



WORKING IN INDUSTRY 4.0

IPS Seminar on Human Capital Needs in Industry 4.0 Report

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ABOUT IPS

The Institute of Policy Studies (IPS) was established in 1988 as an independent think tank to study and generate public policy ideas in Singapore. IPS became an autonomous research centre of the Lee Kuan Yew School of Public Policy at the National University of Singapore in 2008.

Today, IPS continues to analyse public policy, build bridges between thought leaders, and communicate its findings to a wide audience. The Institute examines issues of critical national interest across a variety of fields, and studies the attitudes and aspirations of Singaporeans through surveys of public perception. It adopts a multi-disciplinary approach in its analyses and takes the long-term view in its strategic deliberation and research.

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FOREWORD

On 17 July 2019, the Institute of Policy Studies hosted a closed-door seminar titled Human Capital Development in Industry 4.0 as part of our extensive research into the future of work. This seminar, held under Chatham House Rule, brought together business leaders, policymakers and educators to answer a fundamental question; what is the future of work in Singapore? The dynamic changes of Industry 4.0 will inevitably disrupt our existing understanding of work. Artificial intelligence, Internet of Things and data analytics will reshape our way of life and how we work. In addition, in past conversations with business leaders, workers and government officials, we found a disconnect between the interpretation of Industry 4.0 among various stakeholders and the follow up requirements to achieve digital transformation.

We have critically examined and synthesised the feedback we have gotten from the various presentations, past closed-door discussions and research in hopes of providing clarity on Industry 4.0's complex nature. Recommendations were made based on this synthesis to minimise negative impacts of disruption, to strengthen the benefits of Industry 4.0 in order to address the ethical and societal spillover effects of technological disruption and to prepare the workforce and businesses for Industry 4.0.

This report also examined the core ideas of innovation, disruption, failure and adaptability presented throughout the seminar and synthesised these findings with the realities faced by businesses and workers as they technologically transform.

It is hoped that this report will be useful for businesses, workers and policymakers in their respective journeys to reach a deeper understanding of how Industry 4.0 is manifesting itself in Singapore. By having a meaningful understanding of this Industry 4.0 phenomenon, businesses and workers could possibly find new opportunities, facilitated by well-crafted policies and regulations. This would also provide greater clarity for various stakeholders involved in the transformation efforts of Industry 4.0 in Singapore.

We would like to thank our fellow futurists from Infocomm Media Development Authority; Economic Development Board; Association of Small and Medium Enterprises; Singapore Polytechnic; Singapore Institute of Technology; Institute for Adult Learning; Singapore National Eye Centre; Curtin Singapore; Greenology; Mohan Management Consultants Pte Ltd; Spark Systems Pte Ltd; Adecco Group X APAC; Human Capital (Singapore) Pte Ltd; and IBM, for sharing their views and insights into Industry 4.0 and what the future of work might look like.

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PREAMBLE

On 22 November 2018, Minister for Communications and Information, S. Iswaran announced Singapore's plans to become a leading digital economy. To achieve this ambition, the Singapore government unveiled three strategies to build up Singapore's digital capabilities.

First, the Industry Transformation Maps (ITMs) were rolled out in 2017 to enable the digitalisation process among Singapore's twenty-three industries which spans approximately 80 per cent of Singapore's economy. Thereafter, the Industry Digital Plans (IDPs) were rolled out to complement the ITMs and provide roadmaps to industries in their respective journeys.

Second, the government's drive towards the integration of business ecosystems in Singapore. This integration across industrial sectors would enable the creation of new business opportunities, markets and expansion potential for Singapore-based businesses.

Third, the promotion of the Information, Communications and Media (Infocomm) Industry would provide the framework of a digital economy. This requires the nurturing of new skill sets to complement the development of digital businesses that are able to leverage on Singapore's strengths such as connectivity, infrastructure and branding in order to venture into new markets and thrive.

The push for the digital economy is aimed towards creating a new economic landscape in Singapore. This would trigger an evolution of rules and guidelines that would leverage on existing strengths to exploit emerging opportunities. This is likely to pose challenges for both businesses and policymakers as the evolution of traditional industries and the blurring of the inter-industry divisions will force businesses to innovate in new ways to gain an edge over their competitors that will pose challenges to traditional policy tools that themselves have to evolve to keep abreast of the changes and manage them.

To achieve a digital economy, Singapore needs to examine more than just the process of digitalisation. Digitalisation represents but a small, visually obvious segment of the intangible concept of Industry 4.0. Industry 4.0 will bring about creative destruction, greater inter-connectivity between people, machines and ecosystems and innovation in Singapore's economy. It is imperative that businesses, workers and policymakers understand Industry 4.0 in its entirety and the implications on developing human capital and the future of work. The Institute of Policy Studies organised a seminar on 17 July 2019 to bring together business leaders, policymakers, educators, and futurists to discuss these complex issues from a technological and human perspective.

The seminar was framed to take cognisance of technological advances and continued evolution of the business landscape, which has become a key concern for workers and their expectations of continued employment opportunities in the future. In an Industry 4.0 paradigm, businesses are also impacted from their consumers and concerns has arisen over businesses' ability to source for the appropriate skills sets required to meet their business requirements. The seminar provided a platform for participants to have a candid and in-depth discussion to synergise a path towards enabling workers to thrive in a new, digital working environment.



THEME ONE

An introduction to Industry 4.0 in Singapore

AN INTRODUCTION TO INDUSTRY 4.0 IN SINGAPORE



It is important to frame the complex nature of Industry 4.0 in order to understand its dynamics and subsequent impacts on workers and the future of work. This section aims to discuss the background and major Industry 4.0-related trends on the business landscape in Singapore and the government's response to these trends.

It would also include how technology – in particular, digitalisation – has resulted in an evolution of businesses' human capital needs, given that whole industries are evolving due to technological advancements as well. Industry 4.0 will accelerate changes in Singapore's economy. For example hyper-connectivity links and advanced technology would facilitate new business models and new ecosystems that Singaporean businesses would need to learn to adapt and manage.

With workers potentially being displaced in the midst of this evolutionary process, it is pivotal that any discussion on human capital within the context of Industry 4.0 examines the impact on workers as a key theme. Both workers today and new workers in the future will be affected by Industry 4.0. It is therefore important to consider both current trends and future prospects of employment in Industry 4.0.

SINGAPORE'S NEED FOR INDUSTRY 4.0

In Singapore, the focus of digital processes has largely been within the manufacturing industries through concepts such as smart factories although **the concepts of Industry 4.0 can be applied to both manufacturing and services industries.** Manufacturing is an important pillar of the economy and the foundation of Singapore is built upon a strong industrial base. In 2018, EDB estimated that manufacturing contributed approximately 22 per cent of Singapore's Nominal Gross Domestic Product (GDP) and employed approximately 285,000, or 13 per cent, of Singapore's total labour force of 3.4 million (MTI, 2018). A series of business transformations in the manufacturing industry over the past five decades has created a complex, capital and knowledge intensive sector. Today, Singapore remains globally competitive as a high-value manufacturing hub, but it also faces threats from competitors abroad.

At its core, Industry 4.0 aims to create environments where people can operate machines in simple, efficient processes given that these processes are complicated, automated and possibly more sustainable. Industry 4.0 allows the individualisation of customer requirements for their products and services. Order management, product and user experience design, manufacturing and delivery of these products and services are key elements in Industry 4.0.

New business models, technologies and mind-sets such as Internet of Things (IoT), Industry IOT (IIOT), and smart and cloud-based manufacturing are some Industry 4.0 drivers that can help Singapore's manufacturers become more prominent.

A 2017 MCKINSEY STUDY ESTIMATES THAT INDUSTRY 4.0 WILL TRANSFORM AND GROW MANUFACTURING SECTORS GLOBALLY, CREATING UP TO US\$3.7 TRILLION IN VALUE BY 2025.

Within Southeast Asia alone, Singapore's robotised and computerised manufacturing plants are facing competition from low-cost industrial parks in Malaysia, Thailand and Vietnam – the latter hosting several Singaporean manufacturing businesses (Enterprise Singapore, n.d.). Computers and robots, hallmarks of the Third Industrial Revolution in the 1970s, are no longer adequate to provide Singapore's manufacturers an advantage over their competitors.

Despite regional competition, Singapore is geographically advantaged by being in a region that is poised and emerging as a destination for growth and development. Singapore remains a popular destination for start-ups and technology-related businesses within the region, complimenting other destinations such as in Indonesia and Vietnam. Singapore's core strength as an open and connected economy enables these new businesses opportunities to expand. In addition, Singapore has 22 free trade agreements, an unusually high number especially for a city-state. Moreover, an emphasis on Intellectual Property (IP) rights, arbitration, mediation and other advantages such as digital trade, data-friendly policies and geopolitical stability enables businesses to focus more on strategic matters.

REWARDING SKILL SETS IN INDUSTRY 4.0

Strategic thinking requires a higher order of learning and not just knowing and applying, but also analysing, evaluating and then creating. These skill sets are foundational and form the core of business transformation. While not overtly technical, it does require courage to move out of one's comfort zone in order to evaluate and create through an iterative process. One growing concern mentioned by seminar speakers is that when employees upskill or when organisations innovate and in the process create new job scopes for affected employees, there is resistance from their traditionally minded human resource (HR) personnel to accept these changes and restructure the remuneration packages accordingly. As a result, affected employees become disillusioned and leave the organisation.

As remarked by several participants during the seminar, skills certification (e.g., WSQ credentials) in Singapore was not internationally recognised.

The “branding” of such credentials should be driven by industry. For example, if the industry promotes WSQ credentials, then the “branding” and wide acceptance of WSQ within Singapore may eventually lead to international recognition.

Employees on their part should also think about the value of gaining new skill sets because it is not the certification itself that results in them getting a higher pay; rather, it is that how having those skills boosts their relevance in the industry and provides them an edge to perform better in their roles. The enhanced performance is what employees can monetise (i.e., get a higher pay), not the credentials itself. Programmes such as SkillsFuture can provide exposure to new fields and motivate employees to delve deeper into those new areas. Employees need to accept that having a certificate does not equal higher pay. It is how one uses the certificate to improve productivity and innovation that will garner the pay raise.

LEADERSHIP

The role of leadership is critical because the skills needed in Industry 4.0 are different. An organisation's leaders must also be equipped to understand what the disruptions are about and must themselves learn the new skills needed. Leaders are key to business transformation, and they need to have the propensity to learn as well. Business leaders must have a strong grasp of the narratives regarding disruption, and they cannot afford to get the narrative wrong as the actions taken that follow from it will also be ineffective and possibly detrimental to the needs of their respective organisations.

Businesses leaders need to look at their businesses' functions and think about the various possibilities caused by disruption. The beauty of technology today is that these “what if” possibilities can be actualised through ideation, creativity and simulations. One key challenge is our limited imagination when envisioning the future as we are unable to imagine exponential change but rather only incremental change. Focusing only on incremental change is limiting and it is important to also consider the more outlandish visions of the future, anchored by practical realities in order to consider the potential of Industry 4.0.

SPEED OF TRANSFORMATION

Time is always critical and businesses do not have the luxury of time to transform slowly in the face of rapid changes in the business landscape. Businesses have to be sustainable and making profit in this climate. They need to monetise data and focus on having the right skills and talent within their organisations. Technological disruptions have also radically changed the way businesses think and operate. Businesses have higher expectations, demanding instant feedback both for consumers and employees. Business must match these expectations – for example, instead of monthly or weekly sales reports, they need to be able to generate hourly sales reports. In addition, for employees, they must be given instant and continuous feedback on their performances as they now have an “always-on” attitude for their businesses.

**IN INDUSTRY 4.0,
PEOPLE ARE THE
MOST VALUABLE
ASSET FOR ANY
ORGANISATION**

In this climate of rapid disruptions, one key element is having the right talent; therefore, people are the most valuable asset to an organisation. Reskilling and re-tooling staff is important, and businesses need to assist their staff's development in preparation for the future. This also helps to create employee loyalty and to do so, organisations need to constantly engage their staff, using Human Resources technology to provide feedback that is instant and continuous.

Although organisations should provide retraining opportunities where possible, it should be the personal responsibility of employees to keep their skills updated for industry needs. At the individual level, each employee needs to be proactive and adopt a growth mind set. Employees need to inquire what skills are required for them to stay relevant. This is especially critical in terms of upskilling employees. Data can be utilised to provide individualised education or skills-upgrading pathways.

Businesses also need to consider the parallel expectations of a diverse, multi-generational workforce. A multi-generational workforce can be an asset as each generation can learn from one another and they can combine their skills for the betterment of the organisation. Failing which, the intense competition for talent today could result in undervalued employees to leave the organisation.

Industry 4.0 creates an environment of constant changes. Recruitment policies need to be updated as well. A key concern is **the lack of awareness of the difference between tech jobs** (cybersecurity, programming etc) **and tech-infused jobs**. Tech jobs would require specific technology-oriented skills. However, the more common tech-infused jobs may not need four year long degrees in computer science. With today's educational and working environments, graduates and employees from other non-technical fields are often already exposed to technology. With recruitment policies still remaining outdated, employers will continue to struggle to find the right talent, even if the talent is already there. A key recruitment question for companies is if they really need technically trained workers or workers who are comfortable with technology and can learn technical skills easily?

IMDA & EDB: DIGITAL CHAMPIONS

Built on the advantages mentioned, Industry 4.0 is a natural progression for Singapore's industries. Singapore's manufacturers and even service industries are in a prime position to incorporate new technologies, business processes and products into their current business operations. In Singapore, the Infocomm Media Development Authority (IMDA) and the Economic Development Board (EDB) serve as digital champions, supporting industries through digitalisation and transition into Industry 4.0 and utilising the unique Singaporean advantages to facilitate businesses' and workers' transformation.

IMDA

IMDA leads Singapore's digital transformation with infocomm media. To do this, IMDA will develop a dynamic digital economy and a cohesive digital society, driven by an exceptional infocomm media (ICM) ecosystem – by developing talent, strengthening business capabilities, and enhancing Singapore's ICM infrastructure. IMDA also regulates the telecommunications and media sectors to safeguard consumer interests while fostering a pro-business environment, and enhances Singapore's data protection regime through the Personal Data Protection Commission.

As the global digital economy continues evolving, IMDA has identified the increasing importance of data and digital trade flows in Singapore's economy. Business models are beginning to change as a result of technology implementation and the boundaries between industries are blurring. For example, US\$60 trillion in revenues could be redistributed across traditional sectoral boundaries in 2026 (McKinsey, 2018).

New businesses such as Grab are pushing the definitions of a tech business, starting out in the transport sector before branching out into other sectors such as finance with "GrabPay". The development of new business models and ecosystems would present new opportunities as well as challenges to policy as policymakers grapple with new, dynamic industries.

IMDA's push for digitalisation in Singapore's economy is centred upon effective communication between the agency and businesses. The agency has recognised that different industries are digitalising at different speeds and will require varying levels of digital support. However, there is an underlying rising demand from all industries for more workers trained in technology fields or enabling them to operate in an increasingly technology-centric field. The rising cohort intake for science, technology, engineering and mathematics (STEM) courses in institutes of higher learning (IHLs) and more aggressive course entry requirements indicated that the quality of students coming through the pipeline is rising. However, businesses cannot always wait for the pipeline to yield the talent and there is still a need to train those "in flight", i.e., existing workers, and to do a conversion of those in flight to help build the talent capacity.

TeSA | TECHSKILLS ACCELERATOR

An initiative of SkillsFuture

Singapore's Digital Economy requires new mindsets and skills that workers should be equipped with, in the fields of artificial intelligence and data analytics, cybersecurity, cloud native architecture, and many more. The TechSkills Accelerator (TeSA) initiative aims to build and develop a skilled ICT workforce for Singapore's digital economy. TeSA is driven by IMDA, in collaboration with the industry and government agencies such as the SkillsFuture Singapore (SSG) and Workforce Singapore (WSG).

Through TeSA, **workers can stay relevant with in-demand skills** by selecting from a diverse range of training programmes. The training opportunities include structured on-the-job training under the Company-Led Training (CLT) programme, intensive bootcamp training under the Tech Immersion & Placement Programme (TIPP), and short-form courses and certifications subsidised under the Critical Infocomm Technology Resource Programme Plus (CITREP+). Since 2016, more than 81,000 training places have been taken up or committed under TeSA.

In addition, Skills Framework for ICT can be used by employers to develop career maps and articulate job requirements while individuals can use it as a guide to identify key skills required to stay relevant. Training providers can also reference the Framework to develop ICT courses. Over 80 ICT skillsets and more than 100 job roles have been identified in the Framework, including emerging areas such as cyber security, immersive media and data analytics. The refreshed framework will include new tech areas such as AI, 5G, IoT and Data Protection-related job roles and skills, in line with industry needs and trends.

EDB

With IMDA focusing on digitally enabling businesses in Singapore, EDB's role is centred on developing the strategies that enhance Singapore's position as a global centre for business, innovation and talent. Specific to the manufacturing sector, Singapore sees Industry 4.0 as an opportunity to increase the competitiveness of our manufacturing base and uplift our workforce. Agencies such as EDB have provided various tools to help advanced manufacturing businesses harness Industry 4.0 related concepts in a systematic, scalable and effective manner

A key aspect of advanced manufacturing in Industry 4.0 is the rise of cyber-physical systems and dynamic data processing. Operation technologies such as programmable logic controllers, human-machine interfaces, autonomous vehicles, and digital technologies – such as cybersecurity, data analytics and augmented reality – would help accelerate growth and transformation across the entire manufacturing value chain.

#1 TRANSFORMATION OF BASE

- Existing manufacturing facilities to be the best brownfield sites globally, in areas including productivity/efficiency

#2 GROWTH

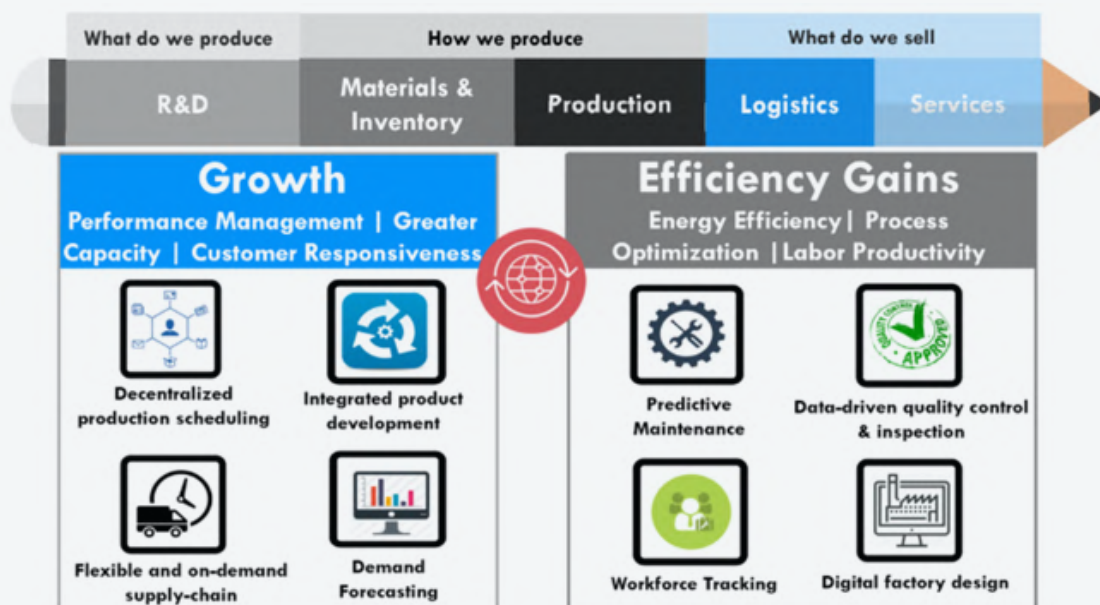
- New product categories and adjacent parts of the value chain
- Creation and export of leading-edge advanced manufacturing (AM) solutions, services and business models

#3 AM-READY TALENT

- Existing engineering talent to be reskilled and upskilled for AM
- Strong pipeline of AM-ready talent
- High quality jobs and pathways for locals

Source: EDB

As presented during the seminar, EDB's role in implementing Industry 4.0 revolution in Singapore's advanced manufacturing (AM) involves the transformation of the manufacturing base, promoting new growth opportunities and ensure that existing workforce are reskilled and upskilled for AM



Source: EDB

As presented during the seminar, EDB's push for Industry 4.0 development in Singapore considers all aspects of the manufacturing process and how businesses can gain from adopting new processes and technologies.

EDB, together with other government agencies, has developed a five-pronged approach to accelerate Industry 4.0's development in Singapore.

1

Industry Transformation Maps (ITMs) to outline key strategies and priorities in areas of jobs and skills, innovation and productivity that sectors require

2

Smart Industry Readiness Index (SIRI) is a suite of frameworks and tools (including the Assessment Matrix and Prioritisation Matrix) to help manufacturers start, scale and sustain their manufacturing transformation journeys. SIRI serves as a common language for industry to understand the different aspects of Industry 4.0 and identify the areas of collaboration.

- The Assessment Matrix serve as diagnostic tool to evaluate manufacturers' current state of Industry 4.0 readiness.
- The Prioritisation Matrix as a second phase is a management planning tool to help businesses architect their implementation roadmap. Comprehensive evaluations of businesses across the 3 core pillars of Process, Technology and Organisation as explained in the SIRI framework is recommended. If the process itself is inefficient, automation and digitalisation will not yield the desired results.
- Organisation: managing the fears of workers and bringing the whole business on board to work together is also important

3

Talent: Skills Future Series for Advanced Manufacturing

- Modular courses aimed at helping the manufacturing workforce to acquire new skills
- Works with the unions and trade associations to create awareness for career pathways and upskilling opportunities

4

Innovation

- Model factories by A*Star to simulate the real-life production environment for test bedding of new manufacturing technologies to mitigate the risks faced by businesses trying to implement new technologies
- National Robotics Programme to look at end-to-end deployment of test-bedding and automation solutions

5

Building a regional Industry 4.0 Community

- Asian edition of Hannover Messe: Industrial Transformation Asia Pacific (ITAP) that aims to be Asia's flagship manufacturing events to showcase their latest technologies and exchange best practices

CRITICAL GAPS TO BE ADDRESSED

Prior to the seminar, discussions were organised with businesses and policymakers to gain insights into their perspectives on Industry 4.0. These discussions surfaced challenges when developing Industry 4.0-oriented policies and activities. The discussions during the seminar reinforced the need to tackle these challenges. Without addressing these challenges or gaps, the effectiveness of policy formulation and implementation could be compromised.

MOST BUSINESSES AND WORKERS ARE STILL IN THE PROCESS OF UNDERSTANDING INDUSTRY 4.0

A fundamental concern revealed during discussions is that **businesses do not understand what is Industry 4.0** and how to start their transformation journeys. This gap in understanding resulted in the adoption of advanced technologies with little emphasis on integrating these technologies into existing workflows among businesses. This misalignment of the needs of the business ecosystem resulted in many businesses adopting technologies that amounted to costly “white elephants” that were visually impressive but added little to businesses’ operational efficiency or effectiveness. While seemingly misplaced, the over emphasis on digitalisation and technology did reveal a critical gap in Singapore’s business environment; most businesses in Singapore continue to struggle in utilising computerisation tools and robotisation, two aspects closely associated with the Third Industrial Revolution.

There is also a clear skills gap which companies need to address in order to utilise new technologies. If workers are unable to utilise existing technologies, it is unlikely that these workers will be able to utilise Industry 4.0-related technologies.

In efforts to counter this trend and promote effective digitalisation among small and medium enterprises (SMEs) in Singapore, IMDA rolled out the SMEs Go Digital programme in 2017 to facilitate the digitalisation journey of SMEs and progress towards Industry 4.0. SMEs Go Digital aims to make going digital simple for SMEs through Industry Digital Plans (IDPs), Pre-Approved Solutions, Digital Consultancy and Digital Project Management Services. Policymakers have deepened their understanding of digitalisation and Industry 4.0, and have recognised that businesses need to be educated and given the right support for success in transformation. Based on IDPs developed in partnership with ITM sector leads, the majority of SMEs are in the early stages of the digitalisation journey. A good number of SMEs have not yet started on the journey, although they are aware of the importance and have the intent to go digital, but find it difficult to digitalise on their own. This possibly explains the greater push by relevant stakeholders to educate, work in partnership with Government initiatives such as SMEs Go Digital, as well as provide opportunities and assistance for business owners to take the first steps in digitalisation and Industry 4.0.

“LEARNING-BY-DOING” CAN HELP POLICYMAKERS

The core ideas of Industry 4.0 are not simply confined to technology alone. Ideally, Industry 4.0 is about creating an environment where people can work with machines in a simple, efficient and sustainable manner given that existing processes are complicated (Vaidya, Ambad & Bhosle, 2018). This requires a new level of organisation and control over the value chain of life cycles among products. The technological aspects only come into play when discussing the importance of connections between physical items to each other and to the Internet, dubbed “cyber-physical connections”.

The lack of understanding of the non-technological aspects of Industry 4.0 is not confined to businesses alone. Seemingly policymakers that have to implement and operationalise the Industry 4.0 concepts vary in their understanding of what the concept means and may also lack the various expertise required to facilitate this transformation for businesses. In Singapore, the propagators of Industry 4.0, be it among policymakers or within businesses, are mainly technologists and programmers. These experts understand Industry 4.0 mainly from a technological aspect.

For example, initial policies such as grants to promote adoption of advanced technologies and software (ESG, 2019), encouraging programming classes through SkillsFuture education programme, primary school education and even terms such as digitalisation indicate the technology-centric approach by lead agencies.

Ideas such as organisation redesign, data-oriented processes and greater autonomy for decision making within the overall business architecture, all core themes of Industry 4.0, appears to be an afterthought as policymakers and businesses hastily pursue acquiring the latest technologies without considering the humanistic elements of their businesses.

However, Industry 4.0 goes beyond technology and implementation requires experts who understand both the policy implementation and business processes as well. With more varied expertise, IMDA or EDB approaches could be more effective as policymakers are now able to speak in the same language as business owners. In a sense, policymakers had to undergo their **version of Industry 4.0 transformation in policymaking by engaging in a “learning-by-doing” process.** Learning-by-doing requires businesses and policymakers to experiment with initiatives, make mistakes, learn from said mistakes and improve their strategies. When initial policies focusing on technology received only a lukewarm response from businesses, lead agencies learnt from those initial policy missteps and increased stakeholder engagement to better understand businesses' and workers' needs. It is through this risk-oriented, experiential and innovative learning process that policymakers were able to realise the importance of both technological and non-technological aspects of Industry 4.0, thus enabling the introduction of more effective policies such as SME: Go Digital Programme that included by digital transformation consultancy services at the SME Digital Tech Hub.

CONFUSION OVER INDUSTRY 4.0 AND WORKERLESS WORKSPACES

It is unfortunate that policymakers, businesses and workers have mistakenly associated computer-integrated manufacturing (CIM) with Industry 4.0. CIM emphasises on workerless environments where repetitive production tasks can be completed without a worker's intervention and maintain quality standards (Hermann, Pentek & Otto, 2016). Most workers can visualise CIM as robots displacing humans. Hence, most people approach Industry 4.0 with fear over loss of jobs.

Industry 4.0 is not computer-integrated manufacturing.

Industry 4.0 emphasises the importance of the human role in production of a good or service. Workers are intended to be strategic decision makers and flexible problem solvers within the overall production process. Modern and interdisciplinary approaches in production development and in design, production and sales require businesses to create common, integrated and interdisciplinary methods, processes and solutions. Such complexities require workers to have intimate knowledge of their businesses, utilising technology to augment workers' output as they pursue the quantum leap in innovation.

KINDER TONE AND LANGUAGE WHEN DISCUSSING INDUSTRY 4.0

As mentioned earlier, the manner and language used by policymakers, businesses and workers when discussing Industry 4.0 with businesses is often fear-inducing and technology-oriented, according to several participants at the seminar. For example, ideas such as "robots replacing workers", "must upskill and reskill to remain employable" and "programming is a necessary skill" often induces fear and panic (Humberd & Latham, 2019) among workers – particularly the older workers who are less agile and younger workers without a background in computer sciences or engineering. **Workers are unaware of their value proposition.** They need to know that with Industry 4.0, more menial jobs will be eliminated as robots and programmes eliminate repetitive tasks.

However, new and better jobs will arise as Singapore's businesses develop their Industry 4.0 capabilities. Workers need to be aware that despite not having advanced programming skills or IT knowledge, **workers can still find a place in Singapore's economy** as Industry 4.0 still demands workers who are innovative, critical thinkers and experienced problem-solvers. Industry 4.0 will require workers of all ages trained in sciences, engineering, IT as well as design, humanities and social sciences. Singaporeans need to be aware of their resilience and capability to adapt and working in multidisciplinary teams. Unlike the jobs of yesterday where workers were more isolated, the jobs of tomorrow will require workers to constantly operate in networked, multidisciplinary teams which Singaporeans are already well prepared for.



THEME TWO

Developing Human Capital for Tomorrow

DEVELOPING HUMAN CAPITAL FOR TOMORROW



Credit: Straits Times

Education remains pivotal in nurturing Singapore's human capital, more so in the ever-evolving landscape of Industry 4.0. The reality is that virtually all Singaporeans pursue education with the end-goal of gaining employment. Hence, education has placed an emphasis on upskilling and retraining of workers, particularly in technical and IT skills.

However, rapid technological change in dynamic Industry 4.0 settings could render workers' skill sets irrelevant very quickly. It is important for the education system to instill basic principles and skills that will remain relevant in the new industrial paradigm. To do so, educators have deepened existing collaborations with industries to ensure graduates of Singapore's education system are armed with future ready skill sets.

This section aims to discuss the education system's response to Industry 4.0 and how educators and industry are deepening their collaborative activities to ensure graduates joining the workforce are prepared for the rigours of Industry 4.0.

EVOLUTION OF EDUCATION

The ecosystem in which workers learn their skill sets is a complex one. The Institute of Adult Learning (IAL) identified that various stakeholders – including the educators, government, employers and the lesser known professional, licensing, employer bodies and unions are also integral to this ecosystem of learning. However, with multiple stakeholders, each with their own interests, comes a greater need and difficulty to coordinate education programmes for workers. Assuming a future that is inclusive and focused on augmentation of work and labour requires not only the whole ecosystem to work towards such a future, but also requires a change in teaching and learning paradigms.



Source: Bound, 2019

As presented during the seminar, IAL considers how the education system does not only involve schools. The ecosystem of education includes a variety of stakeholders with different interests and modes of operating.

Despite evidence of exciting forms of delivery and learning design, currently in Singapore, there is a lot of front-end downloading in formal adult learning settings. For example, seating in many classrooms face the front and tech-enabled learning is too often a case of loading reading materials on line. Adult educators and training providers ask, 'How to blend classroom, tech-enabled and workplace learning?' (Bi, Bound, forthcoming). Teaching and learning spaces are designed such that theory and practice, technical and generic but important skills such as teamwork, resilience, empathy, learning to learn are often taught separately. Changing teaching paradigms and their systems requires changing beliefs about teaching and learning, moving beyond the walls of the classroom and educational institutions, developing strong partnerships with industry and institutional knowledge about the impact of Industry 4.0. Singapore Polytechnic's reinvigoration of its engineering programmes and Singapore Institute of Technology's new degree design are examples of institutions adapting to the realities of Industry 4.0

Industry 4.0 necessitates educational institutions to become people developers. Changes need to be made so that students are future-oriented; able to be critical thinkers, co-create knowledge, develop deep understanding enabling them to solve complex, wicked problems. This requires a shift towards understanding learning as participatory, believing in your learners' ability to make sense of their world. It also requires changes in learning design such that learning is authentic, 'soft' and 'hard' 'skills', learning to learn and entrepreneurial capabilities are integrated, and holistic.

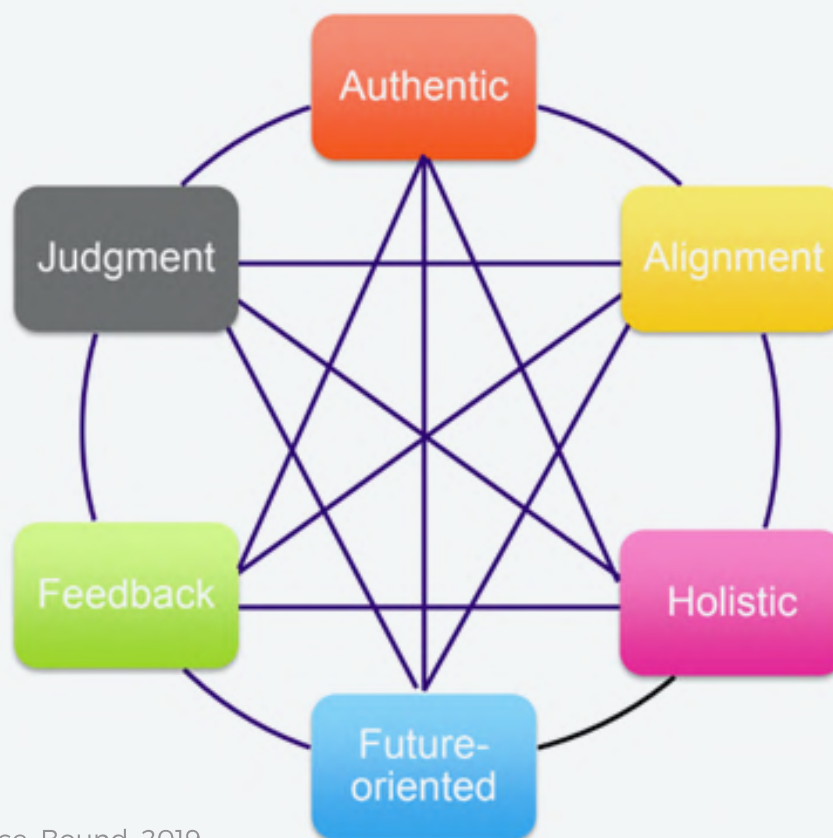
Singapore's economic future requires its people including workers to have good potential for employment, not just for the elite (Bound, 2019). Recognising that mastery and expertise are distributed throughout the workforce (A Wealth of Talent Approach, Brown, et al, 2018) requires members of the ecosystem, employers included, to recognise and provide opportunities for their people. Such an approach requires educational institutions (inclusive of private providers) to step outside their boundaries, integrating authentic learning experiences throughout their period of study (not just the internship at the end of 3 years) and stepping into workplaces, hand in hand with employers for workforce development. Singapore workers have the potential and necessary aptitude to learn and deepen new skills to succeed. The key is to channel resources into the effective educational pathways to enable this wealth of diverse talent to surface and be developed.

**IN INDUSTRY 4.0,
EDUCATIONAL
INSTITUTIONS
NEED TO
BECOME PEOPLE
DEVELOPERS**

SIX PRINCIPLES OF DESIGNING LEARNING

The six principles of learning design offer a framework for designing learning that meets the needs of rapidly changing contexts, such as Industry 4.0. The 6 principles of learning design were identified as part of analysing ethnographic data across industries in an IAL study (Bound, Chia & Karmel, 2016).

When curriculum and learning designers use the 6 principles of learning design, students are actively engaged, develop future-oriented capabilities, deep understanding and learning to learn capabilities in integrated, holistic ways.



Source: Bound, 2019

As presented during the seminar, the six principles of learning can be used to reshape the education process during times of rapid change (Bound, Chia & Karmel, 2016)

1

Authenticity – Using real-world work practices and settings. This embodies the complexity of work and enables engagement between students and the working environment.

2

Judgement – Involves making and evaluating ethical judgements. This enables students to make judgements about their own and others' performance.

3

Holistic – Integrates knowing, doing, thinking and feeling into the learning experience. The integration of theory and practice, the technical and the generic enables students to learn the ability to learn. This ability to learn is the most important skill for workers.

4

Future-Orientation – Inculcating the ability to learn and create a deeper understanding of the subject at hand. This enables effective application of learnt material to multiple situations and contexts inquiry. At the core of Industry 4.0 are a multidisciplinary approach and a deeper understanding, which will allow future workers to excel in their working environment.

5

Feedback – Involves giving and receiving feedback from multiple sources and create opportunities for learners to act on their feedback.

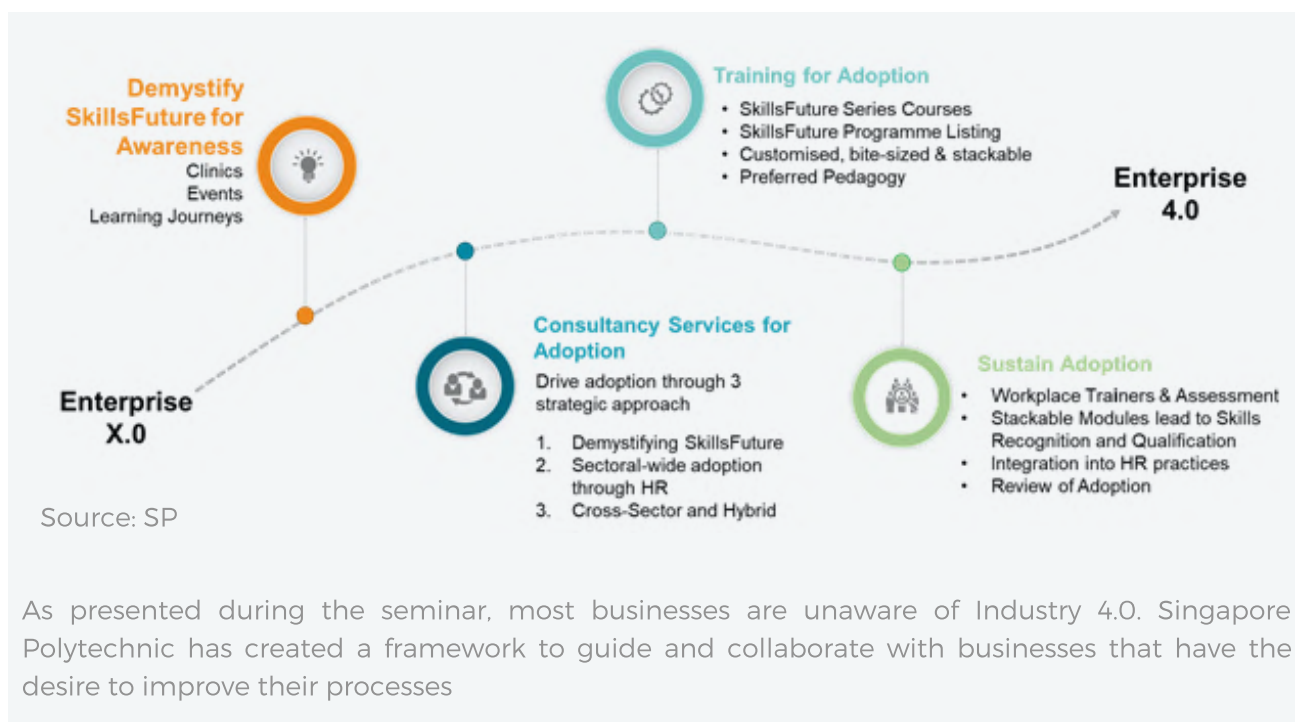
6

Alignment – Designing aspects of learning such that they work together.

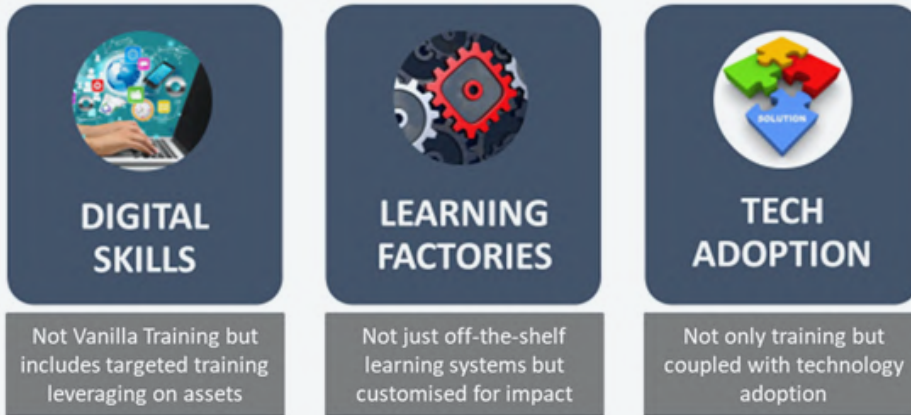
CASE STUDY: SINGAPORE POLYTECHNIC & MANUFACTURING

In response to policies such as SkillsFuture, SME:Go Digital and SIRI, resources were channelled into preparing industries and businesses for Industry 4.0. The focus of Singapore Polytechnic drastically shifted within five years from providing limited programmes and focusing on pre-employment training (PET) to providing stackable modules to providing continuing education and training (CET) to respond to the industry's transforming needs.

Singapore Polytechnic (SP) also acts as a guide and offer consultations for SMEs that are hesitant in embracing Industry 4.0, by helping businesses adopt skills framework and transform accordingly. Working with numerous SMEs, SP's educator shared that most SMEs were still scrambling to understand business transformation issues even after referring to SIRI or digitalisation guides. Singapore Polytechnic demystified the Industry 4.0-related policies by identifying SMEs' concerns and provided consultancy service. Following that, Singapore Polytechnic enables organisational change in businesses by changing the mind-set of workers adverse to digital transformation and updating their skill sets.



ADVANCED MANUFACTURING TRAINING COMMONS



Source: SP

As presented during the seminar, Singapore Polytechnic has been designated for advanced manufacturing. As such, the institution has a deeper understanding of the training requirements for workers in the industry.

It is important to create training ecosystem that nurtures a highly qualified workforce. Singapore Polytechnic focused on the energy and chemical sectors by offering a comprehensive training progression – from new hire to master-craftsman – that has the mandate of and is jointly developed with key stakeholders and industry leaders. Singapore Polytechnic, the designated advanced manufacturing SkillsFuture lead, created a training programme that covers comprehensive skills, provided a training testbed in the form of a digital chemical plant, and developed practical intelligence for the use of workers. Workers can progress both horizontally and vertically in the ecosystem easily. To help businesses retain their staff, Singapore Polytechnic works with international organisations to internationally certify experienced staff.

Going beyond the requirements for traditional jobs, Singapore Polytechnic also prepares current students for the **gig economy**.

The gig economy has gained greater traction among younger workers due to the increased independence and empowerment gigs provide. Many jobs in Industry 4.0 can be “gigsterised” as new technologies and business models have enabled a new mode of temporary and flexible gigs instead of the typical full-time, heavily structured employment. Students can pursue the **Authentic, aGile, Industrial Learning Environment (AGILE)** track, on top of the conventional academic track to learn to be a self-directed learner. AGILE modules give credit to students for embarking on real-life projects that are credited as AGILE modules.

The AGILE track is highly popular among students as it allows them the opportunity to participate in real projects. Such participation allows students to utilise their learned skills, gain useful experience and provide a sense of accomplishment after completing the project. Such intangible benefits cannot be overlooked, given the changing desires of a new generation of workers.

CASE STUDY: SINGAPORE INSTITUTE OF TECHNOLOGY & CURRICULUM EVOLUTION

TOP SKILLS IN 2015

1. Complex problem-solving
2. Coordinating with others
3. People management
4. Critical thinking
5. Negotiation
6. Quality control
7. Service orientation
8. Judgement and decision-making
9. Active listening
10. Creativity

TOP SKILLS IN 2020

1. Complex problem-solving
2. Critical thinking
3. Creativity
4. People management
5. Coordinating with others
6. Emotional intelligence
7. Judgement and decision-making
8. Service orientation
9. Negotiation
10. Cognitive flexibility

The World Economic Forum has identified key skills necessary for workers to remain employable in the future. SIT has developed its academic programme with these skills in mind. (World Economic Forum, 2018)

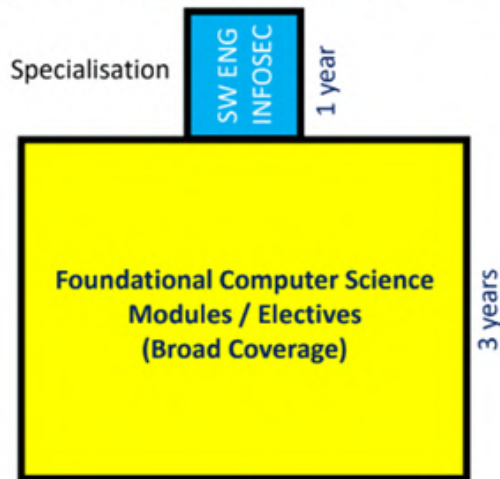
With each industrial revolution, workers are required to do less work to produce more, hence posing challenges as processes get more complex. Industry 4.0 entails and represents different things to different parties with different priorities. Technologies such as IOT have applications across several industries like public health and manufacturing. Hence, the Singapore Institute of Technology (SIT) must ensure that its degree programmes are relevant to Industry 4.0 and produce quality human capital.

Progressive institutions such as SIT recognise that changing skill sets are needed for future work. Skill sets are evolving from the typical technical skills to innovative, deep-thinking prowess.

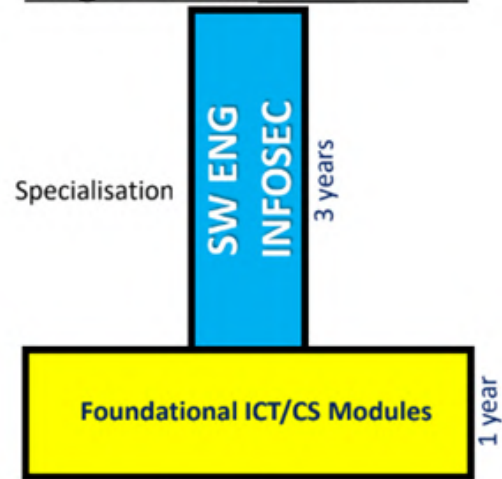
Technological advancements have broad and complex implications. It can affect domestic life and industries. Sectors expand and become increasingly specialised. For instance, data management falls under data analytics. Cyber-security is a recent concern. People, processes and soft skills are vital in the transformation of technology. To accommodate these changes, SIT's degree programmes cater to subsets of the bigger system.

UNITE university education with industry requirements

Traditional Comp Sci Degree Structure



Programmes's UNITE Model



Source: SIT

SIT's UNITE programme differs from most traditional programmes, opting for increased depth and specialisation instead of broad understanding of the subject matter.

SIT's industry-specialised UNITE programmes reduce unemployability that arises through a traditional, broad and shallow education that does not provide students with skills applicable in the workplace. Preparing students for the Industry 4.0 means to equip them with skills to learn, unlearn and relearn to adapt to the fast-paced technological advancements. Students can begin their career after graduation, and then supplement their skills as part of life-long learning. The undergraduate curriculum that is practice-oriented and industry focused accesses students frequently, forgoing end-of-year examinations. Industry involvements in SIT education provide opportunities for students to learn from the industry. This also ensures professors teach relevant materials. Additionally, SIT provides international accreditation for students to be employable overseas.

Bearing in mind that education is a sector, universities should also undergo digital transformation. SIT's digital strategy does not revolve around technology, and it is not the sole responsibility of the university to ensure life-long learning; organisations and businesses also have a responsibility. SIT's internal digital framework is ensuring that staff and students are industry-ready by cultivating a culture where they are willing to learn.



THEME THREE

Transformation of Work

TRANSFORMATION OF WORK



The realisation that Industry 4.0 is already present is often missed by many. Businesses today have to overhaul their organisational structures, business processes and most importantly, their human resource (HR) management. The idea of an administrative or human resource staff doing only “paperwork” is long gone. Departments can no longer operate in silos and the development of an architectural human resource department to examine the macro and micro trends in the industry and business is necessary. Business organisations will need to be deeply aware of the changing business operations internally to ensure the best people for the business are recruited. Job scopes will be redefined with new organisational structures and with changes to the working environment, workers will be affected as well. This section aims to imagine the employers of tomorrow and how businesses can approach the necessary transformation of the business and working environment.

Society needs to maximise the opportunities and minimise the risks that come with human capital in Industry 4.0 through the redesigning of smart jobs, as well as adapting work and technology. There are new forms of labour on top of the traditional corporate labour. In Industry 4.0, the future of work may mean that workers are no longer bound by office hours and cubicles, an uncomfortable reality for some workers and most management. Flexibility, ownership of work and independence will form the cornerstone of Industry 4.0 work. This is precisely why the likes of gig economy, telepresence and shared spaces have gradually emerged in the past decade.

PREPARING FOR THE FUTURE OF WORK

WANTING INNOVATION YET REPRESSING CREATIVITY

The gap between policy and practice, and what is rewarded in organisations are important considerations for businesses. Several participants at the seminar raised concerns that while the upper echelons of businesses preach work-life balance, innovation and creativity, the day-to-day execution of processes contradict these lofty ideals. A worrying trend in organisations is that employers are still rewarding employees who “follow the system” and “punishing” creative staff for being disruptive and non-conforming. There is a fundamental disconnect between corporate policy encouraging innovation and practice within organisations. It is strange that risk-taking enterprising behaviour is frowned upon, yet businesses want innovation when **innovation itself is risky**. Without this innovation and disruptive “futurists” within the organisation, the business is doomed to fail in Industry 4.0 transformation.

PREPARING A SOCIETY FOR CHANGE

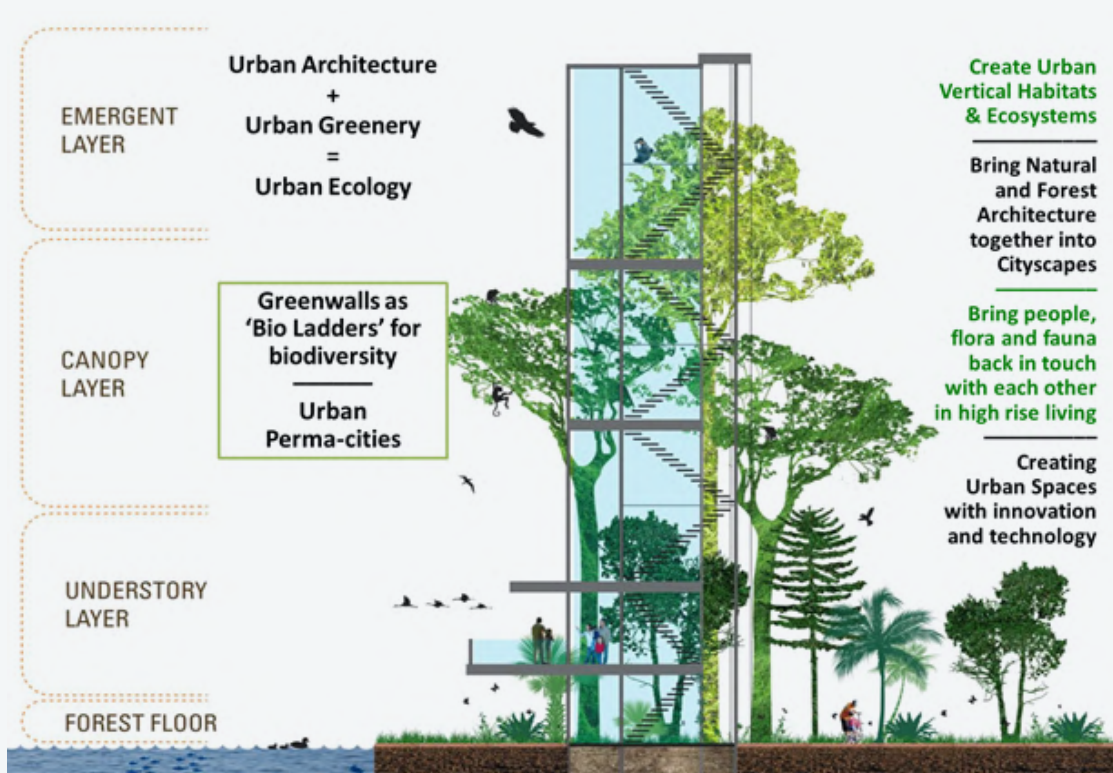
Both employers and policymakers of tomorrow need to understand what skills are needed, how jobs will change, and which parts of jobs will change. Society needs to prepare for a future where workers will change jobs and employers more frequently. As a society, concerns over education, manpower, legal protection and social safety frameworks need to be considered as some workers will lose their jobs while others may see changes to their well-being as a result of disruption.

THE CHALLENGE FOR INDIVIDUALS

In a rapidly evolving future of work and the uncertainty of the future of jobs, workers need to acquire new skills that are in demand. To do this, workers must gain the ability to learn and be adaptable to the changes in Industry 4.0. Creativity and creative thinking – given that artificial intelligence has yet to be able to do creative work as well as people – is crucial for workers of tomorrow. Emotional intelligence, empathy and ethical judgement are other skill sets for tomorrow’s workers, given the increasing collection of data and the responsibility that comes with using it. Employers and employees also need to rethink the traditional notions of where and how people work and what talents and capabilities people will bring to work.

EVOLVING THE WORKPLACE WITH NATURE

In line with the rise of artificial intelligence and human capital needs in Industry 4.0, it may be prudent to consider the physical changes made to a working space and its effects on workers. Greenology emphasised that the importance of Green Intelligence and Green Capital in order to meet the psychological and economic needs of cities cannot be understated. People are naturally social creatures and will suffer if left confined in cubicles and plain offices. Many leading businesses have used technology such as sensors and cloud computing in building and maintaining greenery in offices and cities. There is a need to continuously **learn, connect and integrate nature into our lives and work spaces**, to create an environment where people can be innovative and achieve much in their careers.



Source: Greenology

Greenology presented its philosophy of integrating greenery with the urban working environment, using sensors and cloud computing to manage the biodiversity in the building space. This blend of greenery and technology helps create a more conducive working environment

JOB REDESIGN

By far the most important element of Industry 4.0, the redesigning of jobs is paramount to ensuring Singapore continues to remain successful. Job redesign encompasses several ideas. Businesses need to have an extensive knowledge of their internal processes, through sophisticated mappings or a clear idea of a product's lifecycle. Businesses also need to reconsider how they view roles in their organisations. Human resource and administrative executives are not just "paper-pushers", stuck in dead-end jobs. They are an integral component of ensuring that an organisation functions.

Understanding the job role also ensures the right skills are recruited. Job redesigning should involve the organisation in its entirety as different departments and seniority levels can offer different perspectives. For example, senior management may not see issues in the full extent as junior staff do. Different departments may not fully understand the roles of other departments. Without the understanding of job functions, it is unlikely that recruiters and HR managers will know what skills to look out for in potential hires. In fact, it is likely that unsuitable candidates will be hired, fail and prove costly to the organisation, both financially and in terms of overall organisational cohesion.

People may need to reconsider their perception of certain job roles and how those job roles are named. For example, most associate urban farming with grimy activities. However, urban farming in the future will need engineers, architects and scientists as urban farmers to make data-driven farming decisions based on information from cloud computing and IOT technologies. Job roles that exist today will evolve in Industry 4.0.

**WITH DISRUPTION
BEING A CONCERN,
REDESIGNING
JOBS WILL ENSURE
EMPLOYMENT
OPPORTUNITIES**

New forms of labour will arise as well. Today, the younger Millennial and Generation Z (below the age of 35) generations will form the bulk of tomorrow's labour. These workers are aspirational, where intangible benefits such as recognition and empowerment are important factors for them before they sign their contracts. The current form of corporate labour structure and ladder that financially allow a sustainable career today may not be suitable model for tomorrow. As organisations begin to redevelop their internal processes and structures, the broader ecosystem in which formal institutions, such as banks that are giving out loans, might not be as enthusiastic about the new forms of labour. This means that the entire ecosystem needs to adapt as well to these new forms of labour.

A misconception about younger workers is that they are "tech-savvy" when in reality, they are "app-savvy". While the younger generation are fluent in their use of social media and other lifestyle apps, they are less fluent in productivity apps and software. It is therefore important to ensure that younger workers are savvy in both lifestyle and productivity technologies. Given the high degree of comfort with technology, it should be an easy task to educate younger workers about these different types of technologies.

NEW TYPES OF JOBS

In attempting to maximise opportunities and minimise risks, futurist organisations such as Curtin Singapore are designing SMART jobs. While these jobs are intelligent, SMART jobs are:

S

Stimulating (skill variety, task variety, problem solving demands)

M

Mastery (role clarity, feedback, task identity)

A

Agency and choice in what we want to do

R

Relational and social contact

T

Tolerable demands (the extent to which the job involves time pressure, emotional demands and role conflict)

SMART jobs raise the conundrum of humans having to adapt to new work and technology and the need to think about adapting the work and technology to humans as well. This necessitates the updating of policy, organisational restructuring and job redesign.

CHANGING THE BUSINESS MODEL



Source: Mohan Management Consultants

During their presentation, Mohan Management Consultants viewed business models as processes operating in an environmental context to provide customers products or services.

Industrial Transformation Map digitalisation, SIRI, and Industry 4.0 are vastly macro concepts that overwhelm most businesses, policymakers and workers. While such concepts are important, there is a need to step away from the macro and move to the micro view, and not disregard the unique complexities of individual organisations. The macro aggregations show the symptoms of an issue, but there is a need to zoom in to identify the root causes. To do this is to be introspective and understand the utilisation of Industry 4.0 at the individual level.

The DNA of a single business is known as a business model and the blueprint of how value is created, often consisting of processes and the context. It is important to understand that both context and processes influence each other, and the interaction between the two is what makes businesses unique. Business models can be different from counterparts in the same industry. Contexts and processes need to be changed in order to change business models. There is a need for introspective focus, away from industry level concerns and for business leaders to focus on individual businesses-related concerns

Business models often grow in the way that they started off with, and certain environments, situations and hence, problems are more visible than others. Therefore, the short-term problems that are urgent and important garner attention and get picked up and resolved quicker. This is often an issue as these problems tend to surface time and again as visibility is focused on a small section of the full context and processes in the short time frame. This invariably leads to solutions that are superficial and keeps businesses stagnant. It is necessary to expand the visibility progressively into the long term, to create solutions that are robust and can lead to growth – in addition to capabilities to examine short-term problems. Most SMEs unfortunately do not have that manpower bandwidth to transform their businesses.

**BUSINESSES NEED
TO BE AWARE OF
THEIR ROOTS TO
UNDERSTAND
THEIR UNDERLYING
SHORT AND LONG-
TERM PROBLEMS**

**LONG-TERMISM
WILL ALLOW
COMPANIES TO
ANTICIPATE
FUTURE EVENTS
AND PLOT LONG-
TERM,
SUSTAINABLE
GOALS FOR THEIR
ORGANISATION**

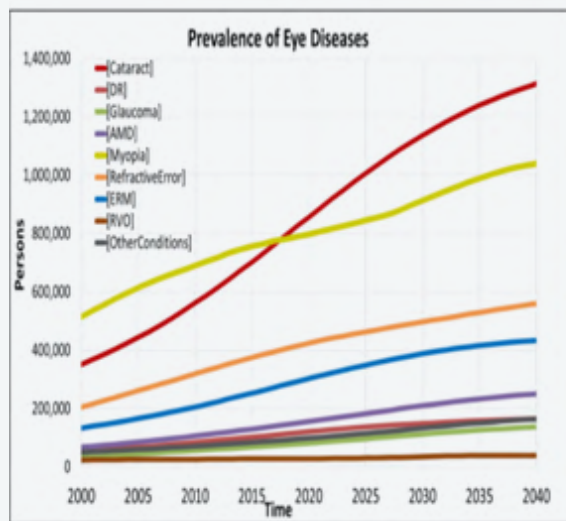
The ways to build long-term thinking involve:

- Dedicated long-term strategist who deals solely with long-term projects in the business
- Allocate time for long-term thinking by dedicating 30–40 per cent of time to having open conversations discussing important albeit non-urgent matters
- Detailed context and process mapping: Mapping current contexts and processes go a long way in seeing what to feasibly do next; things that are important will appear time and again, and this is the signal for what to focus on. This should happen with regularity to increase visibility and move from being reactive to proactive.

CASE STUDY: SINGAPORE NATIONAL EYE CENTRE & DATA-DRIVEN JOB REDESIGN

Snapshot of Ophthalmology Workforce Needs for Singapore

Source: SNEC



Outcomes	Base Year	Projected			% Change 2015-2040	
		2015	2025	2030		2040
Required Ophthalmologists						
Business-as-usual	108	146	197	222	262	79%
Increased uptake	108	147	212	246	305	108%
New model of care	108	146	188	207	234	60%
Combined scenario	108	147	202	229	269	83%
Required Medical Officers						
Business-as-usual	29	37	49	55	66	79%
Increased uptake	29	37	53	61	76	108%
New model of care	29	37	47	52	59	60%
Combined scenario	29	37	50	57	67	83%
Required Optometrists						
Business-as-usual	42	53	71	80	94	79%
Increased uptake	42	53	76	88	109	108%
New model of care	42	53	68	75	84	60%
Combined scenario	42	53	73	82	97	83%
Required Technicians						
Business-as-usual	37	48	65	73	86	79%
Increased uptake	37	48	70	81	100	108%
New model of care	37	48	62	68	77	60%
Combined scenario	37	48	66	75	88	83%
Required Registered Nurses						
Business-as-usual	176	228	306	345	408	79%
Increased uptake	176	228	329	382	474	108%
New model of care	176	228	292	322	364	60%
Combined scenario	176	228	314	356	418	83%
Required Enrolled Nurses						
Business-as-usual	108	140	188	211	250	79%
Increased uptake	108	140	202	234	290	108%
New model of care	108	140	179	198	223	60%
Combined scenario	108	140	192	218	256	83%
Required Ophthalmic Assistants						
Business-as-usual	77	90	122	137	162	79%
Increased uptake	77	91	131	152	188	108%
New model of care	77	90	116	128	145	60%
Combined scenario	77	91	125	141	166	83%

Using disease prevalence data, Singapore National Eye Centre conducted a study employing modelling research to predict future demands of eye-care, the necessary skill sets to deliver eye care, and how best to distribute roles among staff.

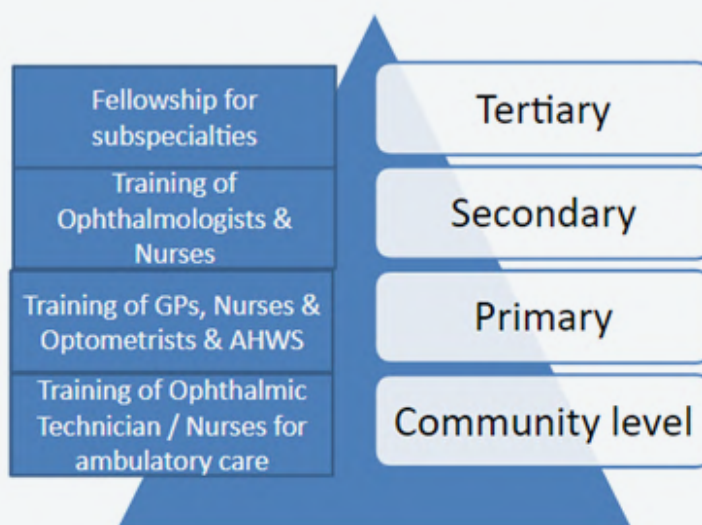
In a bid to anticipate future demands for eye-care services, the Singapore National Eye Centre (SNEC) utilised its database on patient activities and conditions as well as modelling research with Duke NUS researchers to map out the various processes in SNEC, using system dynamics modelling technique with different scenarios to assess the expected demands for eye care in Singapore till 2050. A clear example of **long-term strategic thought**, SNEC's internal studies indicated a clear need for an increase in its manpower to meet the inevitable demand increase for eye-care, especially in light of Singapore's ageing population. This is worrisome as, like most industries, the healthcare sector faces a **shortage of skilled professionals**.

Another key concern for SNEC is the lack of formal, structured and comprehensive training programmes within local institutes of higher learning (IHLs) to match this increased demand and the increasing complexity of care delivery model. Clinical skill development or upskilling the healthcare professionals needs to be done in the clinical environment, and such programmes will be much in demand for developing the future ready healthcare workforce. As these diploma and degree programmes are costly, require expensive, specialised equipment and have low annual student intakes, it is financially unfeasible for IHLs to provide these programmes. The inability to rely on specialised foreign labour sources also hinders SNEC's future abilities to adequately meet local eye care demands from its patients.

In response to these needs, SNEC reassessed its entire internal processes using a combination of patient, disease prevalence data and current workflows. By analysing key processes and patient data as well as collaborating with international experts from the **International Joint Commission on Allied Health Personnel in Ophthalmology (IJCAHPO)**, experts in SNEC redesigned individual roles through task-shifting exercises and developed or modified job roles within SNEC to meet the demands of eye care. This is a major change management exercise which required buy in from all levels and it was done in collaboration with the regulators, training providers, clinical leadership and the overall workforce.

It is important to note that the processes undertaken by SNEC to transform itself are not specific to the ophthalmology or healthcare sector. **Mapping out business processes, workflows, considering the needs of customers, and reallocating or developing new tasks are activities any company can achieve**, regardless of technical expertise or software. The redesigning of job roles and processes only occurred in SNEC after the organisation considered both the current and future demands of patients as well as current and future manpower and technological resources. As such, companies of any nature or industry can adopt the same processes that made SNEC successful. Companies only need to be fully aware of themselves as organisations in order to apply the same principles as SNEC.

Comprehensive Eye Care Training Model

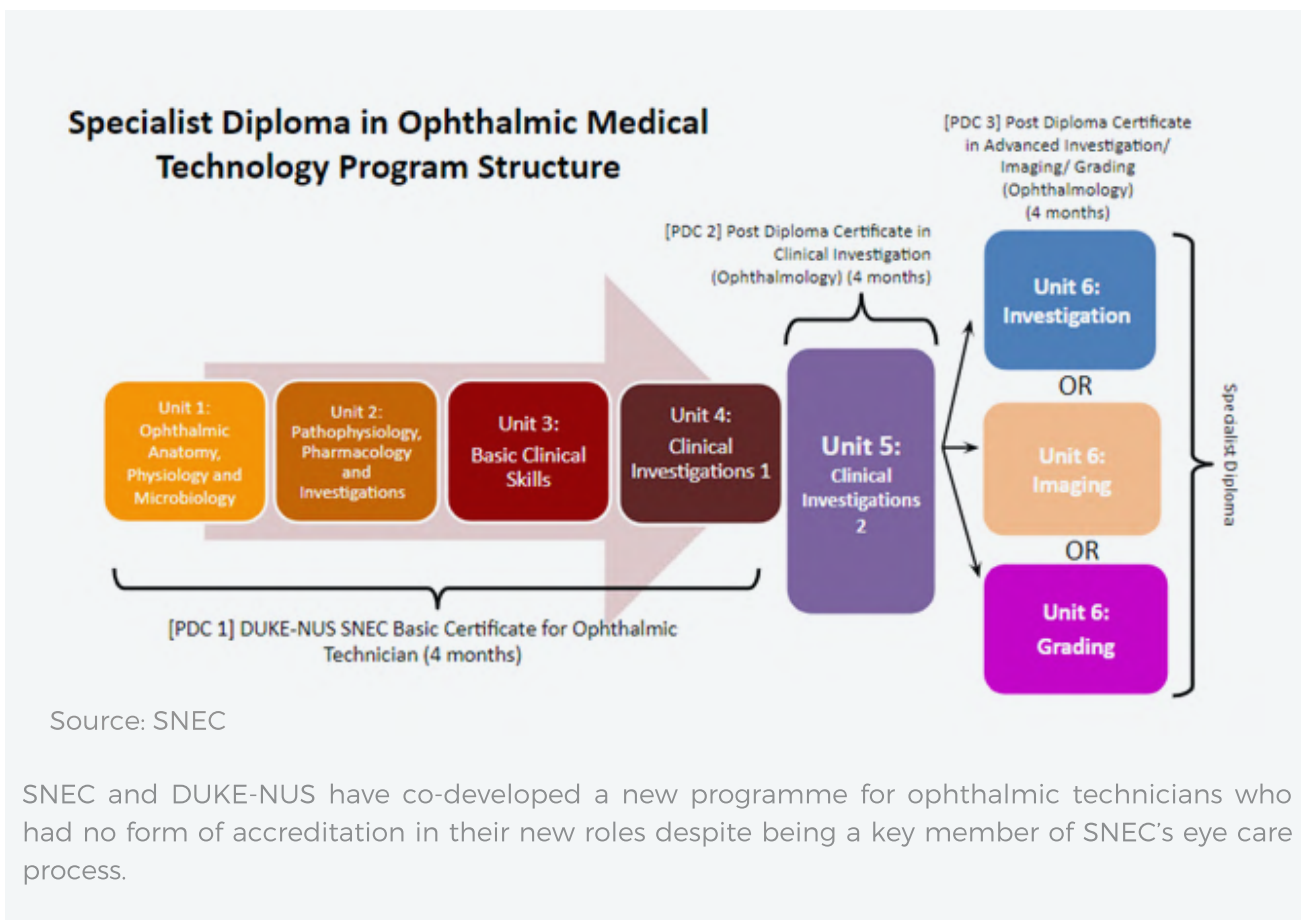


Source: SNEC

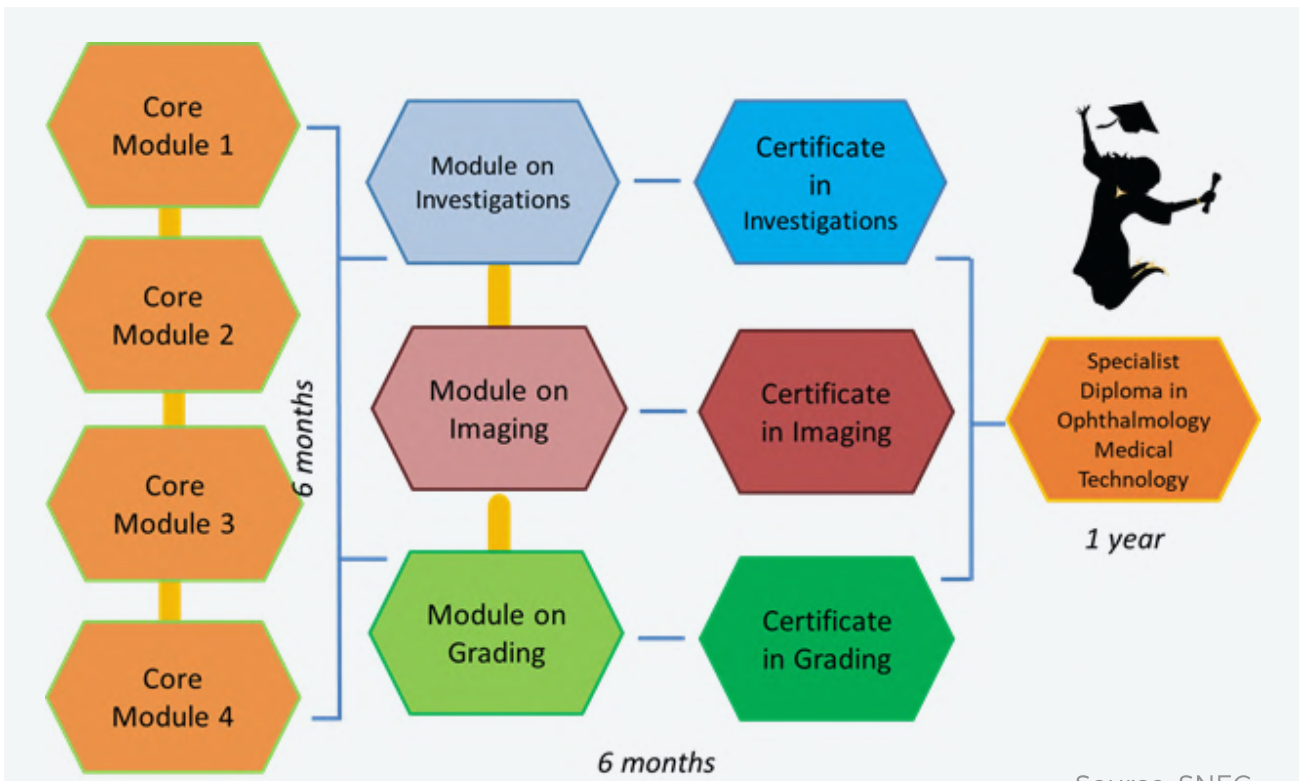
SNEC developed a new eye care training model, working with relevant accreditation bodies like IJCAHPO to ensure that employees in the new job roles are equipped with the right skills to provide quality eye care.

The educational development unit of SNEC created a training programme to retrain and upskill existing workers with IJCAHPO-level certification. The **Allied Ophthalmic Personnel (AOP) Development programme**, which IJCAHPO accredited, was developed to deepen the capabilities of existing SNEC staff to provide excellent eye care to Singapore’s patients.

Modular educational courses, training and accreditation to increase eye care standards and recognition internationally, and the development of an advisory team to ensure the quality of education were ways in which SNEC has worked on in developing new talent pipelines. Key focus was also placed on developing an ecosystem of eye care, ensuring capability development for personnel within the primary, secondary, tertiary levels of eye care and at the community level.



SNEC and DUKE-NUS have co-developed a new programme for ophthalmic technicians who had no form of accreditation in their new roles despite being a key member of SNEC’s eye care process.



Source: SNEC

As technology becomes increasingly important in eye care, SNEC has ensured that their specialists in ophthalmology medical technology have the right accreditations and skills.

Unlike other training programmes, SNEC's unique approach focused on patients and examining how its current workforce needed to reskill themselves to meet the increasing demands. SNEC aspires to be a regional and international training hub for ophthalmic education and has successfully gained regional recognition for its existing efforts.

Despite SNEC's progressive efforts, the organisation highlighted that it still faces challenges to meeting its objectives.

CHALLENGES FOR SNEC

LACK OF PROGRAMMES FOR NEW JOB ROLES

A critical gap in eye care education is that current programmes in Singapore are still based on older job roles and responsibilities. For example, intravitreal injections (IVT) are today being performed by both doctors and nurses, with patients having the option to request a nurse or a doctor. IVTs were previously a doctor-exclusive task but SNEC's task-shifting exercise and re-examination of their internal processes, research on new models of eye care and patient demands indicated that IVTs could be done by nurses as well.

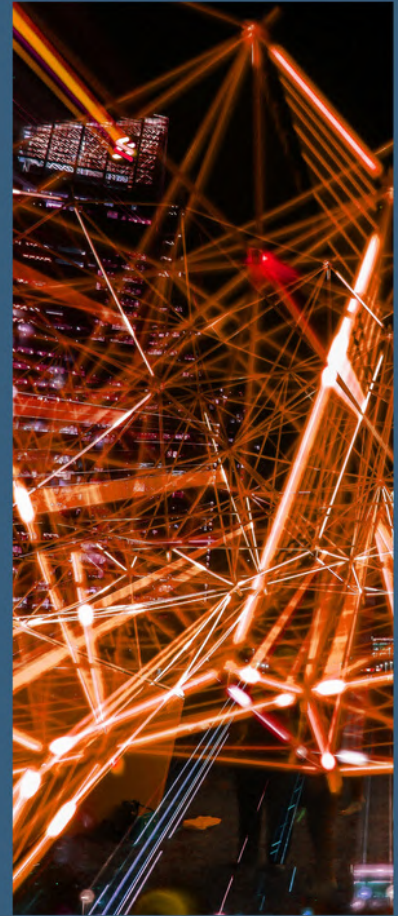
Procedures by nurses are cheaper for patients and data analysis indicated that nurse-administered procedures are cheaper, have shorter waiting times, and despite each procedure taking a slightly longer time, patient satisfaction is generally comparable if not higher compared to doctor-administered procedures. In fact, the longer procedure times were attributed to nurses taking extra time to carefully explain the procedure to patients.

As mentioned previously, since the procedures are not in the traditional job role of nurses, graduating nurses from local IHLs are untrained in the procedure. This means that SNEC must incur high costs to adequately prepare their nurses to administer the procedure. This is even though nurses in other countries routinely perform this procedure and there is a demand locally for such services.

LACK OF TRAINING FUNDING

While SNEC aspires to provide world-class eye care to Singaporeans, it is important to note that the institution is not an IHL. As seen above, due to a lack of educational capacity within local IHLs, SNEC has had to develop educational programmes to enable reskilling. SNEC also has the unique position of providing the clinical practice, which enables the reskilling process — something unachievable in typical IHLs. SNEC is implementing IHL-type programmes but receives little to no funding support typically granted to IHLs, putting a strain on SNEC's financial resources.

**EDUCATION AND
THE EYE CARE
INDUSTRY NEED TO
DEEPEN
COLLABORATIONS
TO ENSURE
SINGAPORE'S
FUTURE
HEALTHCARE
NEEDS ARE
ACHIEVED**



THEME FOUR

The Way Forward

THE WAY FORWARD



Theme 1 highlights the complexities of Industry 4.0 and how, despite the important efforts of government agencies in Singapore to implement new policies to make Singapore Industry 4.0, there are clear gaps to be considered. The issue of businesses policymakers and workers misunderstanding the Industry 4.0 phenomenon limits the effectiveness of innovative policies such as SIRI. The misunderstandings also impact the preparation attempts of organisations and individuals in revamping their decision processes and job roles – and instils a sense of dread among workers that their jobs will soon be lost.

Theme 2 stresses that with the dynamic changes of Industry 4.0, workers need to be equipped with future-ready skill sets. In addition to IT, programming and more STEM-oriented skills, other skills such as empathy, teamwork, innovation and creativity are important as well. Industry 4.0 is not just a technological phenomenon. It is a human phenomenon as well. This means that educational institutions need to evolve in its curriculum and instruction. Progressive institutions such as Singapore Polytechnic and Singapore Institute of Technology have evolved their education system with Industry 4.0 in mind. Incorporating authentic, well aligned, holistic, future-oriented ideas into the education system that allows the creation of feedback to students is an important step in creating workers that are able to judge critically, innovate and be the dynamic problem-solvers who are necessary for thriving in Industry 4.0.

Theme 3 recognises in Industry 4.0 that dynamic evolutions in technology will require businesses, policymakers and individuals to evolve as well. Organisation restructuring, job redesign and redefining business processes are necessary. New types of jobs will be developed and business models will be created as industry ecosystems evolve too. Working experiences may evolve as physical workspaces change to incorporate new technologies, necessitating the incorporation of nature into the working environment as a form of balance.

For organisations, the importance of a long-term futurist mentality cannot be understated. This requires businesses to embrace disruptors and reward them for their innovation and creativity. Broad societal impacts also need to be considered as the future of work transforms as well. The SNEC demonstrates this futurist mentality by considering the demands of current and future patients, keeping in mind existing and potential staff to craft out new job roles and transform the work of ophthalmology.

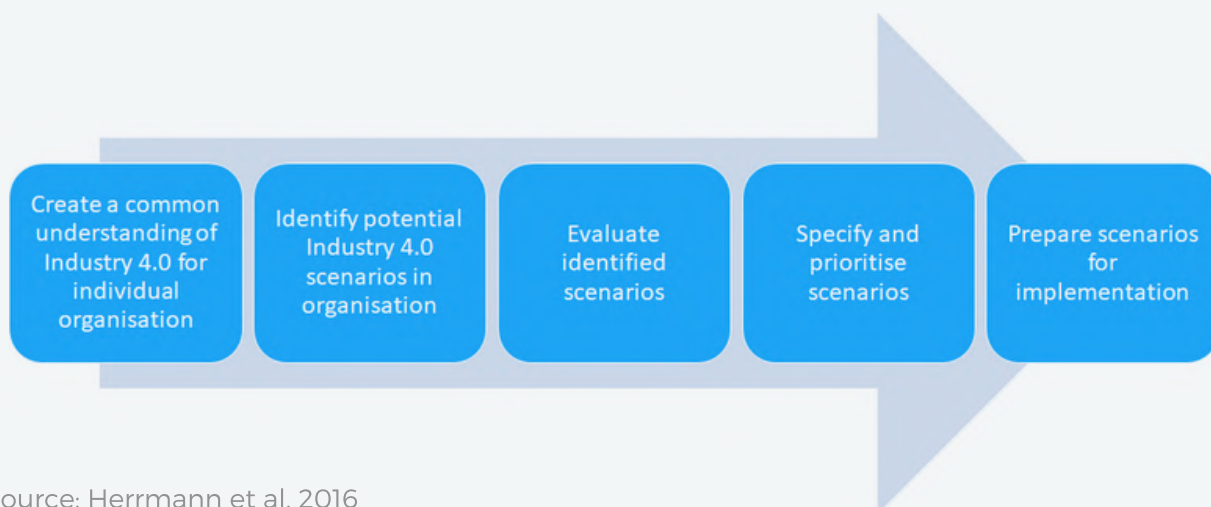
When crafting a future in Industry 4.0, be it in the educational, organisational or employment sense, stakeholders need to contemplate a few key questions:

- 1 How can human skills and learning be maintained and be rewarded appropriately?
- 2 When to trust technology? What enables trust in technology?
- 3 What are the non-technological effects to be considered?
- 4 How should technology be designed so it is an effective team member?
- 5 How to train people prevent complacency with automation?
- 6 How to design jobs that are meaningful and motivating?
- 7 Does technology or humans form the bulk of the solution?

RECOMMENDATIONS FROM THE SEMINAR

BE PREPARED TO ADOPT NEW METHODS AND ROADMAPS

Both policymakers and business leaders need to be aware that their current policymaking and business-decision tools will need to undergo changes as well, alongside organisational restructuring and job redesign. When Industry 4.0 was first mooted by the major German businesses a decade ago, Germany's education ministry underwent major restructuring and changed its internal decision-making processes to ensure that policymakers are just as dynamic as the ever-changing dynamics of Industry 4.0. Old, bureaucratic processes that faithfully met the needs of policymakers and business leaders will need to undergo major overhauls and possibly discarded.

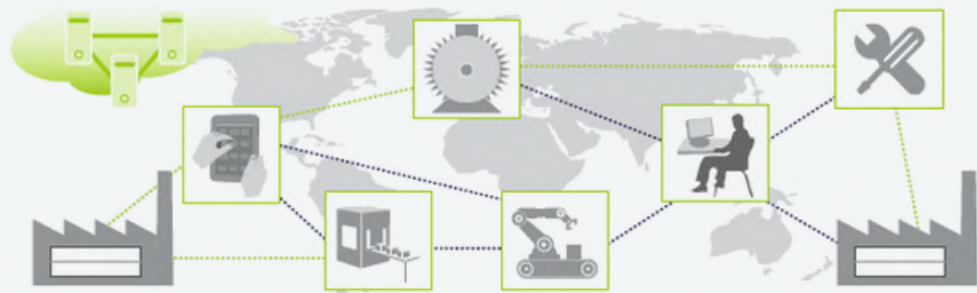


Source: Herrmann et al, 2016

When designing potential Industry 4.0 scenarios within an organisation, it is important to create an **organisation-wide understanding** of Industry 4.0's meaning to the organisation. Industry 4.0 will impact different segments of the organisation differently. Having a holistic view of the impacts of Industry 4.0 allows organisations to evaluate the integrated business or policy processes as a whole, identifying areas of improvement and implemented changes for the betterment of the organisation. This creates buy-in from members as their input is valued and improves the overall transformation journey for the organisation. (Herrmann et al, 2016)

Source: Kagermann, et al., 2013

Figure 6:
Horizontal Integration
through value networks



Source: Siemens 2012

Figure 8:
Vertical Integration
and networked
manufacturing systems



Source: Siemens 2012

Figure 7:
End-to-end
engineering
across the entire
value chain



Source: Siemens 2012

acatech together with Siemens developed a framework of understanding the various forms of integration expected to occur in Industry 4.0 (Kagermann, et al., 2013)

Industry 4.0 requires a great degree of integration – horizontal integration across the entire value chain between different types of businesses; vertical integration and networked systems within businesses and end-to-end integration across products and services life cycles. Such integration necessitates a more dynamic and lean decision-making and policy-developing process. Such lean decision-making and policymaking processes will only occur with introspection, identifying archaic, bloated processes and inculcating greater reception to newer ideas. Both policymakers and business leaders need to be comfortable with discarding older, tried-and-tested traditions and developing new ones. A lack of rejuvenation within organisations will only inhibit Industry 4.0 development in Singapore and place the country at a severe disadvantage.

INCORPORATE LONG-TERMISM INTO BUSINESS DECISIONS

Industry 4.0 will herald long-reaching changes in an organisation, necessitating the need for **long-term strategic thinking** among business leaders. Business processes, job roles, decision-making and even the spatial design of a workplace will change in an Industry 4.0 ecosystem. Businesses can achieve a higher level of effectiveness and efficiency when conducting their processes if they are able to incorporate both the human and technological aspects of Industry 4.0 into their organisations. As workers become more capable, the quality and proficiency of products and services improves. This can also create growth as businesses go from business stagnation to dynamic acceleration in growth rates, profit margins and business scale.

This long-term strategic thinking will permeate various departments within the organisation. Specifically, such thinking will create better HR and recruitment policies. A deeper understanding of the job roles in the organisation will facilitate better recruitment. At present, recruiters and HR practitioners believe that simply because the job role has a hint of technology, potential recruits must have IT, engineering or programming backgrounds when often, the technology aspects of the job role are minor and can be easily taught to non-STEM graduates. Instead, it is the non-technical skills such as empathy, problem solving or even storytelling that are the real skills needed for the role.

Many smaller businesses may struggle with long-termism as the overriding objective of survival in the short run becomes a priority for businesses and the practice of making decisions with a view to long-term objectives or consequences becomes difficult for companies to achieve.

Additionally, these smaller businesses may not have the manpower for long-term futurists in their organisation to ponder the business's future. One suggestion would be to create environments where like-minded businesses or businesses operating in similar industries can converse with one another. A simple "coffee session" is an easy way for businesses to incorporate long-term thinking into their psyche. The main goal of these sessions is for businesses to talk about their common problems and craft potential solutions instead of suffering in silence. These sessions can be held in shared spaces in business parks. Business leaders can sit down in a relaxed manner, have a comfortable conversation with fellow business leaders who can empathise better about the business's context, challenges and opportunities, share ideas and gain new perspectives.

The benefits of long-termism in business decisions are innumerable. Businesses have the opportunity to create an "Ironman effect" for their workers. With the introduction of Industry 4.0 technologies and consideration of how technology can mesh with people, the capabilities and quality of work achieved by every employee will improve significantly. As workers become more networked in teams and become more capable individually, businesses need to take the long-term decisions in providing further training, empowerment, recognition and better remuneration packages.

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