional growth.

Although becoming a priority in country plans, school curricula remain outdated and don't always reflect the skills needed for modern manufacturing. For example, in Oman insufficient STEM education at primary/secondary school level is cited as a barrier to engineering careers.[34] In addition, access to career guidance and advice is often minimal or non-existent, leaving many students unaware of potential career paths in manufacturing and other STEM fields. This lack of guidance contributes to low levels of interest in these crucial sectors, exacerbating the skills gap that threatens to impede industrial growth across the region.

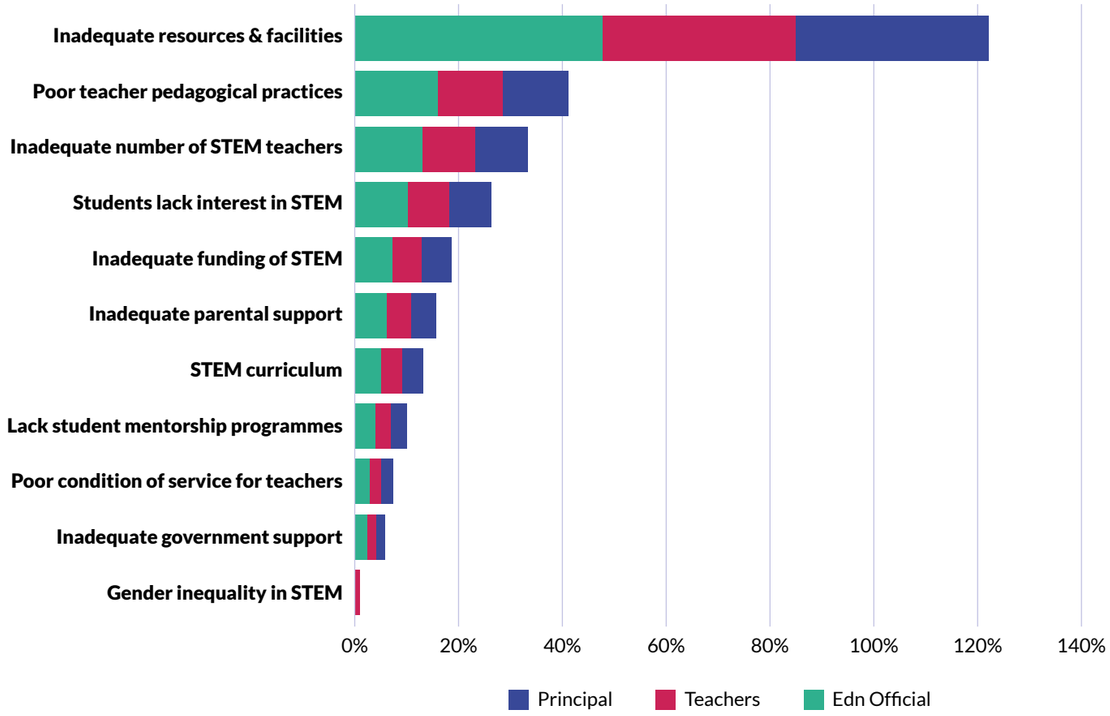
These disconnects mean students are inadequately prepared for further and higher education, and subsequent employment in the sector. Layer on the lack of hands-on, practical learning opportunities, which are crucial for understanding complex manufacturing concepts, the issue is compounded.

In some parts of the MEA region, cultural and socioeconomic factors also limit access to STEM education.

Research from UNICEF explores some of the key barriers which constrain girls from achieving in STEM at different stages of their life, highlighting how gender stereotypes and lack of role models affect girls' interest in STEM from an early age.[35] The gender digital divide is shown to constrain girls' development of digital skills.[35] In Sub-Saharan Africa, boys gain more in digital skills when they are in school compared to girls.[36] Interest (and confidence) in STEM and digital skills among girls is not being converted into further study – whether vocational or academic – meaning manufacturing and other careers are missing out on talent. In almost all countries, more boys than girls aspire to careers in science and engineering or go onto study STEM subjects at the tertiary level.[35]

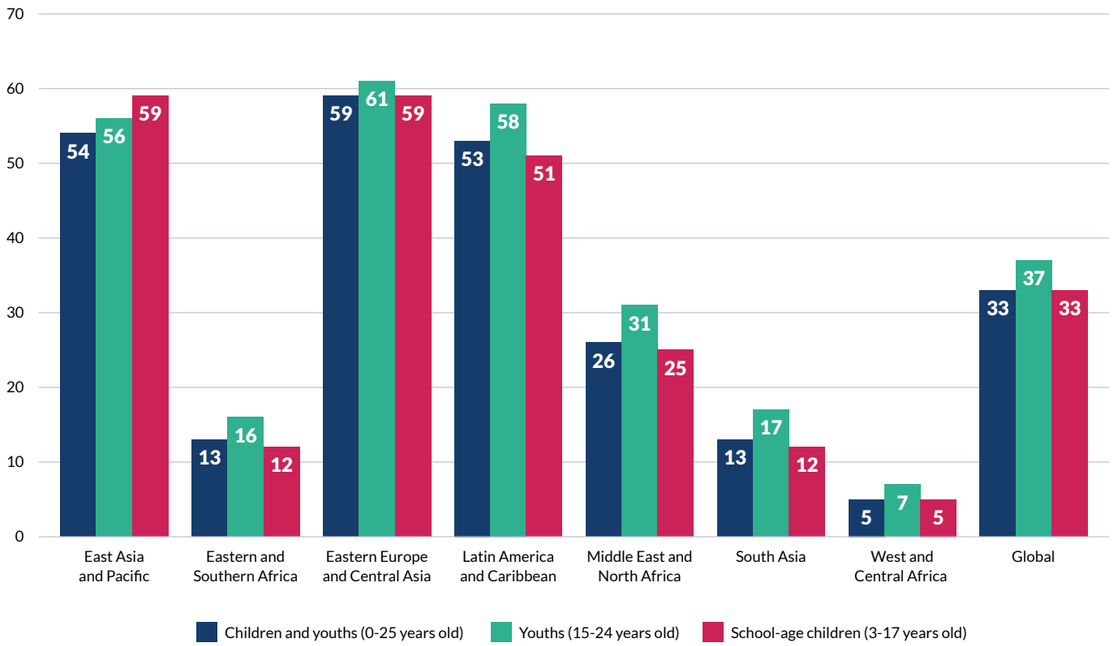
High levels of poverty in some areas mean that many students drop out of school early to support their families, missing out on critical educational opportunities.

Challenges in achieving quality STEM education[37]



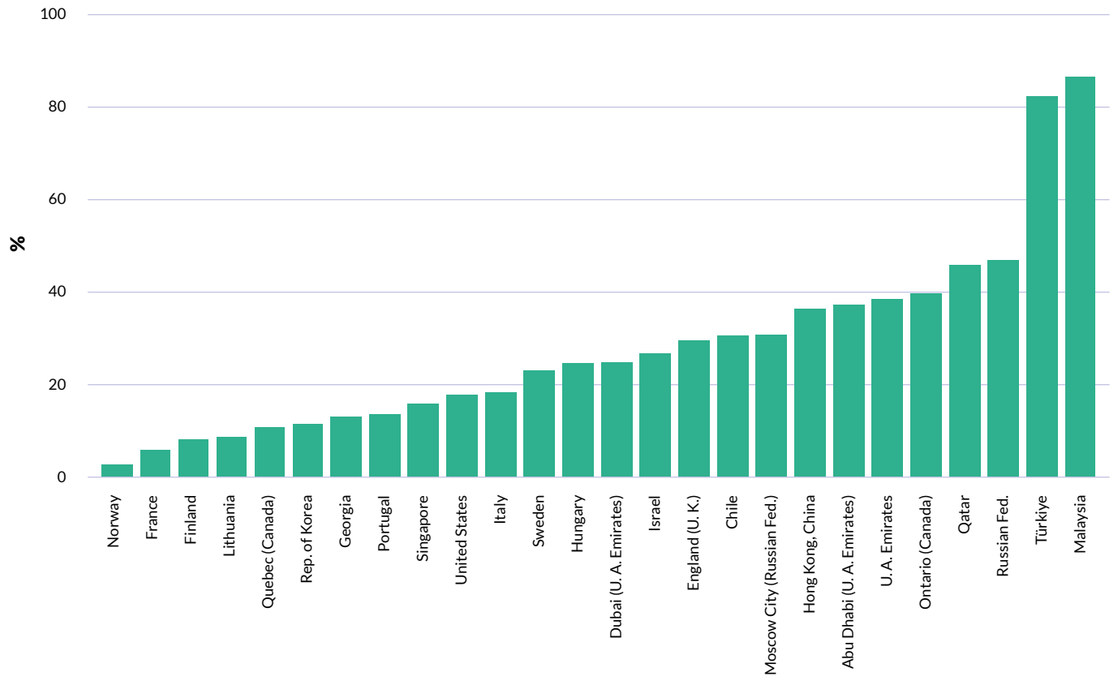
> Sub-Saharan Africa is faced with significant teacher shortages: an additional 15 million additional teachers are needed for 2030, largely to meet a rapidly expanding school-aged population.
>
> **UNESCO**[55]

Percentage of children and young people with internet access at home, by region[29]



A lack of sufficient or competent STEM teachers affects instruction in many schools[31]

Percent of grade 8 principals stating that instruction at their school is affected 'some' or 'a lot' by a shortage or inadequacy of STEM staff, selected countries, 2019



> Schools are facing increasing demands to prepare students for rapid economic, environmental and social changes, for jobs that have not yet been created, for technologies that have not yet been invented, and to solve social problems that have not yet been anticipated.
>
> **OECD**[56]

Initiatives to boost relevant skills in the school age

In the MEA region, efforts to integrate STEM education and basic manufacturing skills into K-12 curricula are underway, but progress varies.

Many countries have issued national science, technology, and innovation or STEM education policies, domesticating the African Union's Science, Technology & Innovation Strategy for Africa 2024 (STISA-2024).[37] These include Ethiopia[38], Nigeria[39], Rwanda[40] and South Africa[41]. Many more have sciences and mathematics within their education policies. Most national development policies in Africa also mention STEM as important for industrialisation and social and economic development.[42]

In the Gulf states, countries like the UAE and Saudi Arabia have made investments in STEM education as part of their broader economic diversification and innovation strategies. For example, UAE's National Innovation Strategy aims to promote innovation in the education sector by introducing creative teaching methods and techniques like Smart Learning, as well as designing and developing innovative curricula that equip pupils with the 21st century skills and knowledge in the fields of science, technology engineering, mathematics and arts.[43]

Increasing teacher capacity is critical. The African Institute for Mathematical Sciences, a non-governmental network of centres of excellence in post-graduate training in Cameroon, Ghana, Rwanda, Senegal and South Africa, established the five-year STEM-focused teacher training programme to provide not only professional development but also classroom resources.[44]

Rwanda has introduced a new competence-based curriculum, spearheading ICT and 21st century skills, such as creativity and problem-solving skills. To develop these skills, the Rwanda Education Board (REB) integrated Scratch[45] in the upper primary school curriculum of Science and Elementary Technology (SET) and in the lower secondary school curriculum of ICT[46].

In South Africa, Autodesk Learning Partner, Modena has supported The National Schools Skills Competition. This initiative, organised by Sasol and the Kagiso Trust, aims to nurture the vocational talents the country needs. By encouraging young people to pursue careers in skilled trades, the competition plays a vital role in boosting employment and supporting economic growth. Over the past seven years, the competition has reached more than 10,000 learners and teachers nationwide, providing hands-on experience in trades like welding, electrical work, automotive services and construction.[47]

In North Africa, countries like Egypt have also made strides in integrating STEM into their education systems. The Egyptian Knowledge Bank (EKB), launched in 2016, provides free access to a wide range of educational resources, including STEM-focused materials, to students and educators across the country.[48]

In Zimbabwe, Autodesk Learning Partner, Advanced Design Colleges (ADC), runs an annual competition for high school students and their teachers. The initiative is designed to help aspiring engineers and designers to develop software design skill and explore exciting and emerging areas of manufacturing, and build capacity within the educational system for developing such skills.

The UN Women project, African Girls Can Code, aims to train and empower a minimum of 2,000 young girls aged between 17-25, across Africa to become computer programmers, creators and designers, placing them on track to take up studies and careers in the information, communication and technology (ICT), education and coding sectors.[49]

Industry has a vested interest in getting school children excited about careers in the sector, and are investing in STEM programmes.

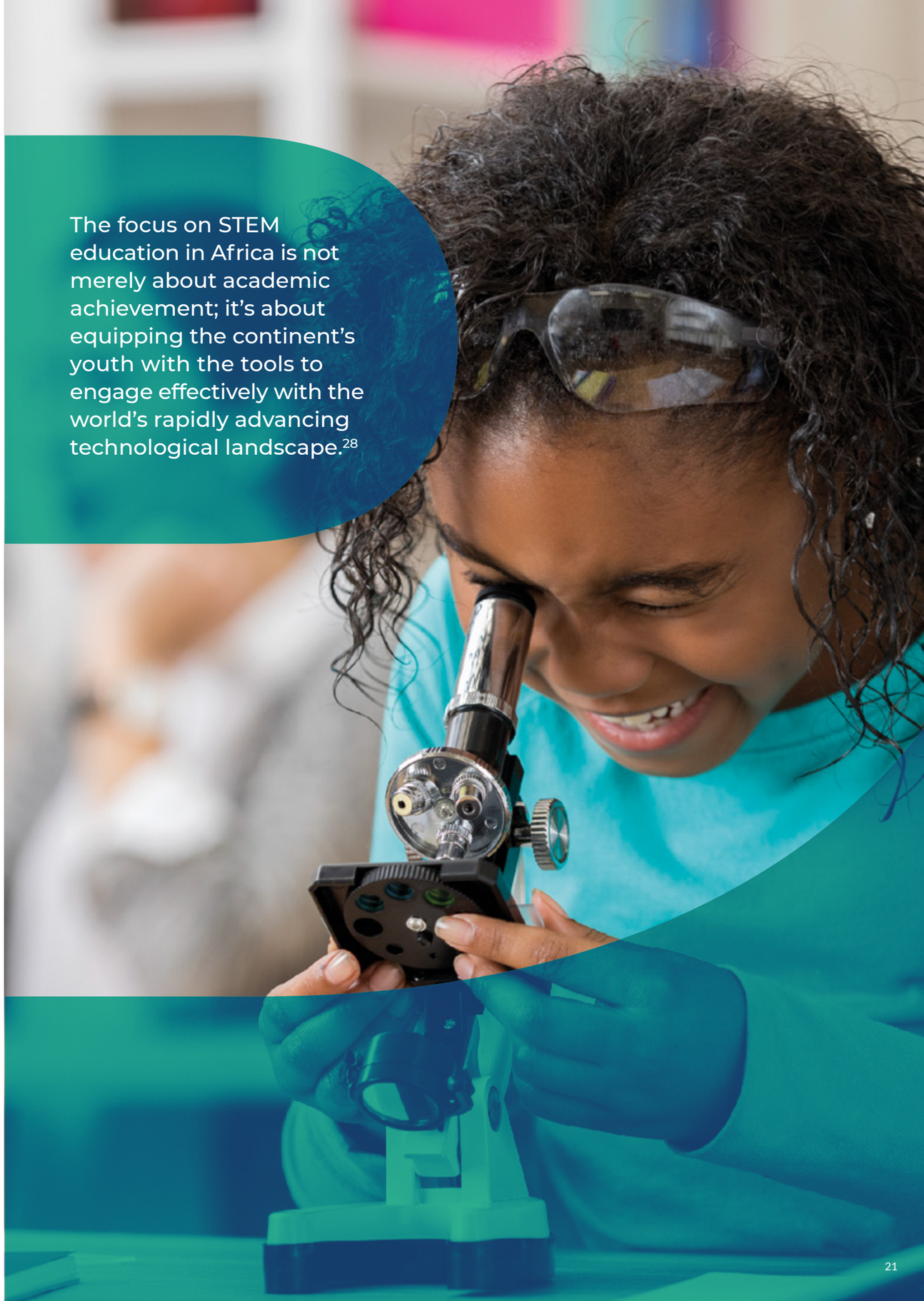
For example, Boeing's STEM Ambassadors programme focuses on learning and development in sustainability and STEM in aerospace engineering. The initiative equips students aged 14-18 years old in the UAE with theoretical knowledge and practical skills in aerospace engineering and sustainable aviation.[50] Autodesk's Tinkercad is used in schools and by young people to created digital designs for 3D printing. Participants are guided through the 3D design process via hands-on lessons, that teach the basics of Tinkercad before moving on to more complex modelling techniques.[51]

In Kenya, Safaricom, a telecommunications company, launched a digital mentorship programme for secondary school students in partnership with UNESCO and the Eneza Foundation. Students receive information on STEM studies and career pathways from mentors and role models through local television and radio channels, and text messages.[52]

Programmes like the FIRST Global Challenge, which includes robotics competitions for high school students, have started to gain traction in some MEA countries, fostering early interest in technology and engineering.[53]

> Africa needs to embrace STEM education at all levels. STEM-related jobs and careers are on the rise. It is estimated that Sub-Saharan Africa alone needs 2.3 million engineers to address its development challenges, including huge infrastructure projects, sustainable energy solutions, improved health care, and improved food production.
>
> **World Bank**[20]

The focus on STEM education in Africa is not merely about academic achievement; it's about equipping the continent's youth with the tools to engage effectively with the world's rapidly advancing technological landscape.[28]



CASE STUDY

Using motorsport to boost STEM skills

The F1 in Schools* initiative is gaining traction across the Middle East.[54] Students between 9-19 years use CAD/CAM software to collaborate, design, analyse, manufacture, test and then race miniature compressed air powered cars. The challenge inspires students to work in teams and apply a range of skills in a practical, imaginative, competitive and exciting way.

Authorized Autodesk Training Partner, Computer & Software Training Center (Compusoft), played a role in the expansion of the F1 in Schools into Saudi Arabia, delivering training sessions to aid the establishment of five new local hubs in the country.

The five hubs, which deliver local activities training and mentoring for Saudi students, have been provided with assistance from F1 in Schools head office team and specialist partners. Autodesk, F1 in Schools Premier Global CAD/CFD Partner supported the activity by providing training in CAD/CAM and CFD software such as Autodesk Fusion. The objective was to provide local staff with the tools and expertise to guide and advise teams at the start of their F1 in Schools journey.

*F1 in Schools rebranded to STEM Racing in December 2024

> The F1 in Schools initiative uses the backdrop of the exciting and exhilarating world of F1 to engage with secondary students. It has long been viewed as a great way to engage future engineers, using a competition format to introduce them to design principles. The work by Computer & Software Training Center (Compusoft) in Saudi Arabia is key to building capability and capacity as the competition looks to expand into new regions and territories.
>
> **Tomas Karlsson, KnowledgePoint**

Shaping the future workforce: the university age

University education should provide individuals with the basic skills required for the labour market, as well as the necessary skills and knowledge to those destined for careers in different disciplines, whether they are teachers, doctors, nurses or engineers. These individuals – students – can develop and improve their analytical capabilities and skills to drive the local (regional and global) economy.

This is particularly true for those students looking to work in roles across the manufacturing sector. Building on the foundations laid in school, universities and technical colleges play a vital role in shaping this future workforce, preparing them to enter increasingly complex and technology-driven industries.

The picture though is patchy.

While some countries have made significant progress in equipping students with the skills needed for the modern manufacturing sector, others still face substantial challenges.

In some, academic programmes are not completely aligned with the needs of the manufacturing industry – nor sufficiently future-focused to anticipate tomorrow's needs. Limited access to hands-on training, a disconnect between university curricula and industry demands, as well as insufficient focus on innovation and entrepreneurship leave many students under-prepared for the realities of modern manufacturing.

Countries like the UAE and Egypt have made investments in higher education, whereas parts of Sub-Saharan Africa continue to struggle with underfunded universities, lack of infrastructure and inadequate faculty training. Across the region, there's also competition for students – some countries simply aren't able to "grow their own talent" to support current and future industrial needs.

These variations highlight the need for targeted and reforms to ensure that students are equipped with the skills required for the manufacturing jobs of tomorrow. Capacity and capability are key.

Strengthening the alignment between university programmes and industry needs, expanding access to hands-on training, and addressing gender and resource disparities are critical steps in preparing the next generation of skilled workers and innovators. By focusing on these areas, countries can ensure that its students are ready to contribute to the growth and modernisation of the regional manufacturing sector.

Skills for the **university age**

1. Advanced STEM knowledge

- As manufacturing becomes more automated and technology-intensive, students require a deep understanding of **engineering principles, robotics and automation systems.** Mechanical, electrical, and chemical engineering disciplines are particularly important for manufacturing processes such as production line automation, machine maintenance and process optimisation.
- With the rise of Industry 4.0 technologies, **data analytics and artificial intelligence (AI)** have become essential skills. Students need to be trained in the use of data analysis tools, machine learning algorithms and AI applications that are increasingly integrated into smart factories and production systems.
- In line with global shifts towards **sustainability**, students should also gain expertise in green manufacturing processes, renewable energy, and circular economy principles. This is particularly relevant in the MEA region, where environmental challenges such as water scarcity and energy efficiency are critical issues.

2. Practical design and collaboration skills

- Ultimately factories want to create products that are easy, efficient and cost-effective to produce. Students should learn core **design and drafting skills** and how to apply design principles and practices into manufacturing processes, thereby reducing the need for redesign, rework or waste.
- Employers are looking for graduates who can meet industry demands in design, prototyping and production. These factors make **3D modelling and visualisation** skills critical. Parametric and surface modelling is required for precise part and assembly designs. Students need to understand how 3D models can be effectively translated into physical products.
- Across the manufacturing sector, projects need to run smoothly from conception to completion. This could include planning, scheduling, resource allocation and risk management. Students should be introduced to **project management** techniques, and be encouraged to develop competence in tools which can enable collaboration and effective projects.

3. Soft skills and innovation

- In modern manufacturing, the ability to **think critically and solve complex problems** is just as important as technical expertise. Employers are looking for graduates who can identify inefficiencies in production processes and propose innovative solutions. Universities need to foster an environment where students are encouraged to think creatively and work collaboratively on practical projects.
- Given the rising importance of small and medium enterprises (SMEs) in the manufacturing sector, particularly in Africa, fostering an **entrepreneurial mindset** is crucial. Students need training in business management, leadership, and innovation to prepare them for the possibility of starting their own manufacturing ventures or leading existing businesses towards growth.

> We may not be exaggerating to say that higher education (specifically university schooling) is the key to the success of any country economically, socially, scientifically, and even politically.[58]

Challenges for the university age

In our fast-evolving world a job-for-life is not necessarily the career trajectory from university. Students need to prepare for a highly uncertain labour market – in a large part due to leaping advances in technology. This new uncertain landscape needs graduates who possess up-to-date knowledge, skills and competencies – and the ability to respond to the demands of a world shaped by technology, among other things.

As a general rule, countries and their universities across MEA are not fully equipped to respond – and the issue becomes ever more acute when focusing on the manufacturing sector.

There remains a disconnect between what students learn in universities and what employers in the sector require. Curricula often focus on theoretical knowledge rather than practical skills that are immediately applicable in the workplace. Research published by the World Bank Group goes further, suggesting that in many MENA HEIs, the emphasis is still placed on memorising rather than on teaching students how to solve practical life problems.[57]

Across the region, some universities lack the equipment, laboratories and capacity needed to provide students with practical experience. These limit students' ability to gain hands-on skills and understand the real-world applications of their academic learning.

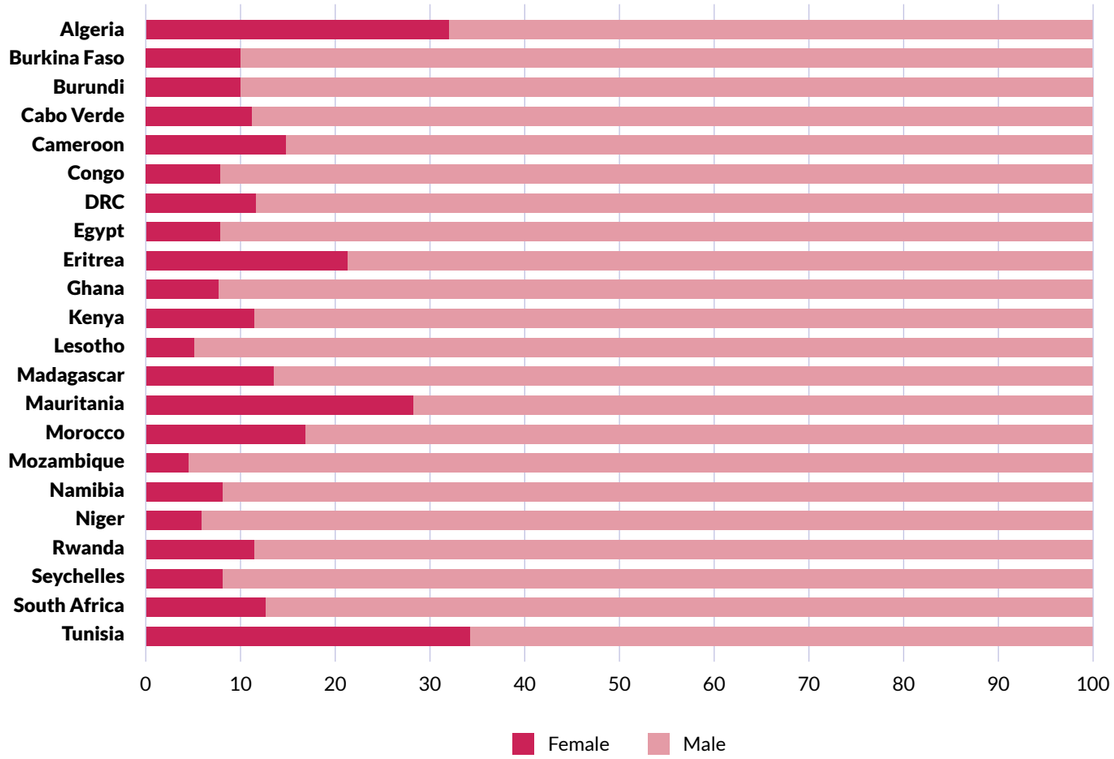
This is seen most acutely in Sub-Saharan Africa, where countries face major challenges in their higher education systems. Universities are often under-funded, over-crowded and, continuing the challenge seen in schools, insufficiently trained faculty hinder the ability to provide quality education.

For example, the ratio of students to faculty members in Arab universities is estimated to be 1:36. In Jordanian universities the proportion is 1:28, while it is 1:15 in the United Kingdom and 1:12 in the United States. The average ratio globally is 1:25. According to experts, the ideal ratio is around 1:15-20.[58]

Although the number of students pursuing tertiary education more than doubled globally in the last two decades, participation levels across the region lag behind.[59] The enrolment rate in the Arab world is 30 individuals for every 1,000 citizens. As examples, this ratio is 20 in Egypt, 75 in Kuwait, 50 in Saudi Arabia, 44 in Lebanon, and 48 in Jordan.[58] In developed countries, this ratio is 40 people for every 1,000 citizens.[58]

More specifically, data are limited on higher education participation rates for STEM subjects, but one report estimates that fewer than 25% of African higher education students pursue STEM fields of study, of whom fewer than 30% are women.[60] Within STEM fields, however, there are clear distinctions. Women represented an average of 28% of engineering, manufacturing and construction tertiary graduates and 30% of ICT tertiary graduates, but 57% of natural sciences, mathematics and statistics graduates – and more than 80% in Bahrain, Maldives and the United Arab Emirates.[31]

Women make up a small proportion of STEM graduates in African countries with data[37]



> Students typically get trained on using 3D modelling tools to design but they are not given any experience of how you manufacture these designs. This is a huge skills gap that impacts the ability to successfully operate in the manufacturing space. A designer/engineer needs to understand how to translate their design into efficient manufacturing processes of physical products.
>
> **Chukwubuikem Felix Amaefule, Generative CAD Services, Nigeria**

> For Sub-Saharan tertiary education institutions to seize their opportunity and more importantly for their countries to reap a demographic dividend rather than disaster, the tertiary education sector needs to place a far greater emphasis on building both the capacity and capability of faculty.
>
> **Professor Etienne Ehile, Secretary General, Association of African Universities**[65]

Initiatives to boost relevant skills in the university age

The quality and accessibility of university education in the MEA region vary significantly by country, with some nations making substantial strides while others lag behind.

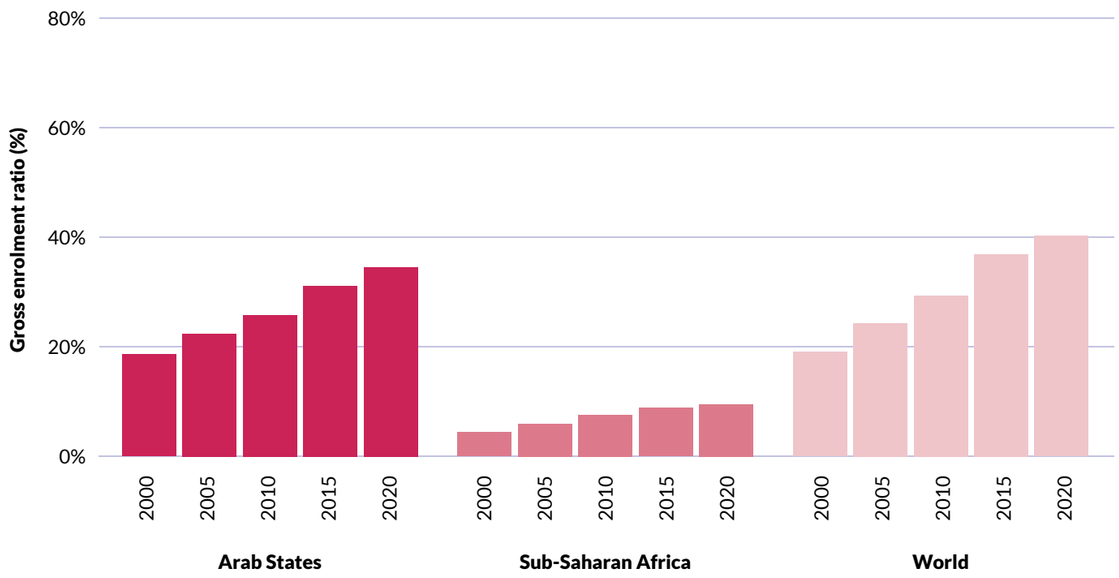
In the Gulf states, countries like the UAE and Saudi Arabia have heavily invested in higher education as part of their broader economic diversification strategies. The UAE's National Innovation Strategy[43] focuses on enhancing technical education, and Saudi Arabia's Vision 20305 emphasises the development of technical education and partnerships with international institutions.

Governments in the Gulf are helping manufacturers upskill their future workforces. The University of Bahrain offers a specialized Master's programme in Artificial Intelligence Systems, while the UAE University's Industry 4.0 District hosts labs that teach students about Industry 4.0, providing training, research opportunities, industrial applications and more.[14]

Egypt has also made significant progress in expanding access to university education and improving the quality of STEM programs. The Egyptian Knowledge Bank (EKB) offers a vast digital library of academic resources to support university students in their studies.[48] Additionally, the establishment of universities focused on science and technology, such as the Egypt-Japan University of Science and Technology (E-JUST), provide students with opportunities to engage in cutting-edge research and development in fields related to manufacturing.[61]

Despite widely reported challenges in Sub-Saharan Africa, there are bright spots. In South Africa, universities like the University of Johannesburg are integrating 4IR (Fourth Industrial Revolution) technologies into their engineering programmes, preparing students for careers in advanced manufacturing.[62]

Gross enrolment ratio (GER) in tertiary education by region, 2000-2020[59]



Measured by Gross Enrolment Ratio (GER), global participation in tertiary education doubled from 19% to 40% between 2000 and 2020.

Across the region, increasingly universities are working in partnership with the private sector and government bodies, collaborating on initiatives to boost skills and increase employability.

Government programmes such as the Youth Employment Service (YES) initiative in South Africa are addressing skills requirements by partnering with the private sector to create internship opportunities for students in industries like manufacturing.[63]

The King Abdullah University of Science and Technology (KAUST) in Saudi Arabia has established strong links with industry, offering students the chance to work on research projects and internships in collaboration with manufacturing companies.[64]

> It is also essential to update educational and vocational curricula so that they take into account labour market trends such as the growing importance of digital and soft skills. This would improve the school-to-work transition for young people. Employers' organizations play a key role in this transition because they know which qualifications and competencies young people need to have if they are to be attractive to employers.
>
> **ILO**[23]

CASE STUDY

Advancing engineering education in Nigeria

The Nigerian Genius National Engineering Competition is designed to advance engineering education in Nigeria and contribute to the development of practical skills, problem-solving abilities, and leadership qualities among the participants.

A team of engineering students representing the University of Port Harcourt emerged victorious in the third edition of the competition, organised by Clintonel Innovation Centre (CIC) Aba.

Finalists in the Nigerian Genius 2024 were trained by industry experts on essential engineering and manufacturing skills such as: Computer Aided Design (CAD), Computer Aided Manufacturing, casting, engineering fabrication, embedded systems and problem solving. Using a project-based learning approach, students designed and produced several products during the training element of the competition.

The Nigerian Genius is part of Engineering for Industry (E4I), a capacity building project for engineering innovation, product development and manufacturing. E4I aims to bridge the skills gap between engineering education and industry, thus enhancing the employability of graduates and facilitating the growth of indigenous industries.

CIC CLINTONEL INNOVATION CENTRE

AUTODESK Learning Partner

“Through the competition we aim to highlight how engineering plays a critical part in manufacturing, industrial and national development. We also want to inspire tertiary institutions across the country to improve their engineering education, helping them to address industry needs.

Engineering students are equipped with essential industry and manufacturing skills. They will be more employable as a result. The competition helps to boost local manufacturing, resulting in employment generation and economic development.

Blessing Eke, Head of Marketing and Publicity at CIC

Best practice: international online student challenge boosts digital skills

The annual Designathon is designed to help students develop critical digital skills for the manufacturing industry. Based around Autodesk Fusion, the event serves a dual purpose: equipping students with key design and collaboration skills and giving them an opportunity to showcase their abilities in a competitive, real-world challenge.

The two-day online event is open to teams of students at tertiary-level institutions.

- The first day involves hands-on training on Autodesk Fusion, where participants learn essential skills like 3D modelling, parametric design and rendering.
- The second day puts these skills to the test in a team-based challenge where participants respond to a topical industrial design problem. The competition emphasises originality, creativity and model integrity, with prizes for the top teams.

More broadly, the Designathon aims to address the growing digital skills gap in manufacturing, particularly as the industry adapts to digital technologies. By boosting digital literacy and fostering collaboration, it plays a role in preparing the next generation of industrial designers and engineers for the factories of the future.

Participants report greater confidence in using digital tools as well as increased readiness for further learning and roles in the manufacturing sector. Certificates of participation and digital badges provide participants with verifiable credentials that demonstrate their new abilities to potential employers. Moreover, winning designs are showcased, further recognition for the students' achievements.

The Designathon is organised by KnowledgePoint and Autodesk, working in partnership with universities and other tertiary-level organisations to align content to curricula and boost student involvement.

> Being recognised as a Designathon 2024 winner is a tremendous honour that will significantly enhance our portfolios, propel our careers forward, and serve as a testament to our creative potential. This achievement will empower us to showcase my innovative ideas on a global stage, demonstrating my capabilities and passion for design to a wider audience.
>
> **Olalere Glory Oluwadamilare and Nwachukwu Praise, second-year mechanical engineering students from Obafemi Awolowo University in Ile-Ife, Nigeria, took part in Designathon 2024**

CASE STUDY

Designnow 2024
student competition at Gazi University, Türkiye

Student competitions offer a fantastic opportunity for future makers to test their design and modelling skills. Gazi University in Türkiye hosted multi-department competition, DESIGNNOW 2024. This in-person event was a collaboration between the Design Engineering Society and the Design Manufacturing and Technology Society, and supported by Autodesk.

Fifty students participated in the two-day competition from departments including Industrial Design Engineering, Manufacturing Engineering, Woodworking Engineering, Automotive Engineering and Industrial Design.

The first day involved training in and demonstrations of Autodesk Fusion's modelling and rendering capabilities from Autodesk experts, with student experts on-hand to provide assistance. On the second day, students were asked to design an "electrical household appliance that can brew both tea and filter coffee". The student teams were given the day to work on their response to the brief.

The competition was then judged by academics from Gazi University: Professor Dr İsmail Şahin and Professor Dr Murat Tolga Özkan from the Department of Industrial Design Engineering, and Professor Dr Abdulmecit Güldaş from the Department of Manufacturing Engineering.

The winners of the competition were recognised for their achievements, receiving their certificates and prizes from the Dean of the Department, Dr Musa Ata.

First place: Ahmet Enes Yılmaz, Meryem Ebrar Karaarslan, Burkay Aşkan. Second place: Buğra Koç, Aykut Danışan. Third Place: Rabia Reyyan Mülayim, Eda Hanım İlhan, Zühlenaz Cide.

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> This competition provided a platform for young designers to showcase their creativity and integrate their ideas with real design solutions. The event was great opportunity for Design and Engineering students to experience how to work collaboratively and simultaneously. The energy and talent demonstrated by the students were truly inspiring, giving us a glimpse of what they can achieve in future projects.
>
> **Furkan Günal, Autodesk Expert Elite**

Developing and applying proficiency: the working age

Around the world, engineers and industrial designers are responsible for transforming ideas and designs into tangible products and solutions. They're exploring and adopting new technologies which can transform manufacturing into a more productive sector. Increasingly, their workplaces are turning from the workshops of the past into smart manufacturing facilities.

Although investment in the latest technologies lags behind the competition in the manufacturing powerhouses of Asia, Europe and the US, the manufacturing sector across MEA continues to evolve.

As the region moves towards technology-enabled manufacturing, roles and skills must shift. The increasing emphasis on automation, data-driven decision-making and sustainability, requires employees to be proficient in not only traditional engineering and technical skills but also emerging digital tools and technologies.

However, skills gaps persist. Companies also experience difficulties in finding employees with the technical and soft skills necessary to operate in modern manufacturing environments.

For the MEA region to build a competitive manufacturing sector, there is a need to upskill the current workforce, ensuring they are equipped with the right combination of skills to thrive in a rapidly changing industry.

Skills for the **working age**

1. Technical skills

- As manufacturers in MEA increasingly adopt **automation and robotics** to boost efficiency and reduce costs, engineers need to be proficient in programming, maintaining, and operating robotic systems.
- Organisations are looking to leverage **data analytics and Internet of Things (IoT)** technologies to improve production processes, monitor equipment health and optimise supply chains.
- The drive towards **sustainable manufacturing** requires knowledge of energy-efficient machinery, waste reduction processes and the integration of renewable energy sources into production lines.

2. Soft skills and adaptability

- Modern manufacturing requires a workforce which can **troubleshoot** issues on the factory floor and develop innovative solutions to improve productivity and quality. **Problem-solving skills** are particularly important in environments that use advanced machinery and require quick responses to equipment malfunctions or production bottlenecks.
- The rapid pace of technological change in the manufacturing sector demands a workforce that is **adaptable** and eager to learn. Teams need continuous training to stay up-to-date with the latest tools and technologies, such as 3D printing, artificial intelligence and digital twins.
- The shift towards digitalisation in manufacturing has also increased the need for strong **communication and collaboration** skills. Engineers must work closely with data scientists, software developers, and other specialists to integrate new technologies into manufacturing processes, while workers on the factory floor need to collaborate with managers and technicians to ensure smooth operations.

> Skills training programs are more successful when the private sector is involved in developing curricula and training methods or in providing on-the-job training.[57]

Top 3 skills of the future[73]

Rank: 1

Ability to implement/ work with AI

Rank: 2

Software development/ programming

Rank: 3

Digital project management

Top industry skills[73]

Knowledge of data safety and security

- Automotive and other transportation

Ability to implement/ work with AI

- Building products and fabrication
- Consumer products
- Process manufacturing

Data analytics/data mining/ data insights

- Industrial machinery
- Life sciences manufacturing

Challenges for the working age

There are insufficient people in the ecosystem with the skills and experience needed. It is estimated that Sub-Saharan Africa alone needs 2.3 million engineers to address its development challenges, including huge infrastructure projects, sustainable energy solutions, improved health care and improved food production.[55]

The mismatch between the skills that workers possess and the skills employers require is holding back the manufacturing sector. When employers complain that workers do not have the right skills, they are reflecting on more than just education credentials or technical qualifications.[66] Workers across the region may lack proficiency in critical areas such as digital literacy, data analytics and advanced manufacturing technologies, leaving them underprepared for jobs in modern factories.

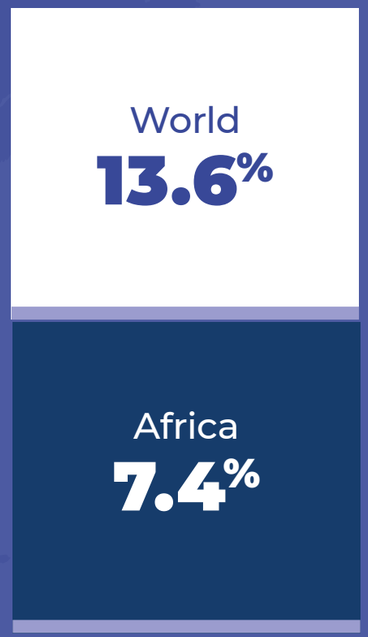
For example, some 46% of Africa's employed youth perceive their skills as mismatched to their jobs.[67] In addition, 21% of business leaders reported that the lack of adequate skilled workers was a major constraint to their operations, with over 29% of production workers rated as unskilled.[32]

As Industry 4.0 technologies continue to reshape the manufacturing landscape, the need for continuous learning and upskilling is critical. According to the World Economic Fund, six in 10 workers will require training before 2027, but only half of workers are seen to have access to adequate training opportunities today.[68] The percentage of firms offering training varies from 9% in Sudan to as high as 55% in Rwanda.[66] According to analysis of data from the World Bank Enterprise Survey, less than 15% of small companies in MENA offer on-the-job training, when compared to around 50% in large organisations.[66]

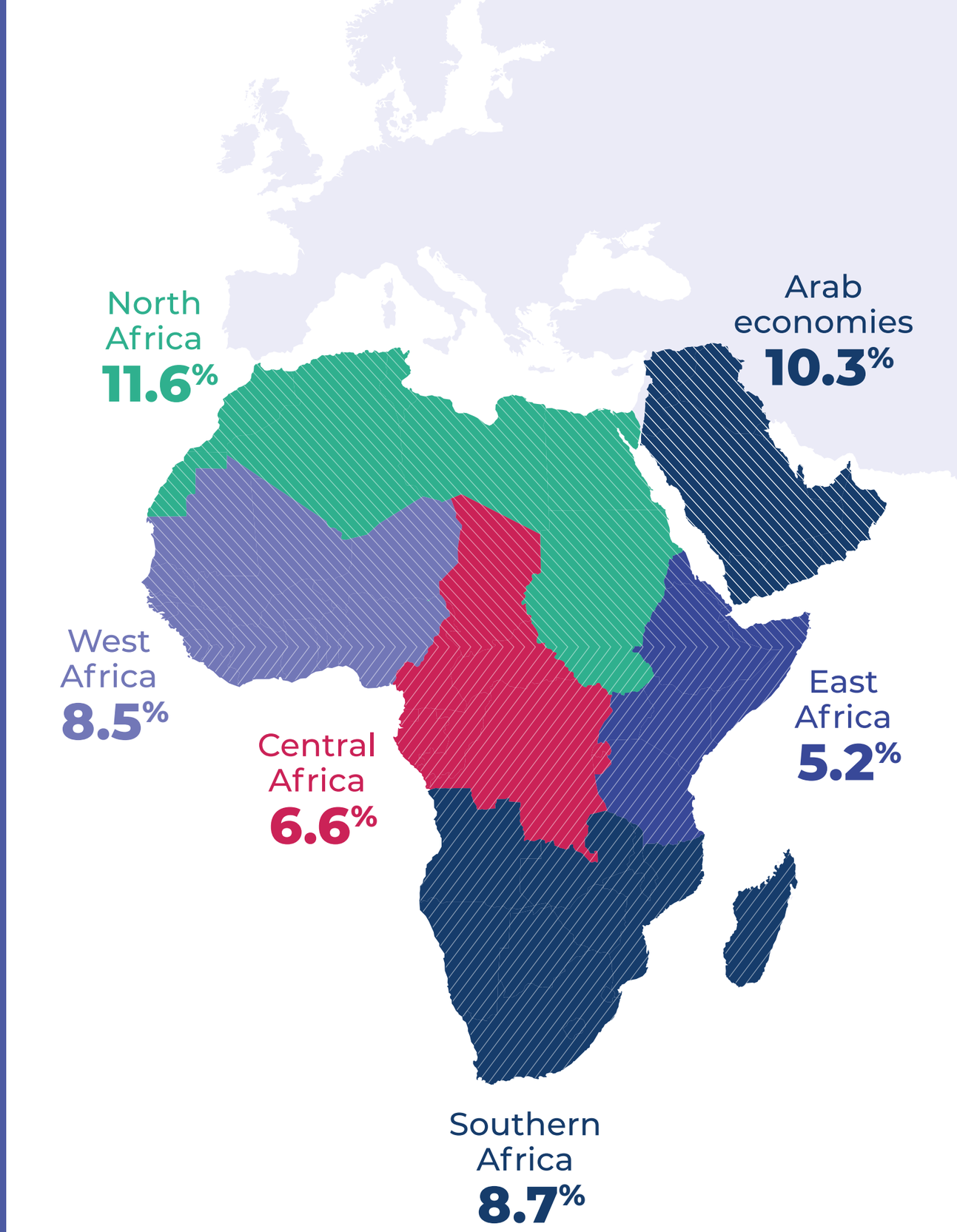
The interest in and uptake of STEM subjects at university level is naturally having an impact on the gender balance in the manufacturing workforce. In some countries, women are significantly underrepresented in engineering and technical roles, with cultural and societal norms often discouraging female participation in STEM fields.

> While there may be an adequate supply of highly skilled individuals willing to work, skills gaps still arise, specifically when the skills of the available workforce do not match those needed for the roles that need to be filled. To attract, develop and retain appropriate skills and competencies vital to the growth of the manufacturing sector, key stakeholders need to work collaboratively to implement recommended initiatives.
>
> **Randa Bahsoun, New World New Skills Leader at PwC Middle East[75]**

Manufacturing share of employment % (2021)[12,13]



> With the shortage of engineering, scientific, and digital skills in Africa, human capital remains a key constraint in preparing for the future of production shaped by the disruptive technologies of the 4IR. Absent major changes in education and training systems, this problem is likely to worsen.[76]



Initiatives to boost relevant skills in the working age

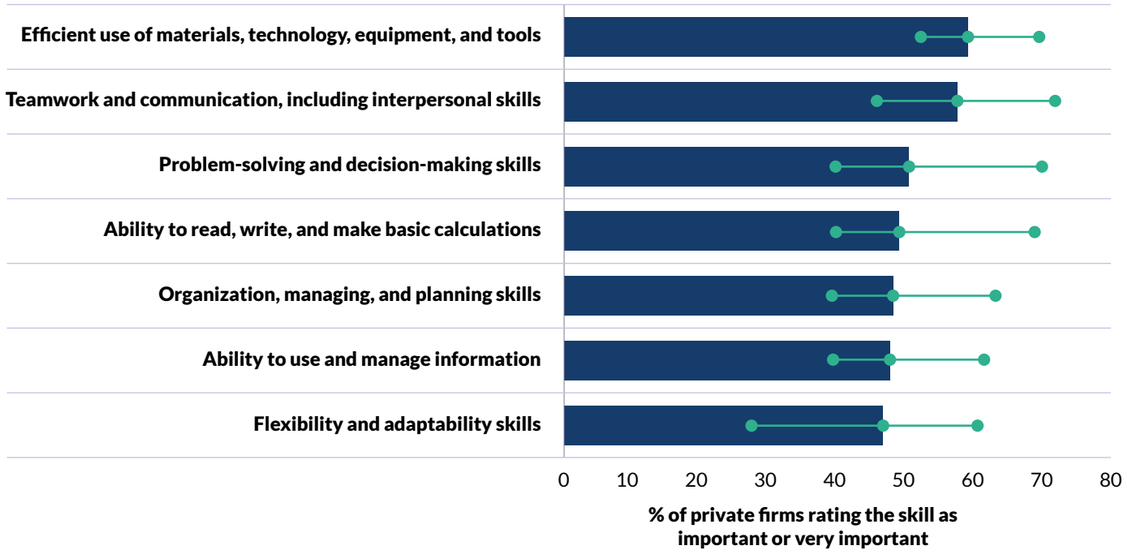
The manufacturing workforce in MEA is as diverse as the region itself, with some countries making substantial progress in building a skilled workforce, while others still face significant challenges.

Countries including Saudi Arabia and the UAE are heavily investing in upskilling their workforce as part of their economic diversification strategies. Saudi Arabia's Vision 2030 places a strong emphasis on developing a highly skilled workforce, with a focus on technical and vocational education.[5] The Saudi Industrial Development Fund (SIDF) offers training programmes to support engineers and technicians in adopting new technologies and modern manufacturing methods.[69] Similarly, the UAE's Advanced Skills Strategy aims to enhance the capabilities of workers through continuous education and training, particularly in areas such as automation and sustainability.[70]

Around the world around 13.6% of workers are employed in manufacturing. In Africa this figure sits nearer to 7%.[12] This disparity may be attributed to a shortage of skilled labour and inadequate educational and vocational training systems. Countries are starting to make headway by investing in industrial parks and training centres to develop the technical skills required by the manufacturing sector. Programmes like Kenya's National Industrial Training Authority (NITA) is a model for improving vocational education by working closely with industry to design training programmes that meet employer needs.[71]

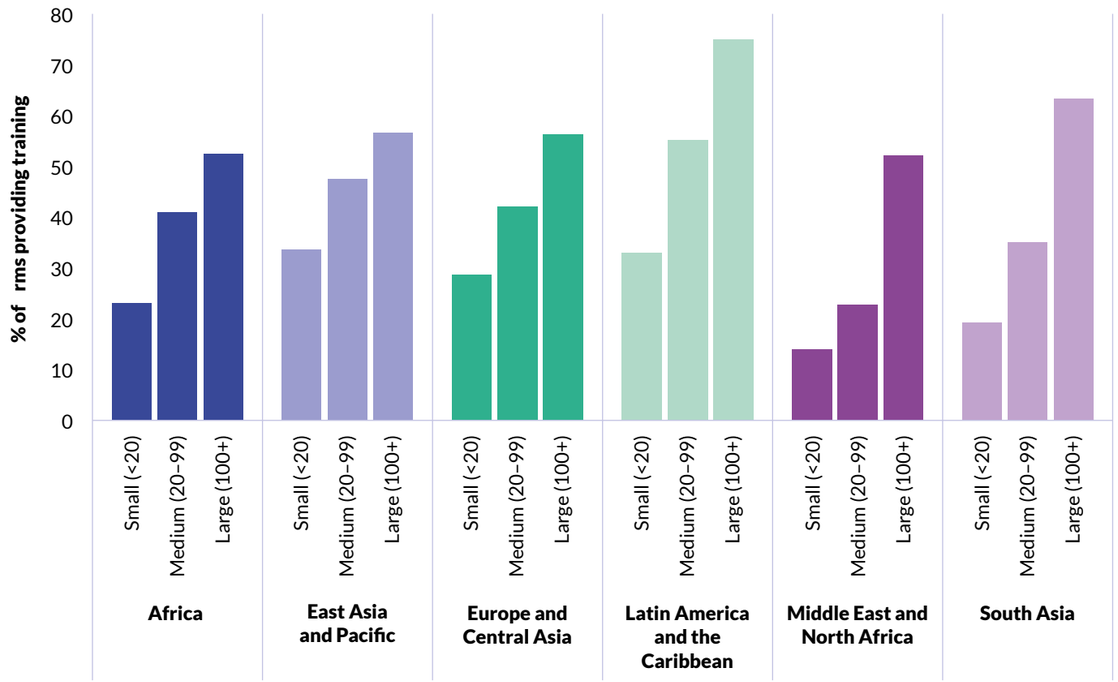
In North Africa, countries such as Egypt are emerging as manufacturing hubs due to their growing population and strategic location. Egypt has developed industrial zones, such as the Suez Canal Economic Zone (SCZone), which offer training facilities for workers and engineers to develop skills in areas such as logistics and automation.[72]

Share of employers rating the skill as important or very important in Benin, Liberia, Malawi, and Zambia[66]



In Kenya and Zambia, workplace training was associated with a 20% increase in the wages of manufacturing workers.[77]

Share of firms providing on-the-job training, by size of firm and region[66]



A team from Deloitte highlighted five roles which are representative of how manufacturing jobs will continue to evolve.

Role	Changes	New skills include
Production planner	▶ From reactively managing shop floor issues to analysing data insights, managing exceptions and identifying opportunities for continuous improvement ▶ From manual processes for monitoring supply and inventory positions to using predictive analytics and digital twins to create optimised production schedules and proactively manage supply issues	▶ Business acumen ▶ Continuous improvement ▶ Data analysis and visualisation ▶ Digital twins ▶ Understanding of the impact of robotics and IoT sensors
Industrial engineer	▶ Increasing use of digital twins and other methods of automation, to create greater connectivity between manufacturing processes and optimise shop floor operations ▶ Focus on optimising human-machine interactions	▶ Greater technical acumen ▶ Design for manufacturability ▶ Data science ▶ Programming languages such as python and R ▶ Implementation of technologies including co-bots, IoT sensors and digital twins
Operator	▶ In the future, operators will use digital tools, such as digital twins and AI "recommendation engine" support, to proactively identify and solve issues ▶ They will be trained as generalists who can work across machines and product lines	▶ 3D models for model-based manufacturing ▶ Predictive and prescriptive maintenance practices ▶ Interpret and act on insights from digital twins ▶ Work collaboratively with robots on automated production lines
Line leader	▶ Line leaders will move from manual work and reactive problem solving to proactive issue identification and prevention through automated processes and tools	▶ Coaching ▶ Team management ▶ Using real-time production data to determine root causes and prevent recurring issues ▶ Predictive and prescriptive maintenance ▶ Understanding of IoT, digital twins, robotics, and automated machinery
Quality engineer	▶ In the future, they will be able to monitor processes in real time, predict quality issues before they occur ▶ They will trace and diagnose any issues through the use of digital twins, machine learning models, advanced analytics and the ability to embed intelligence quality controls	▶ Analytical thinking skills ▶ Ability to use 3D models for model-based manufacturing ▶ Understanding of how to collaborate during design iterations as part of an agile team ▶ Understanding of big data, data science and machine learning

CASE STUDY

Autodesk Fusion Maker Design Competition from Baker Baynes in South Africa

> Marina's design ticked all the boxes – it's strong, durable, and aesthetically pleasing, all while being incredibly functional for a first-time user.
>
> **Autodesk Fusion Maker Design Competition from Baker Baynes in South Africa**

The Autodesk Fusion Maker Design Competition challenged participants to create a sustainable, efficient portable power pack weighing under 10 kg, with a 100 amp-hour capacity, 1.2 kW output, and 6-hour runtime.

Competitors used Autodesk Fusion to bring designs to life, incorporating eco-friendly materials, multiple outlets and user-friendly displays. Judged on functionality, aesthetics, manufacturability, and sustainability.

Organised by South African Authorized Autodesk Learning Partner, Baker Baynes, the event drew diverse talent, from seasoned designers to Fusion newcomers. The competition was designed to showcase Autodesk Fusion's capability to enable impactful, sustainable innovations.

Marina Johnson from Tabazimbi, South Africa was the winner of the 2024 Autodesk Fusion Maker Design Competition. A first-time Autodesk Fusion user, Marina impressed the judges with her creative and functional approach. Her design stood out for its sleek aesthetics, thoughtful component placement and effective use of Autodesk Fusion features.

BAKERBAYNES

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Apprenticeships: reshaping the informal to fill skills gaps?

In sector which needs to modernise, apprenticeships could offer a solution to bridge the manufacturing skills gap, offering practical, job-specific training aligned with industry needs.

Traditionally, apprenticeships in MEA countries have been viewed as a less prestigious alternative to academic education. Many young people and their families prioritise university, perceiving apprenticeships as an option for those unable to pursue higher education. They're also often intrinsically linked with the informal sector, which dominates particularly in Sub-Saharan African markets.

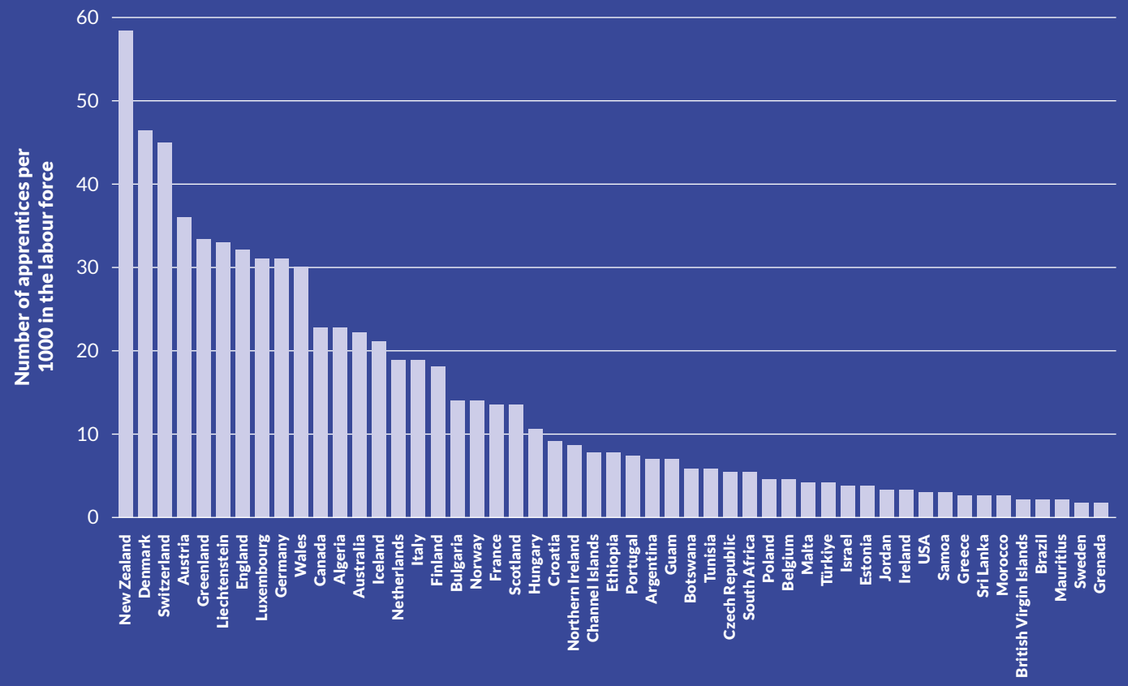
These informal apprenticeships are a means of skills development, especially in the absence of formal vocational training systems. They operate quite differently from formalised systems found in developed countries. They are largely unregulated, with training typically passed from master artisans to apprentices through hands-on experience rather than structured curricula. These apprenticeships are embedded in small, family-owned workshops or businesses, passing down technical skills such as carpentry, tailoring, metalworking, and increasingly, manufacturing-related trades.

For instance, in countries like Ghana and Nigeria, informal apprenticeships are a longstanding tradition. They serve as an entry point into trades where formal education might be inaccessible due to cost or availability. While informal apprenticeships are effective in skills transfer, they often lack certification or recognition, which limits apprentices' mobility and earning potential in the broader economy.

In comparison, countries like Germany and Switzerland have long-established and respected apprenticeship systems that integrate vocational training with career progression, making them highly attractive to young people.

But there has been a shift in recent years.

Apprenticeship participation per 1,000 in the labour force, by economy[81]



> “...young people in many African countries graduate from tertiary education without the skills they need to be able to work. This is connected to the lack of flexible learning and courses, excessive emphasis on theoretical rather than practical education, and the scarcity of formal apprenticeship and internship schemes that support skills development.
>
> **Lucy Heady, knowledge director of Education Sub-Saharan Africa (ESSA)**[84]

Governments and organisations across the region are increasingly recognising the value of vocational training and apprenticeships. Some examples:

Egypt

Egypt’s dual education system (formerly known as the Mubarak-Kohl Initiative), modelled after the German apprenticeship approach, combines classroom instruction with on-the-job training. This system, which is expanding into the manufacturing sector, helps close the gap between theoretical knowledge and practical skills, making young people more employable.[78]

South Africa

In South Africa employers pay a skills development levy (1% of payroll) to the Sector Education and Training Authorities and Skills Development Fund. The country has a national qualification framework and competence-based standards that are registered and allow any provider to deliver any qualification if they get accreditation from a relevant SETA (e.g. merSETA which encompasses Manufacturing, Engineering and Related Services.[80] There are two streams – learnerships and apprenticeships. The former are defined as periods of on-the-job learning and off-the-job training, leading to a qualification governed by a contractual agreement between the learner, the employer and a SETA. Apprenticeships are mainly for existing employees, and involve periods of on and off-the-job learning.[8]

Saudi Arabia

In Saudi Arabia, several large private companies have developed industry-specific apprenticeship programmes. One of the oldest examples is that offered by Saudi Aramco, which was designed to support national strategic objectives but also reduces the burden of finding non university graduates who require substantial retraining.[79]

UAE

The UAE has launched initiatives like the Technical and Vocational Education and Training (TVET) strategy to promote skills-based learning.[82] These programmes aim to equip the workforce with the technical and soft skills required for advanced manufacturing environments, particularly as industries adopt automation, artificial intelligence and other Industry 4.0 technologies. The government also recently released a policy which aims to “increase the competitiveness of the Emirati workforce by enhancing vocational training opportunities in private, government, and semi-government sectors through Apprenticeship Programmes”.[83]

Apprenticeship schemes could be well-suited to the manufacturing sector in the region because they combine part-time formal education with training and experience at the workplace and result in an externally-recognised vocational qualification. To realise this shift, collaboration between governments, educational institutions and private companies is needed.

Investment in high-quality training programmes, alongside efforts to reshape public perceptions, will enhance the appeal of apprenticeships as viable career paths. By doing so, the region could not only meet the growing demands of its manufacturing sector but also create opportunities for young people in a competitive job market.

Common patterns of apprenticeship training in the formal and informal sectors[66]

Characteristic	Formal sector	Informal sector
Target group	New labour market entrants, young people with or without prior technical and vocational training	Young people, with or without prior work experience
Duration	Long-term	Long-term, but also sometimes shorter and product specific
Location of training	Combination of workplace learning and school-based training	Workplace is main learning location, rarely complemented by school-based basic training modules
Objective	Obtain a formal qualification	Reach occupational proficiency
Certification	National certification, in some cases also company-specific certification	Declaration of completion by master craftsmen or business association, if any; usually no nationally recognized certification
Contractual arrangements	Formal apprenticeship contract, based on labour or apprenticeship legislation, safeguarding of basic labour rights	Written or oral agreement between master and apprentice or his family, no formal protection of labour rights
Financial arrangements and social security	In most cases (but not always), apprentice is entitled to apprenticeship wage or allowances (compensation payment), as well as basic social security stipulated by law or collective agreement	Differs from country to country—apprentice may pay a training fee to the master, but may also receive some support for living expenses and some wage with increasing productivity
Training contents and standards	Defined through curriculum and training plan and according to stipulated training standards	Traditionally no curriculum or training standards
Entry requirement	Formal education certificate	Traditionally no or low education entry requirement, but level of education required is increasing
Entry and access	Formal sector recruitment procedures or facilitated by training institution	Informal, network-based arrangements between master and family

Overview of key features of apprenticeship in the eight selected countries[81]

Country	Participation in apprenticeship per 1000 in the labour force	Age of apprentices	Historical context	Particular features
Australia	*22*	Mixed model of younger and older apprentices	Introduced in 1901	The conflation of apprenticeships and traineeships in the data provision make it difficult to separate issues related to each type of provision
Denmark	47	Mixed model of younger and older apprentices	Dates back to the Middle Ages, with ongoing changes	Strength and large scale of the dual system in Denmark
Egypt	1	Predominantly school leavers	Formal apprenticeship provision dates back to the 1950s	The strength and popularity of the higher education route, the institutional vocational routes, as well as informal apprenticeship, make it difficult for apprenticeship to flourish
England	*32*	Mixed model of younger and older learners	Origins in the Middle Ages, with a long hiatus before the more recent apprenticeships were introduced	Policy busyness in terms of rapid and frequent policy change involving apprenticeship
Finland	18	The majority of apprentices are over 25	Apprenticeship relatively recent, with expansion 2000-2012	Generally oriented to adult learners, seen as a 'second chance' route
Germany	31	Predominantly school leavers	Dates back to the Middle Ages, with the Vocational Education and Training Law of 1969 establishing the tenets of the current system	The established nature of the 'Dual System', and the powerful role played by stakeholders including employer bodies and trade unions
India	1	Predominantly school leavers	Relatively recent, with first apprenticeship mentioned in 1927	The dominance of higher education as an aspiration, on the one hand, and informal apprenticeship models, on the other, potentially limits the capacity for growth of formal apprenticeship
South Africa	5	Mixed model of younger and older learners, although the average age of apprentices is high at 28	Formal apprenticeship introduced in the mid-20th century by the apartheid government	Complexity of the pathway with learnerships and apprenticeships on offer. Complex patterns of participation relative to gender, ethnicity and geographical location

Reskilling and upskilling for growth: the business age

In recent years, there has been a notable shift towards diversification in MEA economies, with a strong emphasis on industrialisation and technological advancement. Governments in the region are actively promoting manufacturing through incentives, infrastructure development and regulatory reforms.

This focus has attracted multinational corporations seeking new investment opportunities and local entrepreneurs keen to innovate and create employment opportunities. Operating as they do in a region with abundant natural resources and raw materials, they can build local supply chains which create additional work and skilling opportunities.

These business owners play a crucial role in shaping the region's industrial future. As the Fourth Industrial Revolution reshapes global manufacturing with cloud-based technologies, robotics, artificial intelligence and big data, they face both opportunities and challenges.

Not only are they tasked with adopting new technologies, they also need to successfully navigate the policy and financial landscape.

As region strives to up the ante on its manufacturing capacity and capability, investing in state-of-the-art factories, business owners require teams with a range of new skills including those in advanced technologies. These skills are in short supply worldwide, not just in the region.

Businesses find themselves competing for talent – and many leaders are considering how they will get the skilled, digitally savvy workforce needed now and in the future. Up-skilling and re-skilling initiatives become increasingly important in ensuring workforces are equipped to handle the industry's evolving demands.

Through careful investment in skills and innovation, owners can build resilient, future-ready manufacturing businesses that contribute to economic growth across the region.

Skills for the **business age**

1.

Strategic planning and financial management

- Business owners need to be able to articulate a **clear, long-term vision** that incorporates digital transformation, talent development, and sustainability.
- The effective **management of financial resources** is essential to funding ongoing upskilling and technology adoption initiatives, especially for smaller manufacturers facing tighter budgets.

2.

Supply chain management

- Navigating **supply chain** complexities is another core skill for manufacturing owners, especially as the region faces global and local disruptions. They need to build flexibility and agility into their supply chain to protect operations and profitability.
- Business owners must also keep across **market dynamics** to make agile adjustments and maintain competitive production costs.

3.

Leadership in the age of digital transformation

- Effective **leadership** is at the heart of any successful business, and for manufacturing business owners in MEA, this includes driving digital transformation initiatives to modernise operations.
- Owners must lead by example, fostering a **culture that embraces digital tools** and data-driven decision-making.

4.

Sustainability as a core competency

- Incorporating **sustainable practices** into manufacturing offers both an environmental responsibility and a strategic advantage. Business owners who integrate sustainability into their operations can benefit from potential tax incentives and improved consumer loyalty.

5.

Workforce development

- Know when to invest in **talent development** initiatives, which may include mentorship programmes, digital literacy training and cross-functional teamwork.
- Embedding a **culture of lifelong learning** within an organisation is critical as manufacturing becomes more technology-driven. In regions where educational infrastructure is still developing, on-the-job learning becomes a practical way to close the skills gap, creating a resilient, adaptable workforce.

Challenges for the business age

Industry 4.0 technologies are transforming the manufacturing landscape. However, many business owners face barriers to fully embracing these developments, including high costs and limited expertise.

Digital transformation often requires upfront investment, which can strain the budgets of smaller companies. Additionally, without a tech-savvy workforce, the benefits of digital tools may remain untapped, affecting productivity and growth. Despite the benefits of automation, many manufacturers in the region have yet to adopt advanced digital solutions, often due to financial and skills-related challenges. Many employers are wrestling with a conundrum – what do they do with those in roles which are displaced by technology.

As manufacturing becomes more technologically driven, there's an increasing demand for workers with digital and technical skills. Arguably those displaced could, with reskilling and upskilling support, move into different roles.

Manufacturers frequently report skills gaps, especially in fields like data science, robotics, and machine learning, essential for maintaining modern production lines. A shortage of skilled workers can slow down – or halt – production. Upskilling existing staff is crucial, yet many companies lack the resources or partnerships with educational institutions to provide such training.

Beyond digital skills, there is also a shortage of traditional technical skills in areas such as mechanical engineering, quality control and maintenance. Skilled technicians and engineers are essential for complex manufacturing processes. The lack of qualified technicians and engineers often forces employers to rely on expatriate talent, which can drive up labour costs and create dependency on foreign expertise. This also impacts knowledge transfer to local talent and weakens long-term workforce sustainability.

> Human capital is a critical enabler to achieving economic growth ambitions. Businesses in the region are facing talent shortages, particularly in the high-skill segment.
>
> **Marco Vasconi, Partner at Kearney Middle East & Africa – Public Sector Practice[89]**

Basic literacy and numeracy skills are foundational to understanding technical instructions, quality control measures and safety protocols. However, in some areas of the MEA region, these basic skills can be lacking, especially among entry-level or unskilled workers. Limited access to quality primary and secondary education in some parts of the region has contributed to low literacy and numeracy among the manufacturing workforce, making it more challenging to upskill workers.

Business leaders are acutely aware of these mismatches – and the consequences they have for productivity and innovation. Often organisations struggle to find employees with the right skills. "Underqualification" is one factor, another is that, although educational levels have increased in general, the skills and knowledge acquired by workers through education are often not relevant to the needs of businesses.[85]

Access to capital remains a significant obstacle for manufacturing business owners in MEA. Funding constraints limit the ability to invest in new technologies, expand facilities or support training initiatives.

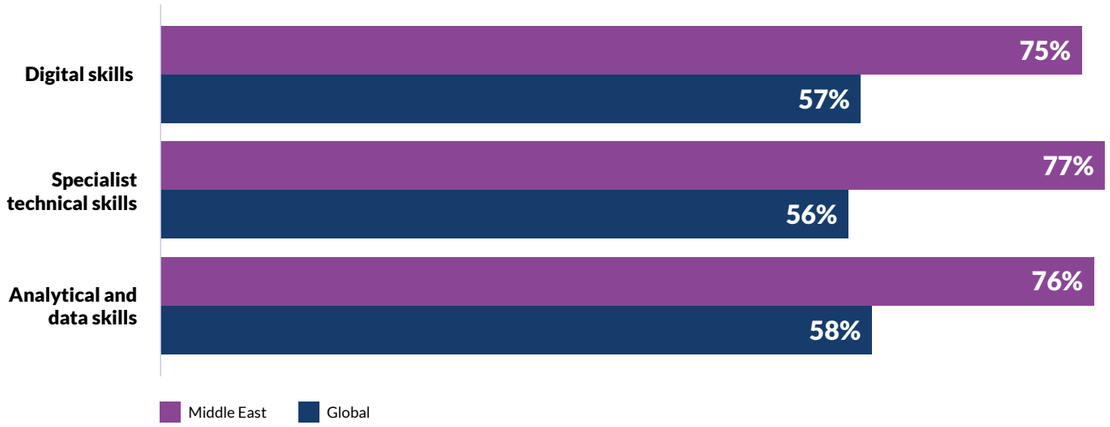
48%

of Middle East CEOs don't think their companies will be economically viable 10 years from now if they do not evolve[90]

74%

of CEOs are planning to upskill the company's workforce in priority areas[92]

More in-demand skills[91]



Initiatives to boost relevant skills in the business age

MEA business owners have a significant role to play in driving the region's manufacturing industry forward. By investing in skills development, phased technology adoption and sustainable practices, they can build resilient, competitive companies capable of thriving in a world transformed by technology. Owners need their employees to adapt to changing tools, systems and processes. They are addressing technical skills gaps through educational partnerships and hands-on training.

In some countries, governments and their partners are gearing up efforts to support new and existing employers across the sector. As businesses across Bahrain adopt the latest technologies, the Economic Development Board is supporting increased ICT investment and fostering a positive startup culture. Such initiatives create job opportunities and support the upgrading of workforce skills through training on new technology and software.[86] In Saudi Arabia, 97,000 employers have benefited from HADAF programmes, including training, qualification, and empowerment, in sectors including manufacturing.[5]

Industry associations are playing their part. For example, the Kenya Association of Manufacturers (KAM) in partnership with German Corporation for International Development (GIZ) launched a Technical and Vocational Education and Training (TVET) project aimed to provide technical jobs and economic opportunities for Kenyan youth and to bridge the skills gap in the country. KAM is working with technical training institutions and the manufacturing industries in ensuring the training is demand driven.[87]

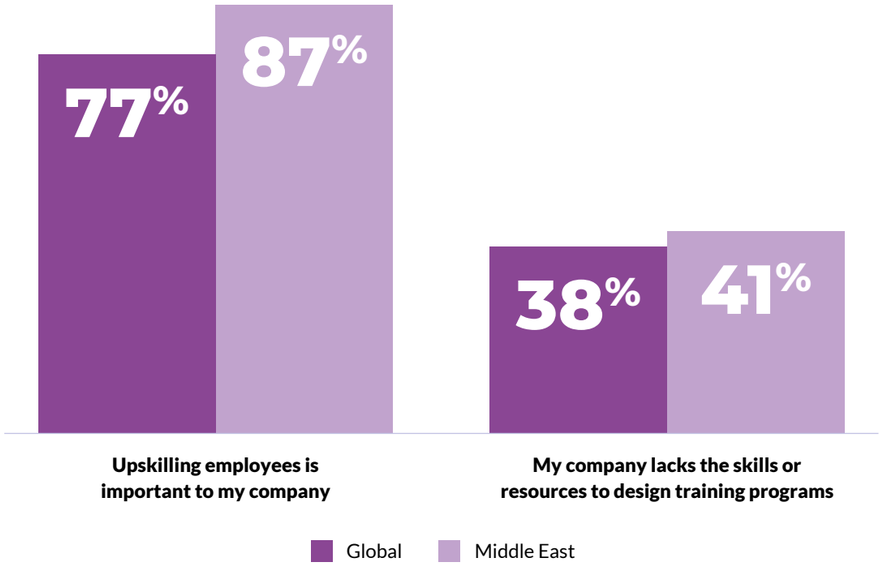
In Sub-Saharan Africa, manufacturing business owners often face limited access to funding and skill shortages. Industrial parks in Ethiopia and Kenya are creating infrastructure that attracts foreign investment and facilitates skill development. Many small and medium-sized enterprises (SMEs) are using in-house training and partnerships with international organisations to fill skill gaps and build capabilities.[88]

In Saudi Arabia, Alat intends to create 39,000 skilled jobs by 2030 and eventually export its hardware. The company is working with the Ministry of Education and partnering with technology and science institutes in the kingdom on finding talent – aiming to create thousands of "good paying jobs" in manufacturing.[89]

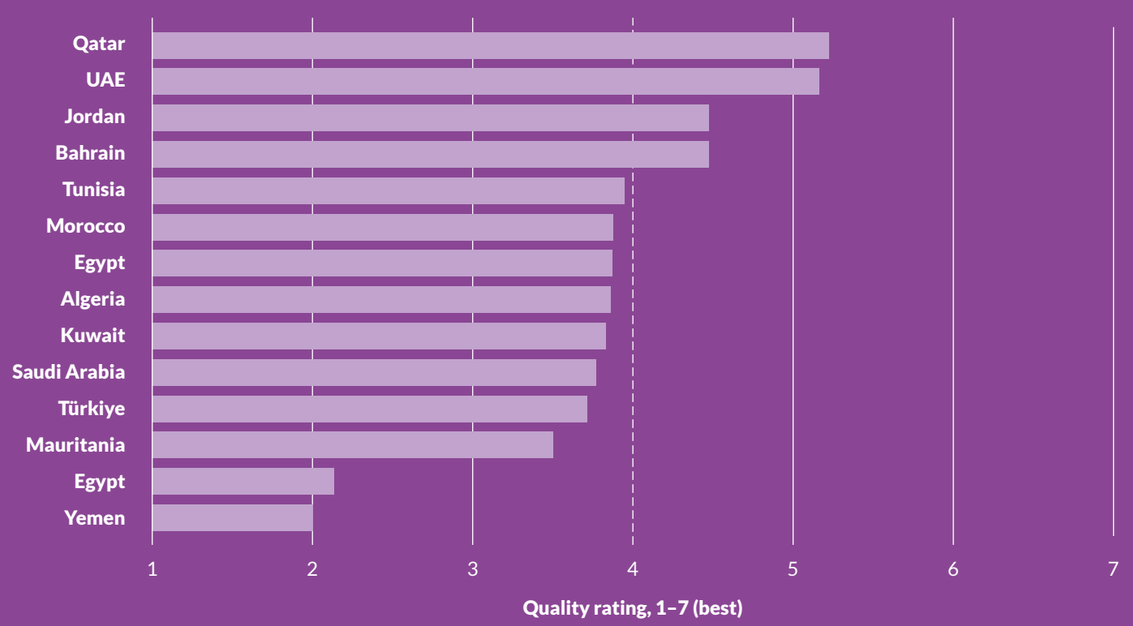
50%

of CEOs believe skills/ labour shortages will have the biggest long-term impact on their industries[92]

The upskilling gap[73]



Ease of finding skilled employees in MENA[24]



Business leader perspective: Middle East

MOHAMED EL YAMANI

Project Director at Kemet Corporation, a digital consultancy with offices in Egypt and Saudi Arabia

Which trends do you think will have the greatest impact on skills in the manufacturing sector?

The manufacturing sector is undergoing significant transformation due to advancements in technology, shifting consumer expectations, and global economic trends. At a global level, the trends I see are IoT, big data, machine learning and AI. In the Middle East, we're talking about digital transformation and industry 4.0 standardisation. Systems automation, integrations and data-driven decision-making systems impact the manufacturing sector in many ways – such as shortage of talented workers, ageing workforce, and the flexibility of the sector to respond to emergency situations such as pandemics and global supply chain challenges.

How are businesses balancing the adoption of advanced technologies like AI, robotics, and big data with the need to build a workforce that has the necessary skills to use them effectively?

Balancing the adoption of advanced technologies with workforce readiness is a critical challenge for businesses, especially in manufacturing. While many organisations recognise the transformative potential of advanced technology, ensuring that the workforce is equipped to leverage these tools effectively requires deliberate planning and investment.

Companies are launching training programmes, often in collaboration with educational institutions and third-party providers, to bridge skill gaps. They're making use of AI-powered learning tools to tailor training programmes to individual workers' needs and skill levels. Short, focused training sessions and certifications are becoming popular, allowing workers to improve their skills while on the job. Companies are also shifting from one-time training to continuous learning models. I'm also seeing a trend towards hiring technology consultants for long-term implementation and support.

Tell us about an example of a skilling initiative in the region?

We worked closely with Autodesk in the Kingdom of Saudi Arabia to help the market in its vision for digital transformation. We co-operated with Ministry of Industry (MOI) on an initiative to "digitalise" small and medium size factories. The MOI funds transformation for factories which show potential. Our role with Autodesk, is to provide software, implementation, training and support.

What's proven to be effective in developing a digitally skilled workforce?

Developing a digitally skilled workforce in a competitive talent market requires a combination of innovative strategies and strong partnerships. One important partnership is the Public-Private Partnerships (PPPs) involving Autodesk, Kemet and the Ministry of Industry in Saudi Arabia. Also important in bringing talent to the market is industry-academia collaboration. This sees us providing "train-the-trainer" courses, course contents and access to technology for free to students and teachers.

Which government incentives or industry-wide initiatives have had the greatest impact on the manufacturing sector's ability to develop the skills it needs?

Within our region, we have an important governmental initiative called Smart Industry Readiness Index (SIRI) and its part of the Kingdom's Vision for 2030.[5] It aims to support small and medium size industrial companies to achieve the highest efficiencies by providing incentives and rewards to the factories who implemented industry 4.0 initiatives and uplift their overall SIRI score. Companies are responding by developing training, investing in professional implementation and go-live support, as well as capitalising on automation and customisation opportunities.

What are your top tips around skills and talent development, particularly in the manufacturing sector?

My top tips for business leaders in the manufacturing sector:

1. Invest in Industry 4.0 understanding and implementation by building a high-skilled professionals and teams
2. Always look at the automation side of any implementation
3. Training is a key factor in any success of digital transformation
4. Engagement with governmental and education authorities
5. Start by pilot projects to understand needs, limits, and challenges

KEMET Corporation

AUTODESK Learning Partner

CASE STUDY

Skilling across the ages: a case study from Lebanon

Lebanon-based learning provider, Edtech Syndicate, has developed several initiatives which foster digital skills and engineering innovation across the ages. Using Autodesk tools, including Tinkercad and Autodesk Fusion, the programmes empower students, professionals, and educators to transform their ideas into tangible products, using essential skills in 3D design and engineering concepts.

Edtech Syndicate has engaged more than **500 students and professionals to date**. Participants have gained technical skills as well as an understanding of how design can be applied to solve real-world challenges, enhance productivity and drive innovation within industries.

> Our training has led to increased employment readiness, with participants leaving our courses equipped with industry-relevant skills that are immediately applicable in the workplace.
>
> The use of Autodesk tools has facilitated a creative and practical learning environment that bridges the gap between theory and application, especially in engineering and design fields, supporting the integration of the 'E' in STEAM by promoting hands-on learning in engineering, technology, and interdisciplinary applications.
>
> **Rabih Baalbaki – President,**
> **EdTech Syndicate in Lebanon**

Curriculum and content to support the development of **STEAM++ Innovation Programme K to 12.** Tools like Tinkercad and Fusion provide an engaging and interactive platform for learners, encouraging exploration in areas such as 3D modeling, robotics, and architecture. They promote not only technical skills but also creativity and critical thinking.

Ziggy: Revolutionizing Education Through Play. Participants design robotics, educational products, and customised replacement parts, which enhance functionality as the Ziggy Turtle Roboti. This initiative highlights the versatility of Fusion as a design tool across varied applications, from educational projects to prototyping.[93]

Global Robotics Competition. Students used Fusion to design their robot for the First Global Challenge FGC, demonstrating their ability to implement complex engineering designs into robotics.

Training prepared students (aged 14+) and makers for success in **the Make:able Challenge.** The challenge saw participants design 3D printed assistive devices for people with disabilities.[94]

Innovation Island enables skills to be applied in real-world settings, actively contributing to industrial processes and problem-solving. Trainees engage in advanced design work and understand every stage of manufacturing, resulting in a seamless transition from concept to execution.

Promoting Environmental Governance. By simulating material usage, energy consumption, and waste generation, initiatives help businesses to understand how to use Autodesk software to create efficient and eco-friendly designs.

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Cross-cutting themes

> Learning should be lifelong. All persons, at every stage of their lives, should be able to access the knowledge and skills they need in order to pursue their aspirations and contribute meaningfully to their community. Lifelong learning allows workers to upgrade their skills and allows firms to catch up with newer, more productive technologies.
>
> **The World Bank**[66]

1.

DIGITAL LITERACY

Digital literacy forms the foundation for participating in a tech-driven economy. Beginning with basic IT literacy in schools, digital skills become progressively more specialised through university and into the workforce. A focus on digital skills across educational and professional stages, means workers are equipped to navigate and apply emerging technologies such as AI, automation and data analytics.

2.

LIFELONG LEARNING

The rapid pace of technological advancements in manufacturing necessitates a culture of lifelong learning, where workers at all stages continue to upskill and adapt to new methods. This approach addresses the evolving demands of the sector by encouraging continuous personal and professional development. Embedding a mindset of lifelong learning early on can encourage students to view as a continuous process. Employers need to establish programmes for skills renewal, reskilling and specialised training, ensuring that workers stay relevant and capable of leveraging new technologies.

3.

COLLABORATION

Effective collaboration among academia, industry and government is essential for building capacity and capability. It also helps to close skill gaps and ensure that educational outcomes align with industry needs. This collaboration enables tailored training initiatives and policy support for developing manufacturing skills in MEA. Learning programmes and curricula can be informed by industry insights – and industry can play a role in supporting specific training initiatives. Work placements and apprenticeships not only provide students/workers with practical experience, businesses can benefit from skilled talent pools.

> A cutting edge education catering for lifelong learners. An environment that produces pioneering, knowledgeable skilled minds able to design and seize the future, and capable of acquiring best-in-class and up-to-date educational opportunities throughout all life stages.
>
> **We the UAE 2031**[95]

> Policies aimed at changing the mindset, behaviour and actions of citizens and institutions are more successful if stakeholders, including the triple helix of universities, business and governments, are involved throughout the policy lifecycle.[85]

Actions for all ages

1.

Expand access to technology

Governments and private sector partners should collaborate to provide schools with the necessary infrastructure, including computers, internet access, and science laboratories. Initiatives like GIGA, a global partnership between UNICEF and ITU, aim to connect every school to the internet and can serve as a model for MEA countries.[96]

2.

Enhance investment in teacher training and development

There should be a focus on training teachers in both subject matter and pedagogy, particularly for STEM subjects. Programmes like the UNESCO-UNEVOC initiative, which focuses on vocational education, can be expanded to include teacher training for K-12 education in STEM fields.[97] In addition, establishing continuous professional development opportunities for teachers, including access to the latest educational resources and teaching methods, is essential.

3.

Curriculum development and reform

Educational authorities need to work on updating school and university curricula to include modern STEM topics, digital literacy and practical skills relevant to the manufacturing industry. Incorporating project-based learning and hands-on experiences, such as maker spaces and school-based workshops, can help students better understand manufacturing processes.

4.

Promote career pathways and a culture of lifelong learning

A clearly defined career pathway from school education through to employment is needed, supported by extra-curricular and/or curriculum-enhancing programmes that provide real-world applications to learning. Employers need to prioritise continuous training and upskilling initiatives to keep engineers and workers competitive in an ever-evolving industry. Governments can support this through tax incentives and public-private partnerships.

5.

Address socioeconomic barriers and gender disparities

Targeted programmes to encourage girls' participation in STEM education, such as scholarships, mentorships and awareness campaigns, should be expanded. Governments should provide financial support and incentives for low-income families to keep their children in school, particularly in regions where economic pressures lead to high dropout rates.

6.

Strengthen university-industry partnerships

Universities should collaborate more closely with manufacturing companies to ensure that academic programmes align with industry needs. Internships, research partnerships and work experience initiatives can provide students with practical experience while also giving companies access to young talent.

7.

Expand access to practical training

Governments and educational institutions should invest in equipping universities with modern laboratories, simulation tools and advanced manufacturing equipment.

8.

Embed industry training and certification into curricula and workplace learning programmes

Not only could industry could play a part in opening-up student access to the machinery and digital tools used in manufacturing, universities could boost student employability by embedding learning and certification into curricula. In addition, governments and private sector partners should work together to expand access to courses and certification, particularly in under-served regions.

9.

Focus on innovation and entrepreneurship

By offering courses and extracurricular activities that encourage creative thinking, problem-solving and business development, educational institutions can foster a culture of innovation and entrepreneurship.

10.

Explore the opportunity afforded by apprenticeships

Formal apprenticeships could offer a solution to bridge the manufacturing skills gap, offering practical, job-specific training and recognised qualifications which are aligned with industry needs.

Conclusion

> Through industrial policies, governments can support the creation of good jobs to stimulate demand and catalyze the creation of a skills ecosystem.[85]

The manufacturing sector in the region is facing a paradigm shift. Digital transformation has the potential to displace millions of people from jobs, but it will also create new roles and transform old businesses.

Policymakers, businesses and academia have a collective responsibility to prepare the skills ecosystem for this shift.

The economic case is clear. Investing in skills across all ages not only delivers improved productivity and innovation now, it also builds the future workforce. A workforce which is resilient, flexible and adaptable – with the right skills at the right time, in the right place.

A collaborative approach is essential.

Structural reforms and targeted policies are needed to make skills accessible and relevant, from foundational digital literacy in schools to advanced digital capabilities in the workplace. Not only does digital investment need to be incentivised, curricula need to be aligned with industry demands.

Only then can the region fully capitalise on the Fourth Industrial Revolution, positioning its manufacturing sector as a global leader prepared for the future.

About the Autodesk Learning Program

With Autodesk courses and certifications, businesses can gain the knowledge and skills needed to create high-quality building and infrastructure designs. Students can develop the skills they need to build productive careers in the AEC sector.

Autodesk Authorized Training Centers (ATCs) are Autodesk preferred training providers who can help with employee professional development. They work with Autodesk Certified Instructors (ACIs) who are recognized for their product mastery and instructional skills. ATCs work with employers to evaluate business needs and adapt their training to workflow and processes. ATCs offer flexible delivery methods from classroom to instructor-led virtual training to ensure that your team gain the required skills in a way that minimizes business interruption.

Authorized Academic Partners (AAPs) are Autodesk preferred service providers to the academic market that help with faculty professional development and add value to programs and courses.

AAPs can offer comprehensive end-to-end service packages that combine training with access to Autodesk software and curriculum resources. They embed Autodesk professional certification within their courses, which are of value to faculties and students. AAPs can support and recognize students by rolling out projects, competitions, and extra-curricular training activities.

About KnowledgePoint

KnowledgePoint adds value to learning organisations by delivering a range of learning support services. From learning materials fulfilled in both print and digital to administrative services and global training network management, we make life easier for our learning industry partners.

Our customers are training and learning organisations and teams; they design, create and deliver learning programmes. We work in partnership with them, providing practical solutions which support these efforts. In doing so, we make a real difference to them and their learners. We help them achieve positive learning experiences and outcomes, boost customer and learner satisfaction, and realise cost and resource efficiencies.

As the Autodesk Learning Partner Distributor for the EMEAR territory, we manage the training partner network including recruiting, revenue management, and providing ongoing support and enablement to academic, training and learning partners.

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