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White Paper

A Global Standard for Lifelong Learning and Worker Engagement to Support Advanced Manufacturing

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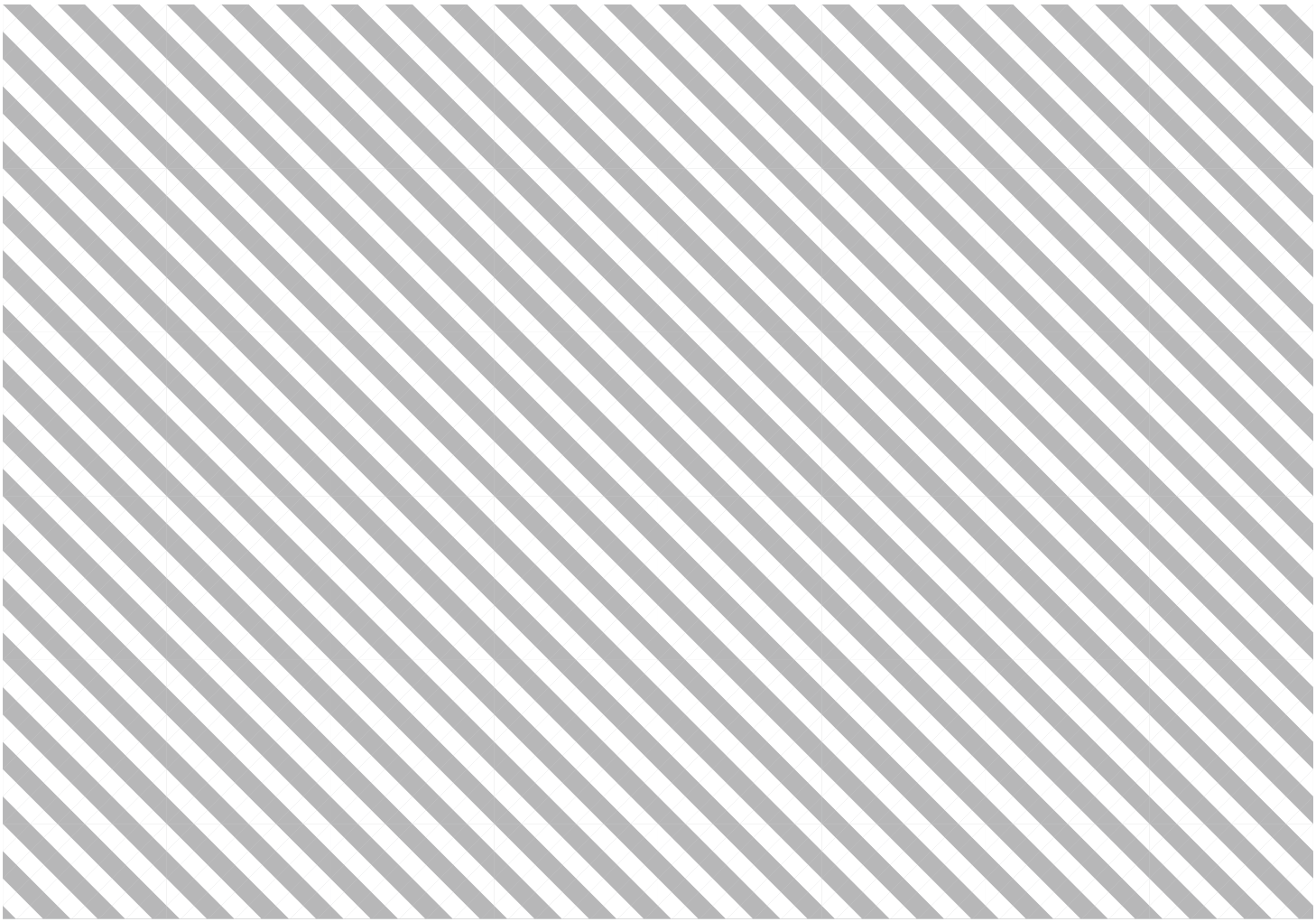

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Introduction

The Fourth Industrial Revolution could lead to the displacement of an estimated 75 million jobs worldwide in the next four years. At the same time, it is expected that new opportunities could also create 133 million new jobs,[1] creating a net positive 58 million new roles by 2022.

Manufacturing accounts for about 22% of global employment, yet the majority of manufacturing companies still lack a clear strategy on how best to equip their workforce with the capabilities required to master the impact of the Fourth Industrial Revolution.

Advanced manufacturing technology is not transforming jobs but it is shifting the tasks of the front-line workforce, and redefining the skill sets required.[2] The public and private sectors are preparing for this massive change, while some companies have already implemented concrete solutions to upskill and reskill their workforces.

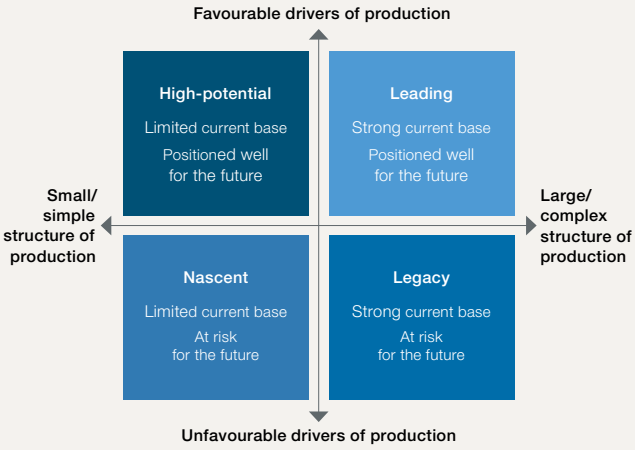
However, there will not be nearly enough skilled workers to allow full use of advanced manufacturing technology without sufficient retraining.

In this context, Fourth Industrial Revolution technologies will not only improve how manufacturing works but also change the way the workforce is engaged, since manufacturing stakeholders must constantly evolve to keep pace with technology. The skills gap represents the highest barrier to adopting new technologies;[3] however, the highest levels of productivity can be achieved with a workforce that is engaged and able to use new technologies effectively. To achieve this, businesses should better understand the implications of automation for their workforce, and design their skills base to ensure that the mix of technology and labour is optimized to enable workers to both understand and contribute to the skills required. Constant collaboration and discussions among companies, workers, labour organizations, governments and academic institutes are essential to build an effective and productive workforce to support advanced manufacturing. To that end, manufacturing companies should increase investment in training on a lifelong basis and shape technologies in ways that enable workers to maximize their potential. Governments and policy-makers should create an environment that encourages organizations to benefit society as a whole rather than just their shareholders.

The public and private sectors should partner to invest in education on a long-term basis and create lifelong learning opportunities that combine on-the-job training with educational courses at universities and other educational outlets. New approaches, collaborations and a change of mindset are required to adapt.

We present the elements of the proposed standard in generic form, recognizing that each will need to be adapted and tailored to fit nations in regards to where they fall within the regional readiness matrix developed in previous council meetings (see Figures 1 and 2).

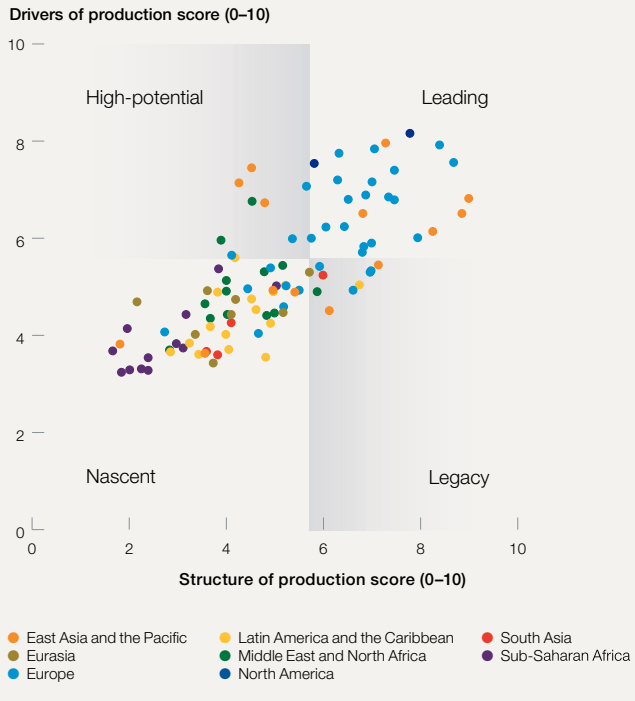
Figure 1: The readiness matrix



Source: "Readiness for the Future of Production Report 2018". World Economic Forum.

Indeed, the examples provided here illustrate that manufacturing organizations around the world are in the process of implementing these principles in ways tailored to their specific stages of development, institutions and needs.

Figure 2: Global map of readiness assessment results 2018



Source: "Readiness for the Future of Production Report 2018". World Economic Forum.

Guiding principles for lifelong learning and worker engagement

The central premise underlying the guiding principles is that continuous training and full worker engagement in integrated processes of designing and implementing new manufacturing technologies and work systems (see Figure 3) are essential if the potential benefits of advanced manufacturing are to be fully realized and shared broadly and equitably among workers, consumers, firms and societies.[4]

We therefore call on firms, labour organizations, industry associations and governments to **work together** to assure that the following principles are achieved.

1. *Industry leaders work cooperatively with high school, post-high school technical/vocational education and college/university programmes that focus on preparing students for career opportunities in advanced manufacturing in order to ensure that these students are being educated and prepared in terms of the skills they will require.*

2. *Continuous training is provided to workers across all occupations in production supply chains (managers, engineers, supervisors, production employees, temporary and contract workers and independent contractors) to prepare them adequately to engage and work with new technologies before these technologies are introduced into their workplaces.*

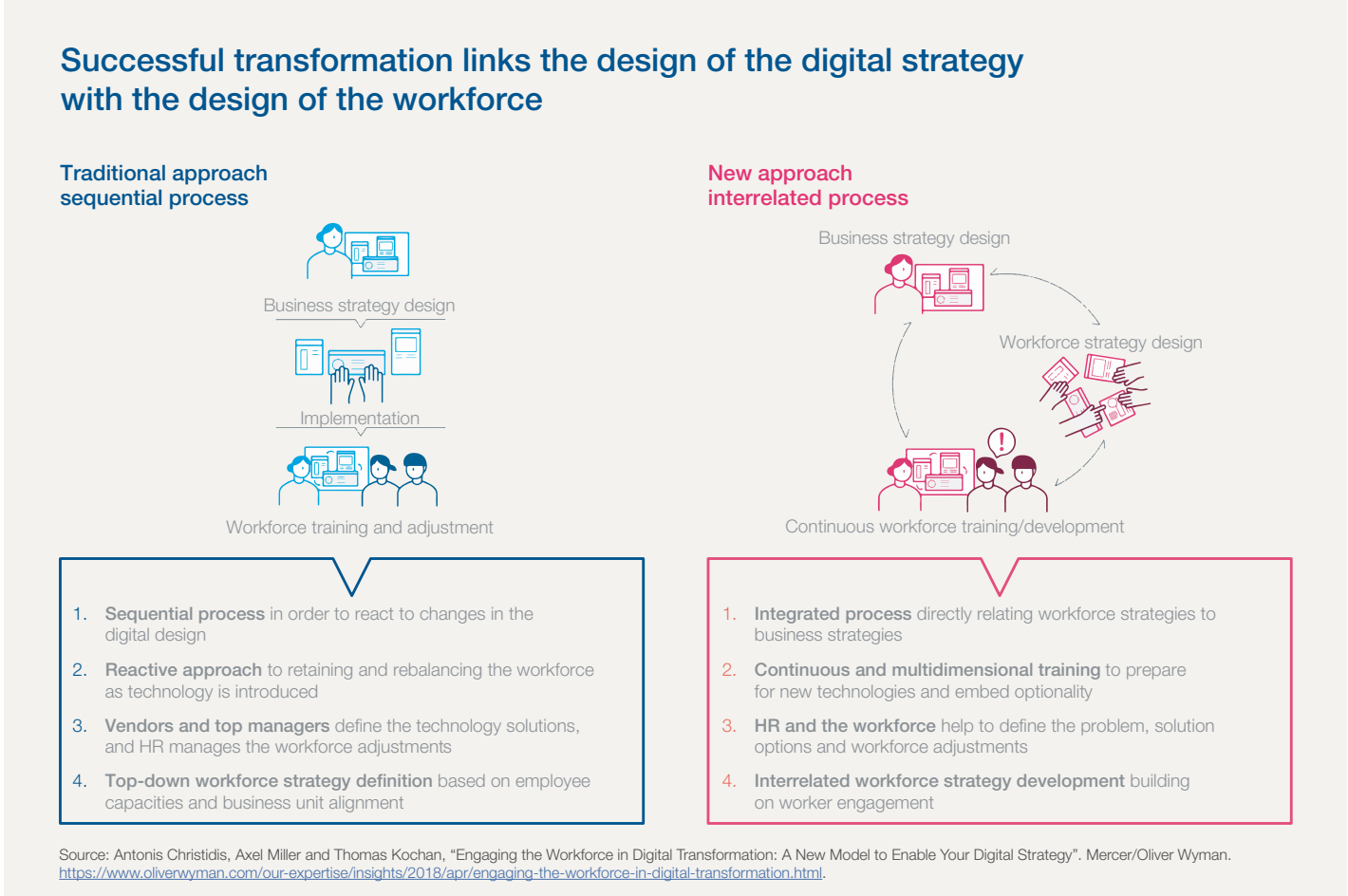
3. *Workers, as defined above to include all occupations in the production supply chain, are enabled to engage and contribute as partners in the design and deployment of new technologies.*

4. *Retraining opportunities in advanced manufacturing are provided to workers who wish to re-enter the workforce after taking time out to care for family or other responsibilities, to transition from military service to civilian occupations or to take advantage of educational programmes that support lifelong learning.*

5. *Workers who are displaced by new technologies are provided with the opportunities and income support needed to move to new jobs without incurring a substantial loss of income or are otherwise compensated for their loss of work.*

6. *The above efforts are informed by, and fully employ, the growing number of data systems and organizations available for matching worker skills with growing job opportunities.*

Figure 3: Integrated model



Source: Antonis Christidis, Axel Miller and Thomas Kochan, "Engaging the Workforce in Digital Transformation: A New Model to Enable Your Digital Strategy". Mercer/Oliver Wyman. https://www.oliverwyman.com/our-expertise/insights/2018/apr/engaging-the-workforce-in-digital-transformation.html.

Evidence and case studies

1. *Industry leaders work cooperatively with high school, post-high school technical/vocational education and college/university programmes that focus on preparing students for career opportunities in advanced manufacturing in order to ensure that these students are being educated and prepared in terms of the skills they will require.*

There is ample evidence that the economic returns to non-college educated workers have declined considerably in recent years. So-called skill-biased technological change has increased the earnings ratio of college-educated to workers with only high school-level education or lower.[5] Yet the demand will continue to be high for "middle-skill" jobs that require technical and vocational training.[6] This is especially true in advanced industrialized countries, where a large proportion of these jobs are currently held by workers nearing retirement age.

Preparing and recruiting new entrants for these jobs requires cooperative efforts from educators, industry and the workforce. Apprenticeship programmes vary considerably in scale around the world. Germany and Switzerland are often cited as having the strongest and most comprehensive training system, which has historically benefitted from active industry and labour collaboration.[7] Yet fine examples of collaboration in preparing young people for these careers can be found in many other companies, industry groups, labour organizations and countries.

We pose the following questions to leaders around the world:

1. What are the fastest-growing and greatest needs for middle-skill workers in your company/industry? What is your anticipated demand for such workers in the next decade?

2. What are your sources of recruitment?

3. What organizations do you work with to ensure that an adequate supply of new middle-skill workers will be available to your organization? Are there industry and/or industry and labour councils or collaborative processes in place that deal with these issues? If so, how effective are they and how might they be improved? If not, how might they be created?

4. What specific competencies (skills and abilities) will be needed to perform the middle-skill jobs of the future in your industry?

Some firms are taking proactive steps to help high school and vocational schoolteachers learn about up-to-date production technologies and processes.

Stanley Black & Decker hosts local high school teachers during the summer holiday break, supporting workplace learning by providing direct experience about trends, skill requirements, new technologies and opportunities in an industry related to their subjects. This enriches and strengthens their teaching, making it more relevant for subsequent college and career choices. Teachers must gain an understanding of local trends in economic and career developments that will affect their students, something the externship programme provides. In return, the company gains a better understanding from the teachers about how the next-generation workforce learns and what motivates them, which will provide valuable information for engaging with future workforces.

During the month-long externship, teachers shadow the Stanley Black & Decker Industry 4.0 team as they continue to deploy digital technologies across their global manufacturing network and gain exposure to supply-chain and distribution operations as well as the company's corporate social responsibility efforts.

Many community colleges in the US are also proactive in forming links with manufacturing firms in their regions and are working to build strong networks to match the supply of graduates with industry demand for middle-skill occupations. One example in this area is the growing number of so-called "bootcamps", a concept borrowed from computer coding academies. These are relatively short-term intensive training programmes focused on a particular issue or new skill and/or on the expectations and requirements of employers in industries with rapidly changing technologies and skill requirements and with high demand for middle-skill workers.[8]

The duration of the bootcamps, from two to three days to two to three months, and the curriculum topics, range widely, though most are directed towards instilling basic entry-level employment skills. Many of these began as a result of government-funded programmes that support experimental short-term intensive skill-based training programmes directed at adults.

The most successful programmes have the following features:

- **Strong industry partnerships**
- **Credit-bearing programmes**
- **Low cost**

Bootcamps are largely aimed at underemployed or unemployed adults with little or no experience in higher education. This is often the student's first interaction with higher education, and many students are intimidated by the idea of college.

For example, Northeast Community College in Norfolk, Nebraska, reported:

"There is a fairly large intimidation factor about walking on to college campuses. Even coming to the college to enroll is a barrier. We don't deliver the bootcamp at the college for this reason. We run the bootcamps in our local business partner's space, or we rent office space. Students who enroll in the bootcamp have told us that 'they aren't smart enough for college' and that 'they wouldn't feel comfortable in a college setting'. … Often these people are employed in local fast food restaurants, like Subway. They don't know anything about the manufacturing industry. They don't know you can't show up five minutes before your shift, that you need to wear certain kinds of clothes, that you need to behave in certain ways. This bootcamp is really about orientating someone, giving them the information they need to walk on to the job ready to learn and be successful."

In some countries, firms have set up their own vocational educational schools. Ford Otosan in Gölcük, Turkey, serves as one example of this approach.

Ford Otosan set up a 1,000 square-metre prototype vehicle manufacturing workshop in the Ford Otosan Vocational School of Higher Education for students to get first-hand experience of production jobs in areas such as robotics, machining etc.

The curriculum of the school is updated yearly, with nearly 40 co-workers helping support the school's instructors.

Ford Otosan has signed protocols with the education ministry to issue high school degrees and associate and undergraduate degrees. As part of this scheme, the company offers paid vocational training programmes in their plants. Trainees attend these plants three times a week during their second year at vocational schools. Throughout the programme, trainees are given the opportunity to work using the company's processes and gain familiarity with their workshops. Thanks to this, these trainees will be ready to work for Ford Otosan when they graduate.

A region-wide initiative to support lifelong learning is about to launch in the US city of South Bend, Indiana. It is a joint initiative of the Peter Drucker Institute, a research centre established to promote the management practices that Peter Drucker, one of the most respected management educators and consultants of the 20th century, taught and wrote about during his career. Leaders of the programme, named "Bendable", are mobilizing employers, community organizations and city officials to build a lifelong learning system in that community. This paper will draw on this initiative to illustrate several of its principles. It speaks to Principle 1 in a number of ways:

- Community residents were interviewed to identify what they need to learn/how they like to learn.
- Multiple community stakeholders are engaged as sponsors in shaping the programme.
- A community institution, the St Joseph County Public Library, will serve as the steward and anchor institution.
- An evaluation team, led by the design firm IDEO, will document the programme and form a network of "Cities of Lifelong Learning" to replicate/adapt it in other locations.
- The programme elements are designed to meet the needs of entry-level workers, incumbent workers and those who wish to learn new skills, unrelated to their current jobs.

The programme will provide a digital portal that will enable citizens to:

- Understand what skills are in demand, based on timely employer input.
- Find opportunities to develop those skills via local institutions or through national providers.
- Keep a record of what has been learned, with credentialing and badging recognized by local employers and others.
- More easily connect with each other – an explicit recognition that learning is social, reflecting the wishes of interviewees to learn from each other and with each other.
- Learn beyond the workplace – for instance, how to prepare healthy meals or gain financial literacy.

The programme will launch in early 2020.

These examples illustrate the variety of ways in which an environment for facilitating lifelong learning can be built. The key is to engage the full range of stakeholders in a given community and to coordinate their efforts in ways that generate good rates of return for each party (including the learners) and that motivate all to continue to work together and adapt to changing economic and technological developments. Moreover, as will be noted in Principle 4, it is critical that special attention is given to the diverse needs of the modern workforce, including those mixing paid and unpaid work and family responsibilities at different stages of their careers.

2. *Continuous training is provided to workers across all occupations in production supply chains (managers, engineers, supervisors, production employees, temporary and contract workers and independent contractors) to prepare them adequately to engage and work with new technologies before these technologies are introduced into their workplaces.*

Three points dominate in contemporary discussions of the most effective techniques in regards to training and workforce development for the incumbent workforce. First, training and development will need to continue throughout one's career as technologies and work arrangements continue to change. This applies to all segments of the workforce and is particularly relevant for those in engineering and related technical occupations in which production systems experience the most rapid changes. There is evidence that a high number of engineers in computer science and other highly specialized fields face skill obsolescence at a more rapid rate than those in less technically specialized occupations.[9] Second, training in new technologies and ways of work needs to be provided before major disruptions – the introduction of new technologies or transformations in work processes – occur. Third, given trends in global and domestic outsourcing and the rise of global supply chains, training has to be provided to all workers in a firm and industry supply chain, not just those employed directly by original equipment manufacturing firms that purchase components from contractors and suppliers.

We pose the following questions to leaders around the world:

1. How much does your firm invest in continuous workforce training?

2. Who in your firm and in your supply chain has access to training and what are the rates of take-up from those with access to training?

3. What skills are most important and most in need of further development in your firm and supply chain? What is the best mix of behavioural (e.g. communications, problem-solving, teamwork etc.) and technical skills to provide workers with the "agility" to adapt to changing technologies and other potential disruptions?

4. What other organizations do you work with to provide training (e.g. other firms in your industry or region, educational institutions, suppliers, vendors of new technologies, labour organizations, government agencies, etc.)?

Ford Otosan describes its training programmes for suppliers as follows:

Alongside the training provided for our employees, we train our suppliers regularly in 25 different topics. We evaluate the efficiency of each training module by examining the attendees before and after completion. In addition, we educate our suppliers about the Fourth Industrial Revolution by first assessing their knowledge and inviting them to send their employees for technical plant tours to expand their awareness. Through these tours, we aim to include all our manufacturers in our industrial change and training programmes.

ROLD, a medium-sized manufacturer in Italy, is a "Lighthouse" organization cited by the World Economic Forum for its leadership. A concrete example of the digitization strategy at ROLD is found in its new digital information and production monitoring system known as SmartFab.

SmartFab's digital interface is highly intuitive, using touch monitors and smartwatches to draw on workers' experiences with similar devices in their lives outside the factory. It was developed with continuous contributions from factory supervisors, managers and manufacturing engineers. Having support from those who use it every day is a major reason for the success of SmartFab.

SmartFab is still undergoing continuous improvement, but one concept never changes: simplifying sense-making at the shop floor (i.e. information is sent to workers independently wherever they are located instead of requiring them to be at their machines to monitor performance). The objective data generated via SmartFab applications augment the tacit knowledge and experience of the workforce and thereby improve decision-making.

ROLD has trained more than 160 operators, not only in the use of the platform but also in how to access the greatest benefits from it by managing and sharing the information it provides for monitoring the performance of the machines in their work units. SmartFab is used by everyone: operators, supervisors and managers. Its success is closely linked to the fact that all users, both workers and managers, were involved in the initial definition of user requirements and functionalities of the system and in testing it before final deployment, thus helping shape it to meet their needs.

Training in ROLD is carried out extensively, focusing on both technical skills and soft skills for workers in collaboration with union representatives and HR staff. Augmenting the soft skills of workers means introducing courses on collaboration, teamworking and creativity. Professors from top business schools and technical universities have been enlisted to teach these topics to classes of workers in the factory. The combination of traditional teaching with practical approaches leads to a progressive empowerment of workers.

Gearbox is an innovative non-profit incubator and training programme in Nairobi, Kenya, that provides informal-sector artisans (jua kali) with the opportunity to learn how to use advanced production tools such as 3D printers and advanced plasma cutting machines to design, prototype and manufacture their inventions.

In partnership with the Kenya Commercial Bank Foundation (KCBF), Gearbox is playing a vital role in developing Kenya's base of middle-skill workers. The non-profit is currently training 250 jua kali artisans in metalwork and carpentry in Nairobi's Kamkunji area, acquainting them with the technology, methods and outlook consistent with the Fourth Industrial Revolution, all while maintaining jua kali artisans' current manufacturing methods. Indeed, the technical training will revolve around machines built and designed by Kenyans.

Ultimately, Gearbox is striving to link high-demand occupations and skills with market demand. For example, Gearbox in partnership with Africa Innovation Ecosystems Group is seeking to ensure that jua kali artisans, after training, will be linked to markets through the government's Big 4 Agenda. This will begin specifically with its "Affordable Housing" pillar, which plans to provide 700,000 new low-income housing units.

Tata Steel Kalinganagar (TSK) has developed a highly sophisticated training strategy as part of its aspiration to transform the company into what it calls a "self-sustaining digital organization".

TSK believes digital will become a "way of life" and crucial to all transformations in the coming years: To ensure that it has the necessary human resources, it has developed a three-pronged integrative approach for capability-building using a combination of academies, experiential learning on projects and self-learning modules.

To date, more than 120 employees have completed a 10-week advanced analytics academy led by 16 global experts. Participants include employees from all levels of the organization, from senior management to production workers, who move through a three-step certification process (learner, practitioner and master) to become certified as data scientists, data engineers or champions, depending on their level in the organization (see Figure 4 below).

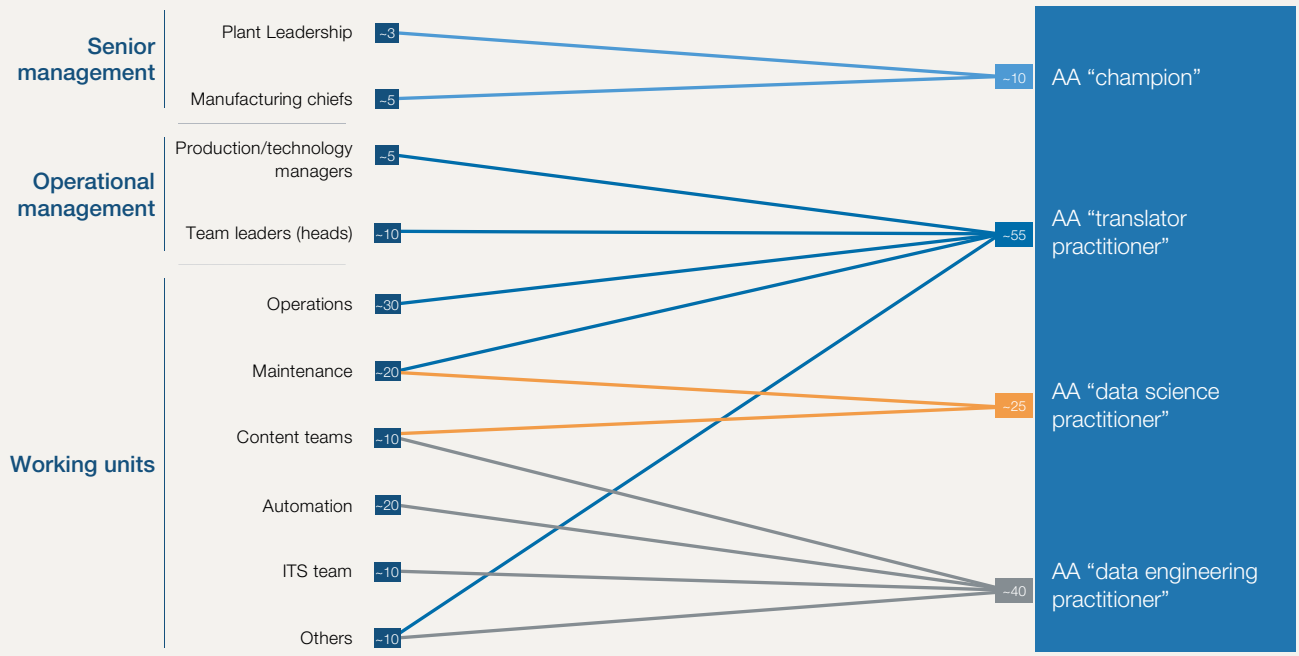
Academy-trained employees are now leading projects in Tata Steel to polish their skills under the guidance of experts. Analytics team meetings, refresher sessions enabled by industry experts and ongoing partnerships with academic institutes will enable their transition to masters and then practitioners.

Another approach is to provide individual workers with a "right to training" as illustrated in this example of a collective bargaining agreement in Italy.[10]

An "Individual Right to Training" was introduced in the 2016 national-level collective bargaining agreement of the Italian metalworkers' union FIM-CISL and the employers' associations Federmeccanica and Assistal. Employers are required to provide their employees with a minimum of 24 hours of training over three years or a stipend of 300 euros for training programmes is available to workers from sources outside the firm.

In 2016, Apple launched Everyone Can Code, a free and comprehensive programme and curriculum to help students from kindergarten to college and beyond learn coding to solve problems and prepare them for the workforce. The programme is intended to teach critical skills for jobs in some of the fastest-growing sectors. With teacher guides and lessons, students learn the basics on iPad with Swift Playgrounds, which uses real code to solve puzzles and control characters. App Development with Swift helps aspiring app developers build their first iOS apps. Today, more than 5,000 schools, community colleges and technical colleges worldwide are using the Everyone Can Code curriculum.

Figure 4: More than 130 practitioners have trained across TSK via the Advanced Analytics ("AA") Academy



AA certification

130+ TSK employees trained over two Academy sessions

32 high performers certified as learners (11 Gold & 21 Silver)

20 of them currently engaged across different projects as practitioners

As textile and apparel manufacturing is considered to be one of the sectors most at risk of being automated, with simple garment production projected to be fully automated by 2025,[11] Esquel is putting its efforts into upskilling workers to become technicians. Since 2015, it has teamed up with local universities in China to design diploma programmes for aspiring workers who seek higher education. The curricula, including streams in business administration, mechanical and electronic engineering and automation, are all specifically designed to prepare workers for the future of manufacturing. As of 2018, 1,250 workers, many of whom were sewing workers, have enrolled in the scheme. The first class of 260 have graduated with full sponsorship.

To support workforces using mobile technology, Esquel launched the "You Can Code" campaign in 2016. The campaign introduced "App Inventor" – a programming tool developed by the Massachusetts Institute of Technology (MIT) – to workers who were from less technology-savvy communities, teaching them how to develop basic yet fully functional mobile apps through a simple graphical interface. The campaign's main objective was to help workers build their self-confidence when dealing with technology. It also set out to upskill workers and expand their capabilities in logical reasoning, programming and computational thinking, preparing them to become innovators, problem-solvers, collaborators and process owners in their workplace.

The campaign was well received and launched a number of self-developed mobile apps that fitted the daily needs of the employees. Examples include a safety app for women, designed by a Sri Lankan employee to provide a GPS tracking function for female workers commuting late at night; and a recruitment app for human resources departments to handle online personnel data entries.

The most successful and widely used mobile app developed by Esquel employees is Esquel Carpool. Available to more than 23,000 employees in Esquel's largest production facility in Gaoming, the app addresses multiple issues such as duration of commutes, real-time public transport updates and availability of parking spaces at factories. Within the first 22 months, the app accommodated more than 75,000 carpool requests, which could be translated to reductions in consumption of 57,000 litres of petrol and emissions of carbon dioxide by over 130 tons. The app inspired employees to contribute to a more sustainable lifestyle.

These examples illustrate the growing recognition that those already in the workforce – experienced workers – can adapt to new production technologies if given the opportunity to do so before the new tools, processes and systems are introduced. The key is to provide training in both technical literacies and the social/behavioural skills needed to work with advancing technologies, both individually and in project teams. By providing advanced training in technical and social skills, organizations can ensure that their workforces are well prepared to apply the philosophy embraced by Toyota and other Japanese firms when they introduced new technology into the car industry: "It is workers who give wisdom to the machines."

3. Workers, as defined above to include all occupations in the production supply chain, are enabled to engage and contribute as partners in the design and deployment of new technologies.

There is long-standing evidence that the greatest returns to investment in new production technologies are realized when workers and their representatives are engaged early in the planning, design and implementation of new systems. This was first demonstrated with the introduction of the Toyota Production System into global automobile operations in the 1980s and 1990s.[12] The inverse was also illustrated when Tesla announced in 2018 that it intended to operate the most highly automated auto assembly line ever created, only to fail in meeting production goals for its model 3.0 vehicle. Chief executive officer Elon Musk famously later admitted that he "underrated" the importance of the human factor and had to bring in extra workers to address production shortfalls.[13]

Negative experiences like this are still all too common because successful production techniques require the sharing of data and responsibilities with workers that employers and engineers may view as either proprietary or restricted information.

Figure 3 summarizes two approaches to these issues: a traditional sequential approach in which technology design and decision-making precede considerations of workforce or work-system issues; and a more integrative technology and work-system design and deployment process.

We pose the following questions to leaders around the world:

1. At what stage in the design and implementation of new production technologies are plans shared with workers and/or their representatives? How is this done?

2. What have been the experiences (positive and/or negative) of sharing information and/or engaging workers and worker representatives in technological planning, decision-making and implementation?

3. What role do HR executives and staff play in the planning, decision-making and implementation of technological change?

4. What are the obstacles to shifting from a sequential to an integrated strategy?

A recent and ongoing example of extensive and early engagement of workers, unions and works council representatives was provided by employer and union leaders at the Daimler Truck Corporation in Germany. They reported on their processes of engagement at a workshop held at MIT in September 2019 by describing how their formal institutional structures of co-determination, works councils and union representation work in practice.[14]

Michael Brecht, the chairman of the Daimler Trucks Works Council and deputy chairman of the company's supervisory board, stressed the relevance of mutual trust and communication, which he declared as essential for his task of effectively representing workers' interests in collaboration with the company. In turn, Daimler Truck's head of human resources, Juergen Hartwig, stressed that the key to making co-determination effective is to seek cooperation at three levels of the employment relationship:

- At the supervisory board, where just under half of companies' supervisory boards' members are representatives of the workforce.

– At the works council level, where leaders elected by the workforce consult on human resource and employment policies and practices, often trained by German trade unions.

– At the workplace-personal level, where workers, supervisors and union leaders interact, learn about higher-level decisions and offer their own advice and input into workplace practices.

Another way to engage workers and plant-level managers is to offer funding for "bottom-up" ideas for innovation. For example, the German metalworkers' union IG Metall has negotiated a "Pact for the Future"[15] with Schaeffler, a major German car parts supplier. The union hopes to use this as a model for other suppliers in this sector. It calls for application of co-determination principles and consultation with the works councils to the digitization process within all of its plants, and created a €50 million fund to finance development and implementation of employees' ideas for innovation in production processes.

An even larger example of a "bottom-up" strategy is provided by Siemens Corporation in Germany. In May 2018, Siemens Corporation and its works council created a Fund for the Future to finance qualification projects in Germany:[16]

– Between 2018 and 2022, Siemens will provide up to €100 million for such projects, in addition to the company's regular annual budget of around €500 million for training and continuing education.

– Managers and works council leaders in specific facilities can apply to a company-level committee composed of managers and works council members to support learning opportunities.

Another German example illustrates the proactive role workers and their union can play in the design of new technology.

From 2014 to 2016, IG Metall worked with a multistakeholder partnership of research centres and employers' associations with funding from the Federal Ministry of Economic Affairs and Energy to develop a digital tool called "Appsist".[17] Appsist is a data analytic tool that supports simulations with augmented and virtual reality technologies and produces data to help workers and managers control and assess production and work processes. Involvement of workers and union officials in the design of this tool gave them a full understanding of how it would be used in practice and how the workforce could be prepared to use it.[18]

While European countries with industry-wide collective bargaining, works councils and/or worker representation on supervisory boards have structures that support and engage with workers and their representatives, some labour management partnerships in the US also follow this practice. While there is no legal mandate in the US to engage workers in upfront technology design choices and processes, this has taken place in a number of settings where companies and unions have previously implemented innovative production practices and work-system advances. This is the case at Ford Motor's Cleveland, Ohio, engine plant, where the company and the United Automobile Workers Union (UAW) and the International Brotherhood of Electrical Workers (IBEW) have long histories of working partnerships. This plant was a pioneer in the development of what is now termed the Ford Production System, a flexible, team-based system designed to support lean production practices. Working together, management and labour leaders developed a work system that provides significant cross-training and employee involvement in problem-solving, thereby laying a solid foundation for process innovations, technological changes and new product launches as they arise.

A labour-management team recently described how they adapted practices to support the launch of several different versions of the "Eco-Boost" engine used by several popular models of Ford's cars and trucks,[19]

There are four training methods that the Cleveland Engine Plant implemented in launching its newest engine: work simulation, engine familiarization, virtual OIS and OJT (on-the-job training).

Work simulation, virtual OIS and engine familiarization involve:

– Two days of training in a simulated production environment. Employees are first educated about the proposed build process and alerted to a number of critical processes and parts. They then build an entire engine in the static position while tests, before and after, assess their learning. Employees leave this stage of the process with a deeper understanding of the function of all parts of an engine.

– OJT (on-the-job training). Individuals are then paired with certified operators to deliver training on the floor in a production setting where they work on meeting time goals in live production processes. As they move across jobs in their team area, employees become certified at each workstation. There are four levels of certification.

Ford has also started to pilot computer-based virtual training. Cleveland was a pilot for the programme using computer animation prior to actual engagement in production. This was followed by working on a live production process to progress through the same four levels mentioned above. Throughout the development of the virtual training process, production workers made suggestions for improvements. Once the process was finalized and launched at the Cleveland plant, it was distributed to other Ford production facilities. The Cleveland plant won Ford's award for technical excellence for its work in developing and piloting these systems.

A number of firms, such as Tulip Interfaces, are developing information and data management tools to support workers working with advanced technologies. For example:[20]

- Nautique Boat Company uses a data management tool developed by Tulip to provide real-time targeted feedback to its operators. By guiding work with apps, operators collect live-cycle time data, which lets them see how their individual performance compares with the target cycle time. With that data, they coach underperformers to help them improve their productivity. Those experiencing difficulties meeting the targets can get assistance by observing what those exceeding the targets are doing, and this information can then inform the development of more standardized operating procedures/practices.

- Dentsply Sirona, the world's largest dental implant manufacturer, reduced training times by 75% by using manufacturing apps that train employees on the spot and let them acquire new skills on demand. Furthermore, they were able to enable high-mix low-volume operations in which operators fulfil highly customized orders (with more than 1 billion combinations). Using apps that connect with internet of things (IoT) sensors to guide their work, they have almost completely eliminated human error from their shipping line.

- Using manufacturing apps to guide operators, Jabil increased throughput by 50% and production yield by 10%. Furthermore, they reduced manual assembly quality issues by 60%.

Another example of how workers without highly specialized skills and backgrounds can be trained in using robotics and can help develop new technological solutions and designs is to be found in the Georgia Institute of Technology's Robotarium.[21]

The Robotarium facility is located on the Georgia Tech campus. It provides off-campus researchers, educators and students with remote access to robotic systems that allow for rapid prototyping and testing of novel designs without users incurring the prohibitively high costs associated with developing and maintaining their own robotics facility. At the same time, the system can be accessed and controlled at different levels of abstraction by users with varying degrees of expertise. Such a model could be scaled up across a number of technological platforms to help workers to contribute in the design and deployment of new technologies.

The process of denim finishing has traditionally been extremely complex, using many chemical formulations, manual processes and excessive water consumption in bulk production. Hirdaramani has collaborated with Jeanologia (a leader in eco-friendly technology solutions for the denim industry) and leading brands such as Levi's and Uniqlo to develop a new operating model using laser technology to digitally finish denim jeans. This system significantly reduces the chemicals, processes and time required to process jeans while employing Fourth Industrial Revolution technologies to offer customized and personalized products to end consumers.

To effectively lead change in the industry, Hirdaramani put workforce training at the centre of its drive to implement these new technologies. The group has partnered with Jeanologia and its customers to retrain employees in software development, laser pattern-making and sustainable washing techniques, conducting training programmes in California, Valencia, Bangladesh and Sri Lanka. Once the employees involved in sampling and pre-production were trained, the group formulated a "train the trainer programme" to enable it to scale the use of these technologies across its seven denim-washing plants in Bangladesh and Sri Lanka.

These examples illustrate a variety of innovative ways to combine training of production workers, technicians and engineers in using advanced technologies with opportunities to influence how these technologies can be best adapted to different work settings and production environments. The key is to lay a solid foundation of workforce training and have a culture of worker and management collaboration and engagement before the new production systems are implemented.

4. *Retraining opportunities in advanced manufacturing are provided to workers who wish to re-enter the workforce after taking time out to care for family or other responsibilities, to transition from military service to civilian occupations or to take advantage of educational programmes that support lifelong learning.*

The contemporary workforce is highly diverse, yet production jobs are traditionally viewed as a male environment. If this is to change significantly in the years ahead, training and development opportunities will need to be better tailored to both women and men who take time out of the workforce to care for family members, to further their education and training or for other reasons such as military service.

We pose the following questions to leaders around the world:

1. What is the current gender composition of your production workforce and your industry?

2. What do you see as the major obstacles to recruiting and retaining a diverse workforce in production jobs in your firm/industry?

3. Are there established benchmarks for effective methodologies in recruiting and retaining women, people with disabilities and other previously under-represented groups in production jobs in your industry?

4. What training and/or other accommodations does your firm, industry or government provide to support those who take time out of regular employment to attend to personal or family responsibilities?

Several of the Manufacturing USA institutes funded by the federal government have developed retraining programmes in cooperation with the military to support veterans as they transition back into the civilian workforce. One example is the programme developed by the Lightweight Innovations for Tomorrow (LIFT) Institute.

Operation Next is a programme sponsored by LIFT to equip military personnel in the process of returning to civilian life with the skills and credentials needed for the most in-demand advanced manufacturing civilian careers in the US. Operation Next sets participants on a fast track to in-demand machining and industrial technology maintenance careers. The hybrid virtual and lab-based programme gives participants credit for what they already know, delivers focused training on the additional technical skills needed and provides participants with nationally portable credentials that prove to any employer they are ready for the job. Participants enter the programme while in military service so that they are prepared on leaving for jobs in advanced manufacturing.[22]

A number of staffing companies such as ManpowerGroup have also developed partnerships with manufacturing companies such as Rockwell Corporation and clients that purchase Rockwell's automation systems to train and place US military veterans in jobs that use advanced manufacturing tools and processes.

Rockwell Automation in partnership with the ManpowerGroup has an Academy of Advanced Manufacturing for Veterans. Rockwell clients pay for the 12-week course. They have a goal of training 1,000 veterans in advanced manufacturing roles, instrumentation and automation using Rockwell Automation tools. When the veterans graduate, they are certified to work as a technician in several different areas.

Rockwell notes that the programme is quite rigorous, requiring considerable time and personal investment from participants. It also notes that: "It's working – with a 95% graduation rate in all classes so far."

A variety of non-profit and some for-profit organizations work with small and large companies in the US to offer retraining and internship programmes for women re-entering the workforce. For example, the Society of Women Engineers' STEM Reentry Task Force partners with the re-entry firm iRelaunch to provide women re-entering the workforce with retraining for technical careers.[23]

Other consulting and/or staffing firms have developed similar programmes to help women re-enter the workforce after taking time to shoulder family responsibilities. One example is provided by Encore, a programme developed by the consulting firm Deloitte.[24] Encore is a paid programme that eases the transition back into the workforce and typically runs for three to four months. Participants are assigned to a client and have access to Deloitte's innovative leader development curriculum. Deloitte professionals serve as mentors and help the participants network and make the most of their resources.

To date, however, these programmes are mostly focused on women with advanced educational degrees, and placements are most often in professional service industries. Manufacturing firms can learn from these experiences and build programmes that similarly take advantage of this often underused source of talent.

The German metalworkers' union IG Metall and a number of German metalworking companies have gone a step further by negotiating agreements that allow workers to take time off or reduce their working hours sufficiently to obtain the training needed to update or expand their skills in ways that qualify them for new jobs.

Individual workers, in consultation with their works council, have the right to request a "qualification interview" with their employer to determine if they need additional training. If the employer agrees that new qualifications are needed, employees can change their working hours to an "educational part-time" status that may extend to up to seven years.[25] During that time the costs of training are shared by the employer and the worker.

As more workers experience the need to develop new or refresh existing skills at various points in their careers, colleges and universities will need to transform from four-year programmes that primarily serve students before they enter the workforce to institutions that offer refresher continuing education and training (CET) courses that support transitions for experienced workers. The National University of Singapore (NUS) is in the process of doing so, with CET an integral part of students' education and personal development and a means to ensure that they remain competitive.[26]

NUS's recently established School of Continuing and Lifelong Education (SCALE) works with all NUS faculties and schools to aggregate and contribute to CET capabilities by expanding course offerings, degree and certificate options and partner relationships. Through SCALE, NUS offers courses that are contemporary, skills-based and industry-relevant on topics such as data analytics, cybersecurity, entrepreneurship and advanced manufacturing.[27] Together with NUS faculties of engineering, science, systems science and computing, SCALE has also introduced the Master of Science (MSc) in the Fourth Industrial Revolution.[28]

NUS also recently launched All-You-Can-Learn (AYCL), a fixed-fee programme that offers a semi-customized CET catalogue to corporate clients for skills-based modular courses and postgraduate modular courses.

Financial support from Singapore's Ministry of Education is available to Singaporean citizens and permanent residents for many CET courses.[29] Course content is guided by the Industry Transformation Maps (ITM) published by Ministry of Trade and Industry[30] and the supporting Skills Frameworks published by SkillsFuture Singapore under the Ministry of Education.[31]

CET students have the option to stack selected courses into qualifications such as graduate diplomas, or even Master's degrees. Short courses run from one to five days, while modular courses meet weekly over a 13-week period (which corresponds to 39 contact hours and translates into a four-credit module). Classes are typically in the evenings or at the weekend to meet the needs of working adults. Instruction is by research and the teaching faculty, as well as by industry experts.

This supply of university-based lifelong learning programmes will need to expand considerably in all regions of the globe to meet what is likely to be a growing demand for up-to-date education.

5. Workers who are displaced by new technologies are provided with the opportunities and income support needed to move to new jobs without incurring a substantial loss of income or are otherwise compensated for their loss of work.

All significant epochs of technological change – e.g. prior industrial revolutions – have resulted in a significant creation of new job opportunities as well as a significant loss of income and job security among displaced workers. There is every reason to believe many workers will experience the same risks and losses as technologies and production systems continue to advance. Yet the safety nets available to compensate and protect those displaced by changing technologies vary widely across countries and industries. To avoid the anger, fear and frustration experienced around the world in recent years as globalization and related developments have increased divisions in the labour market, substantial expansion and deepening of the social supports for displaced workers will be required.

We pose the following questions to leaders around the world:

1. Which workers in your organization and industry are most at risk from job displacement as technologies advance?

2. What other jobs are those at risk prepared to transition to if displaced? Are these workers ready/able to take up the new jobs likely to be created? What will be the likely income effects of these job transitions?

3. What transition assistance and income replacement options are available to displaced workers in your country, industry and business? What have been the labour market experiences and outcomes for workers who have been displaced?

4. To what extent is your organization engaged in working with local and/or national-level governments to address the needs of displaced workers?

One of the best known examples of a comprehensive adjustment strategy initiated by a private-sector firm is that of the Nokia Corporation.

When faced with significant decline in market share in its cellular technology business, the company announced a major restructuring initiative that would involve layoffs of large numbers of workers in its home country of Finland and internationally. To manage these dislocations, it implemented a "Bridge" programme that provided affected employees with five options:

1. Find another job within the company. In facilities that were not entirely closed, employees were given information on the requirements of the jobs that would remain. A selection committee reviewed and selected applicants for the open positions.

2. Find another job outside the company. Those who chose this option were provided with career counselling, résumé writing assistance and support in using private job-matching firms such as LinkedIn and government employment service agencies.

3. Start a new business. The Bridge programme offered grants to employees wishing to start a new business either by building on the work they were performing at Nokia or an entirely new business venture. Support was also provided via mentors to create business plans, help with networking etc.

4. Learn something new. Displaced workers could apply for funds to support enrolment in training programmes for careers of their choice.

5. Create their own plan. Financial support was also available to those choosing to leave the workforce for volunteer work or early retirement.

More than 80% of eligible employees participated in one or more of these programme options. Some 85% of participants in Finland and two-thirds of those outside of Finland were satisfied with the programme.[32]

While businesses facing significant restructuring need to invest in proactive and comprehensive programmes such as Nokia's Bridge scheme, the private sector cannot manage the full scale of disruptions that are likely to lie ahead. Proactive and comprehensive government policies are needed to support and supplement private-sector initiatives.

Singapore is one of the leading countries in anticipating and avoiding large-scale worker displacement as it adapts its workforce to changing technologies. The government encourages and supports tripartite discussions about sustaining its position as a centre of innovation in Asia with a high-productivity, high-wage economy. For example, working with industry and workforce representatives, Singapore's government has put in place more than 20 industry transformation maps (ITMs), each encompassing specific plans to promote productivity and innovation with a special focus on digitization. These ITMs also identify skills-gap measures to future-proof the workforce.

Through a related government-funded programme called SkillsFuture, jobseekers and workers in every sector have access to a customized framework to guide them as they advance in their careers. Each citizen is given a $500 voucher annually to use to take online courses to learn skills needed in the changing world of work.

Sweden provides an example of a labour-industry-government collaborative approach to provide transition assistance to workers before large-scale disruptions occur. The 2004 collective bargaining agreement between the Swedish Labour Confederation and the Confederation of Swedish Enterprises created a jointly administered employment transition fund[33] that allows workers to apply for financial support for retraining, starting new businesses or searching for new jobs when large-scale restructurings were anticipated or had taken place. The ETF is one of 10 job security councils established by the "social partners" (industry, labour and government) to support employees affected by industrial restructuring.[34]

Currently, Bangladesh's garment industry employs 4.4 million workers, of which 80% are women. However, the country is known for low-end manufacturing and "fast fashion". Since the pattern of consumption is changing, Bangladesh needs to focus on increasing the value and diversity of its exports. To do so successfully will require substantial upskilling of the nation's workforce. As an example, the Mohammadi Group is providing educational opportunities for garment workers to be trained for managerial positions via its Pathways for Promise programme. The programme identifies highly talented women with limited opportunities and supports them in taking courses at the Asian University for Women, Chittagong, that can lead to an undergraduate degree. There are currently 100 workers enrolled in the programme.

These examples illustrate the importance of having strong private-sector, education and government programmes to aid the transition of workers to new opportunities and to compensate those experiencing the greatest long-term losses of income due to the digital transformation of the manufacturing industry.

6. The above efforts are informed by, and fully employ, the growing number of data systems and organizations available for matching worker skills with growing job opportunities.

A growing number of labour market matching tools and organizations have emerged in recent years that support workers and firms in identifying and matching worker skills to job opportunities. Some of these have become household names such as LinkedIn; Burning Glass, Gearbox, Indeed etc. Others are emerging to focus directly on the needs of lower-wage workers such as Jobcase while the likes of Syndio focus on ensuring gender equity and transparency in accessing jobs and compensation systems.

We pose the following questions to leaders around the world:

1. Are data systems and organizations available in your industry to provide information and access to job applicants and job openings? How widespread are these tools and organizations, and to what extent does your organization engage/use them to fill production job openings?

2. What are the advantages and disadvantages in using these intermediaries in your recruiting and staffing practices?

3. To what extent do these emerging organizations balance the interests of prospective job applicants with the interests of employers?

4. How does your organization assess the skills of your current workforce and match them to skills needed in jobs in high or growing demand?

The community-wide lifelong learning programme in South Bend, Indiana, mentioned to illustrate Principle 1, is another example of using advanced social media, online apps and data services to connect people to job opportunities in the local labour market. According to the Drucker Institute:

"The platform will provide timely local labor market data to help users figure out how much different occupations actually pay, which employers are hiring, what skills are needed to obtain a particular position and which jobs are most in demand today – and are most likely to be in demand tomorrow."[35]

Specialized "career collections" will be recommended to local residents that personalize the learning opportunities available to equip them with the skills required by the fastest-growing sectors in the region.

The Kenya incubator Gearbox (see above) provides another example of using networks and social media to link potential production entrepreneurs and informal artisans to promote market opportunities.

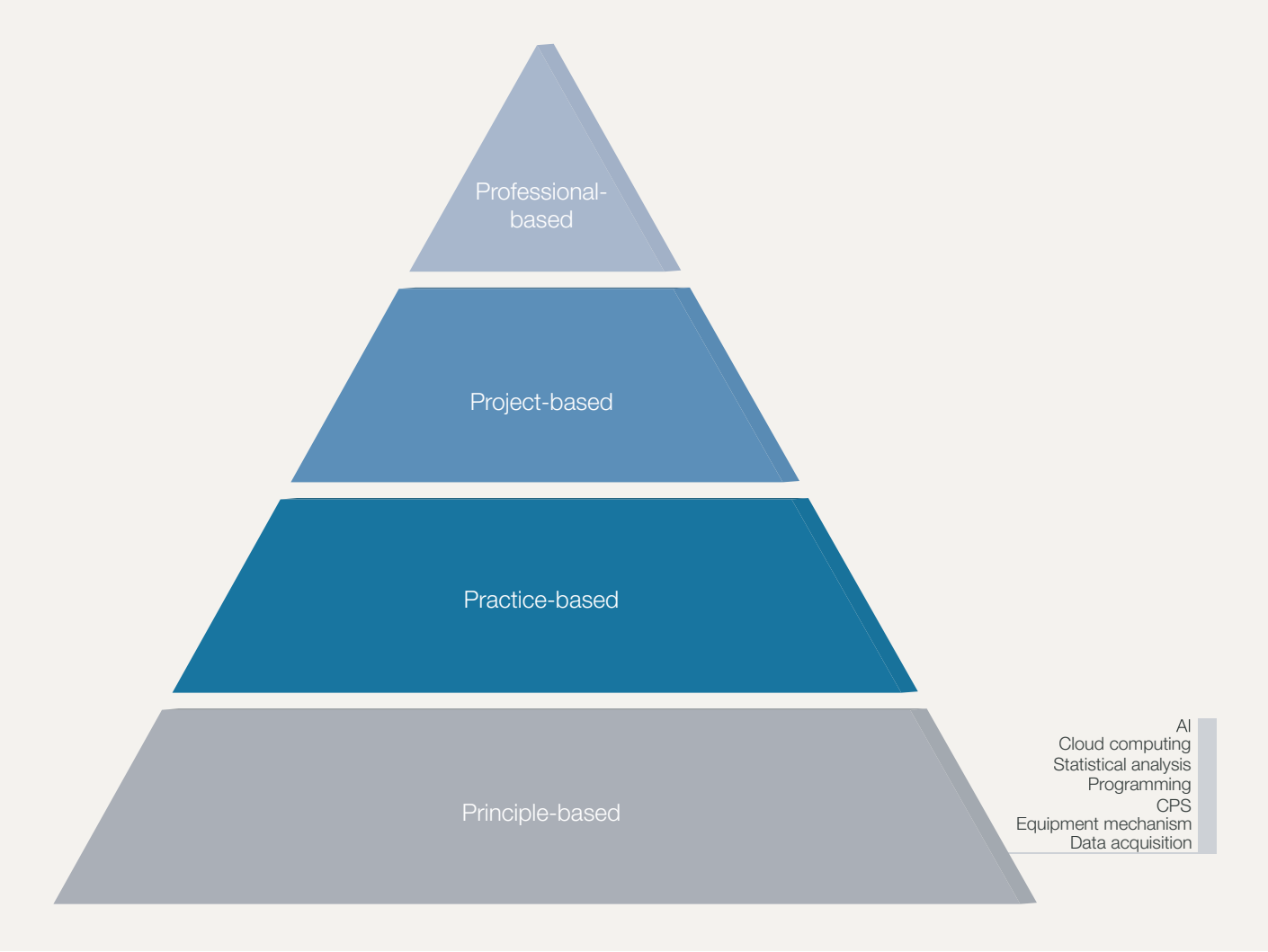
Gearbox maintains close relationships with various universities in the country, ensuring that the platform is known to students. This way, a pipeline of entrepreneurs and informal artisans suited to Gearbox's services is established.

Gearbox also participates in workshops, panels and events and hosts its own events in order to maintain a presence in the innovation environment. This in turn provides opportunities for networking with inventors, entrepreneurs and other manufacturers who would benefit from Gearbox's services.

Summary

The “4P” (principles, practice, project and professional-based learning) framework (see Figure 5 below)[36] for training manufacturing workers of the future serves as a useful summary of how the different learning strategies discussed in this report can be combined to form an integrated learning system. In principle-based learning, attention is paid to teaching foundational concepts and/or tools such as cultivating, algorithm theory, industrial knowledge and modelling tools. In practice-based learning, students use problems and industry data to solve a clearly defined real-world challenge. In project-based learning, students need to address problems using real-world issues. In professional-based learning, students need to cultivate the ability to discover and define problems in complex systems, to design large-scale schemes and systems and to lead teams to complete system development and implementation challenges. By combining or building on these different approaches, workers can gradually grow into industry-oriented leaders and become professional.

Figure 5: The 4P framework



Next steps

The full benefits of the Fourth Industrial Revolution can be realized and broadly shared only if the workforce is provided with adequate opportunities for continuous training and is fully engaged in the processes of designing and implementing advanced manufacturing technologies and changing work systems. This will require new forms of collaboration from business, labour, education and government stakeholders.

We call for these six guiding principles to support the creation of international standards for lifelong learning and worker engagement in advanced manufacturing. The examples provide evidence of how some of these stakeholders are already working to manage the transformations in technology and work in this integrated fashion.

We encourage organizations participating in the World Economic Forum's Platform for Shaping the Future of Advanced Manufacturing and Production to continue providing examples that help deepen our understanding of how these principles are being put to work in production processes around the globe. Doing so will help to build a well-informed consensus and broad support for establishing these principles as a new international standard for lifelong learning and worker engagement.

Our hope is that this will serve as a valuable input for discussion at the World Economic Forum Annual Meeting 2020 in Davos and that participants endorse these principles as a new global standard for lifelong learning and worker engagement in production in the digital age.

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