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THE FEDERATION OF THAI INDUSTRIES



NEW MANUFACTURING TECHNICIANS RESPONDING TO INDUSTRY 4.0

This policy paper has been developed through a collaborative effort among experts from the Chisholm Institute, a leading technical education and training provider in Australia, prominent Thai manufacturing companies, the Federation of Thai Industries, the National Science Technology and Innovation Policy Office, top technical universities in Thailand and the Kenan Institute Asia. The Chevron Enjoy Science Project, funded by Chevron Thailand Exploration and Production, Ltd., supported this initiative with the objective of identifying policies to guide human resources development in Thailand, especially with regard to promoting a skilled technical workforce to respond to the needs of industry and Thailand 4.0 national policy.



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ABSTRACT

Export-orientated manufacturing is an important part of the Thai economy. However, opportunities for growth in manufacturing are under threat due to new competitive pressures from technologically advanced and developing nations. This has led the Government, through Thailand 4.0, to encourage Thai manufacturing companies to embrace an advanced manufacturing future enabled by connectivity, data and automation. The move to this future poses significant challenges for the manufacturing workforce, not the least of which is the need to produce a new generation of IT savvy technicians with cross-disciplinary skills in mechatronics and technology. There is a global shortage of technicians with these skills and Thailand needs to ensure that manufacturing companies have a ready supply of Industry 4.0 ready technicians. To this end, the paper has proposed the introduction of STEM through Technology Program that is supported by a professional development program for teachers, new private-public funding arrangements for technical education and a campaign to build awareness of technician careers in manufacturing industry.

1. INTRODUCTION

Thailand was one of the world's poorest nations following World War II. Since then the country has grown rapidly, experiencing an average rate of growth of 6.3% between 1952 and 2005, and moving into the upper middle income group of nations in 2011. This turnaround was due in large part to the rapid expansion in export-orientated manufacturing. More recently growth has slowed to around 3.5% per annum. This has led some commentators to question whether Thailand has fallen into the middle-income trap. This is a situation in which developing economies stop growing before they become rich. Opportunities for growth in such countries are restricted because they are unable to compete with low-wage / low-skill competitors in their established markets and lack the skills, research and innovation base required to compete with the rich, innovative and technologically advanced countries that dominate higher-value industry sectors.

To escape this situation, the Asian Development Bank has argued that "...Thailand needs to move into the higher-value segment of economic activity and create high-quality jobs. Innovation, adaptation, and use of technology are critical to such growth, driving improvements in productivity and enabling the production of more sophisticated and higher-value goods and services."¹ This move to refocus the Thai economy on higher-value economic activity lies at the heart of the Government's latest national development initiative, Thailand 4.0. It is envisaged that through this initiative, Thailand will escape the middle-income trap and emerge as a high-income nation.

1 Asian Development Bank: Thailand: Industrialization and economic catch-up. Mandaluyong City, Philippines, Asian Development Bank, 2015.

A central component of Thailand 4.0 is the promotion of an advanced manufacturing future. A future based on high-value production, enabled by innovations in connectivity, data and automation. These innovations are transforming manufacturing worldwide and have laid the foundation for what is being called Industry 4.0 or the fourth industrial revolution. In this new environment, sensors, machines and IT systems will be connected along the value chain beyond a single company. These smart systems will “... interact with one another using standard Internet-based protocols and analyze data to predict failure, configure themselves, and adapt to change”² These digital production systems will enable fast, flexible and efficient production of higher-quality goods. This will reduce production costs, improve productivity and enhance competitiveness.

Countries across the world are actively pursuing industry policies designed to take advantage of these new technologies. This has been led by the development of Industrie 4.0 in Germany. Similar initiatives have been launched in other advanced economies, including the USA [Advanced Manufacturing Partnership], Japan [The Industrial Value Chain Initiative], France [Industrie du Futur], South Korea [Innovation in Manufacturing 3.0], Taiwan [Productivity 4.0] and Singapore [Smart Nation]. Like Thailand, other developing countries have launched industry policies directed at adopting Industry 4.0. These include the Made in China 2025 and the Make in India programs.

In each of these countries, programs have been put in place to support the move to Industry 4.0. Thailand will need to take similar actions and build a new generation of Industry 4.0 ready manufacturing technicians if it is to realize the ambitions of Thailand 4.0.

2. DRIVERS AND STATUS OF INDUSTRY 4.0 IN THAILAND

A large, low cost labor force has underpinned Thailand’s emergence as a global center for manufacturing activity. This has ensured the competitiveness of Thai manufacturing and provided a major incentive for international investment. However, as Thailand has entered the ranks of upper middle-income nations this cost advantage has weakened.³ In order to remain competitive, especially with low wage competitors, many Thai companies have automated production and applied new manufacturing technologies [see Case Study 1].

Case Study 1: The Somboon Group – Automation to meet global supply chain requirements

The Somboon Group is a leading manufacturer of automotive parts that employs about 2,900 people, including 2,000 engineers and technicians. The company has progressively automated its production processes to meet the cost imperatives of global supply chain requirements. This has transformed the company’s workforce. Overall the production workforce has declined but the demand for skilled workers, especially technicians, has increased. With increasing automation and systems integration, the company has increased demand for multi-skilled technicians with expertise in mechatronics, robotics, ICT and materials technology. The company has had difficulties in recruiting new entrants with these skills. To address this problem the company has developed a Learning Academy to equip staff with the skills to work in new manufacturing. The Somboon Group has identified a particular need for multi-skilled technicians, which it describes as the “key man,” who is able to work across the company’s operations.

² beg.perspectives, The future of productivity and growth in manufacturing industries, The Boston Consulting Group, 2017

³ Average monthly wages in manufacturing in Thailand rose to 12416.10 THB in the second quarter of 2016. This compares with an average of 8023.65 THB per month in the period 1999 to 2016.

While cost is a significant driver for the adoption of new manufacturing technologies, many larger companies are applying these technologies to improve quality, increase speed to market, comply with international value chain requirements and meet client demand [see Case Study 2].

Case Study 2: The UTAC Thai Group – Automation to deliver quality products

UTAC Thai Group is a leading independent provider of semiconductor assembly and testing services for a broad range of integrated circuits. The company operates three plants and employs 6,000 workers of whom 1,000 are technicians and 400 are engineers. These plants are heavily automated with an excess of 10,000 fully automated machines. Technicians within the plant are expected to commission, maintain, problem-solve and repair these machines and the interconnecting systems. Quality control plays a critical part in each process from the selection of raw materials through to product delivery. Integrated circuits, at the microchip level, are impossible to see with the naked eye so testing and quality control uses sophisticated technology to undertake these tasks. Automated processes enable UTAC to drive quality and meet rapidly changing customer requirements. UTAC has difficulty in recruiting technicians, especially new graduates, who are able to work in this complex environment. Very few graduates, according to the company, have the required work ethic, technical know-how and awareness of modern manufacturing. UTAC has established its own Training Academy to address this ‘skills gap’.

The adoption of new technologies varies across the manufacturing sector. While larger, export orientated companies, such as UTAC and the Somboon, have been relatively quick adopters many manufacturing companies lag behind. A recent Federation of Thai Industries [FTI] study revealed that 75% of Thai enterprises are operating below Industry 3.0 level [see Figure 1].

FIGURE 1: LEVEL OF INDUSTRIAL DEVELOPMENT IN THAILAND

Level of industry	Main component	% of industry
Industry 2.0	- utilizes electrical energy - utilizes conveyor belts for transportation - utilizes machinery that derives power from electricity source	40 %
Industry 2.5	- operates through mass production process, operates with conveyor belts for installation - operates through electrical system controlled by semi-automation relay - operates by controlling of machines through a numeric control system	35 %
Industry 3.0	- utilizes Computer Numerical Control (CNC) - utilizes Programmable Logic Controller (PLC) and Microelectronics for controlling machine operations - utilizes robots for supporting production process - communication between machines of the production line - operates with Enterprise Resource Planning (ERP) system	20 %
Industry 3.5	- operates with a computer that controls the whole operating system of the organization - uses barcodes or Radio Frequency Identification (RFID) to introduce itself for system acknowledgement - operates through Material Requirement Planning (MRP) system - communication conducted through internal network system of the organization	5 %

Source: Federation of Thai Industries (FTI) 2016

Companies operating at Industry 3.0 and below make limited, if any, use of robotics, automation, new manufacturing technologies and materials and interconnected digital communication systems. Data released by the International Federation of Robotics [IFR] showed that the use of industrial robots in Thailand is considerably lower than in other major manufacturing countries in Asia. In 2015, robot density, or the number of industrial robots for every 10,000 workers was 33 in Thailand compared with South Korea [347], Japan [339], and Taiwan [129]. The use of industrial robots is predicted to increase in Thailand. However this will take time, as the purchase of industrial robots is predicted to be much lower in Thailand than in other manufacturing countries in the region.⁴

The FTI and IFR studies indicate that many Thai manufacturers are unlikely to achieve the level of industrial automation and connected systems envisaged in Thailand 4.0 in the immediate future. This has led the FTI to argue that the focus of Thailand 4.0 in the next five years should be on assisting companies to move from Industry 2.0 to Industry 3.0. This, the FTI argues, will require investment in automation, quality control, human resource capability development and industrial applications of information and communication technologies.

The results of the FTI study were reinforced by the Global Competitiveness Report 2016-17. In this global survey, Thailand ranked 63 out of 138 nations in terms of technological readiness. The relatively low level of technological readiness, linked with the high upfront capital requirements for new plant and equipment, the limited awareness of government investment incentives and the lack of skilled personnel are likely to limit the manufacturing sector's capacity to absorb Industry 4.0 technologies. These barriers are well known and a number of initiatives have been put in place through Thailand 4.0 to boost Industry 4.0 readiness. These include: providing investment incentives for companies, developing Industry 4.0 industrial clusters, supporting digital start-ups and improving STEM and technical training provision.⁵

3. SKILLS FOR TECHNICIANS IN INDUSTRY 4.0

While the level of technological readiness in Thailand may be uneven across the manufacturing sector in Thailand, increasing automation and digitisation is beginning to create demand for a new breed of tech-savvy manufacturing technicians. This demand will grow with increasing use of new manufacturing technologies. Policy makers, companies and training providers need to be aware of: [1] how new technologies will change manufacturing processes, [2] the new tasks that technicians will perform, [3] the new tools, technologies and materials that technicians will use, and [4] the generic skills that technicians will require to carry out their roles.

Regardless of the speed and extent of Industry 4.0 adoption, the implementation of new manufacturing technologies will increase demand for technicians who have skills in mechatronics, automation and robotics as well as the ability to transfer these skills to new manufacturing processes. Over time the tools, technologies, materials and machines used by technicians will change. In the future in fully automated plants, "... smart machines will coordinate manufacturing processes by themselves, smart service robots will collaborate with workers on assembly lines and smart transport systems will transfer goods from one place to another. Smart devices, such as tablets and wearables, will be used to gather and analyse real-time information."⁶ In these new manufacturing environments, processing and analyzing data will become a key skill that technicians use in their day-to-day jobs.

⁴ The IFR reported that the shipment of multipurpose industrial robots to Thailand was predicted to increase from 3,657 units in 2014 to 4,500 units in 2019. This compares with shipments to Korea of 24,721 units in 2014 rising to 46,000 units in 2019 and from 3,657 units to 13,000 units in Taiwan during the same period.

⁵ Bangkok Post, ICT pushes drive towards Thailand 4.0, 27 May 2016

⁶ Roland Berger Strategy Consultants, White Paper Summary, Skills development for Industry 4.0, BRICS Skills Development Working Group, Roland Berger GMBH, 2016, page 6.

As manufacturing processes become more integrated, both within and between plants and companies, technicians will require more sophisticated communication, problem solving, time management and team capabilities. The ability to analyze and interpret data from a range of digital sources will be critical. Technicians will perform less manual work and will devote more time to control and supervision functions. Adoption of Industry 4.0 will lead to the disappearance of many low skilled jobs through automation. However as productivity increases and work functions become automated even the number of skilled workers needed to run fully automated plants may decline. The impact of digitization on the skills needs of workers in technical industries was highlighted in the Future of Work report released by the World Economic Forum [WEF] in January 2016.

FIGURE 2: DEMAND FOR SKILLS 2015 AND 2020 SHARE OF JOBS REQUIRING SKILLS FAMILY AS PART OF THEIR CORE SKILL SET

Skills family	Heavily technical industries [Basic and Infrastructure and Energy] (% of jobs)		All industries (% of jobs)	
	2015	2020	2015	2020
Complex problem solving skills	42	33	36	36
Social skills	17	17	20	19
Process skills	10	19	18	18
Systems skills	22	26	16	17
Resource management skills	21	15	14	13
Technical skills	25	20	14	12
Cognitive abilities	10	19	11	15
Content skills	6	13	10	10
Physical abilities	-	-	5	4

Source: Adapted from World Economic Forum, *Future of Work*, January 2016

As indicated in Figure 2, the WEF predicts that nearly a third of all jobs by 2020 will require complex problem solving skills and physical abilities will be a less important feature of most jobs. In many heavily technical industries the need for complex problem solving skills will diminish due to automation. Likewise the adoption of automation and intelligent systems may mean that some technical skills and resource management skills will cease to be part of the core skills requirements in these industries. Interestingly, it is predicted that the need for cognitive abilities, which include mathematical reasoning, visualization and logical reasoning are set to become more important. Systems, content and process skills, which include abilities such as judgement and decision-making, systems analysis, ICT literacy, communication, and critical thinking skills will also become critical. The need for technicians with these skills is becoming more pressing as manufacturing companies automate and integrate their production and distribution processes.

Case Study 3: The Betagro Group – Automation driving job opportunities for multi-skilled, IT savvy technicians

The Betagro Group is a leading agro-industry and food business in Thailand. The company is highly vertically integrated with its operations covering all aspects of the food supply chain, ranging from animal production through to food retailing. Betagro operates a network of semi-automated and fully automated feed mills. The company's fully automated plants employ latest technologies to: [1] synchronize, control and monitor all machinery and processes, [2] link their plants directly to their in-house resource planning software so that information flow is real time and accurate, and [3] operate the plants using process control software and PLCs. The establishment of fully automated plants, which include the use of industrial robots, has increased the company's demand for multi-skilled technicians, who possess: strong mechanical and electrical skills, ICT awareness, diagnostic skills, system troubleshooting skills and maintenance technology skills. The company's demand for technicians has increased while its need for semi and unskilled labor has declined. Betagro reports that a new fully automated feed mill will require 20 to 30 workers, half of whom will be technicians, whereas a comparable conventional operation requires up to 200 workers.

4. INTERNATIONAL RESPONSES TO ADDRESSING THE SKILLS REQUIRED TO SUPPORT INDUSTRY 4.0

Countries across Europe, America and Asia have initiated industry and skills policies designed to boost Industry 4.0 readiness.

The German government has contributed over €200 million to the Industrie 4.0 initiative that is the centerpiece of its High-Tech Strategy 2020 Action Plan. This initiative has brought together representatives of government, industry and education to develop and implement a 15-year plan for applying new digital technologies in industry. A Work, Education and Training Working Group is focused on how people work and learn in Industrie 4.0. Currently the group is investigating three key issues: [1] designing human-machine interfaces, [2] facilitating working and learning in Industrie 4.0, and [3] developing training and qualification programs that address operational skills, process oriented learning and new forms of learning.

The Swedish Government has released a Smart Industry strategy. One of the four pillars of this strategy is the skills required by advanced manufacturing industry. To meet these requirements the strategy sets out to: [1] promote student interest in STEM, [2] improve the match between industry's labor requirements and the education system, [3] develop the capabilities and skills required to support the transition to a digitalized economy, [4] support lifelong learning, and [5] promote pathways between education and work.

The Future of Manufacturing Report, which was released in 2013, in the UK, highlighted the increasing reliance of British manufacturing on high skilled workers. The authors of the report argued that there is a need for a highly talented, skilled and flexible workforce and that to achieve this effort must be made to boost the number of young people doing STEM subjects, equip future workers with high quality technical and soft skills needed by industry and counter the current poor perception of manufacturing industries. In response to this latter objective, the UK Government has launched the Make it in Great Britain and the See Inside Manufacturing Campaign to bolster awareness of manufacturing industry amongst students, teachers and careers counsellors.

In the USA, the public-private Advanced Manufacturing Partnership [AMP], drew together representatives of industry, education and government to advise the President on how emerging technologies could create high quality manufacturing jobs and enhance the global competitiveness of US manufacturers. In its report, the AMP identified three key areas in which action is required: enabling innovation, securing the talent pipeline, and improving the business climate. In addressing the second area, the report argued that the adoption of new manufacturing technologies requires a highly trained and flexible workforce as well as a commitment to both entry-level and ongoing workforce training. In response, a host of private and public organizations in the USA have launched programs designed to address the entry-level and ongoing skill needs of technicians and engineers and improve the understanding of teachers and trainers of modern manufacturing industry.

The Government of Singapore, through the Economic Development Board [EDB], has adopted a three-point strategy for promoting faster adoption of Industry 4.0. This focuses on [1] enabling technological capability development, [2] transforming industries and enterprises, and [3] equipping the workforce with Industry 4.0 capabilities. The third component of the strategy focuses on identifying and responding to industry skill needs and providing support to companies, workers and new entrants through initiatives such as the EDB's Job Creation and Capability Development Framework and the Ministry of Education's STEM Applied Learning Program.

Japan's response to Industry 4.0 is an initiative involving 30 large Japanese companies called The Industrial Value Chain Initiative. This will create standards for technology to connect factories, manufacturing processes and communication networks worldwide. The Internet will connect all information systems at participating small, medium and large companies. The Internet of Things (IoT) will facilitate the synchronization of all procurement, production, distribution and after sales processes. Fully automated, autonomous interconnected machines will undertake production tasks that will be overseen, programmed and maintained by highly skilled technical staff.

Korea has established Innovation in Manufacturing 3.0. The strategy has two broad goals: [1] technological advancement and [2] the dissemination of 'smart factory' technologies. By 2020, 1,500 smart factories will be established across the country. A prototype 'mother factory' has been established in which IoT and Cyber Physical Systems power the entire production process. Skills training and upgrading of technical staff is a key focus of the initiative.

In Taiwan, the government is planning to spend US\$1.12 billion over the next nine years as part of its Productivity 4.0 project to boost the country's role in the global supply chain, diversify its production base and support the introduction of smart factories. It is intended that this will lead to a 60% increase in the per capita productivity of Taiwan's manufacturing industries by 2024. To support this development, the Taiwanese Government has supported a range of initiatives aimed at growing the nation's Industry 4.0 skills base. These include [1] reforms to the national training system, [2] the provision of tuition subsidies for vocational students, [3] supporting the development of vocational training programs in areas such as digital control, the Internet of Things, big data and cloud computing, [4] fostering linkages between vocational schools and industries focused on Industry 4.0 technologies, and [5] establishing a Smart Machinery Promotion Office.

All countries implementing Industry 4.0 are facing problems in ensuring that industry has an adequate supply of manufacturing technicians. In responding to this challenge virtually all countries have put in place skills strategies directed at: [1] identifying the skill needs of companies implementing Industry 4.0, [2] supporting the development of new education and training programs that provide the mix of engineering, ICT and soft skills required by manufacturing technicians, [3] increasing young people's awareness of technical careers in manufacturing, [4] developing training pathways that link schools and work, [5] developing partnerships between industry and education providers, [6] developing the awareness of teachers and trainers of new manufacturing, and [7] strengthening STEM provision at all levels of education and training.

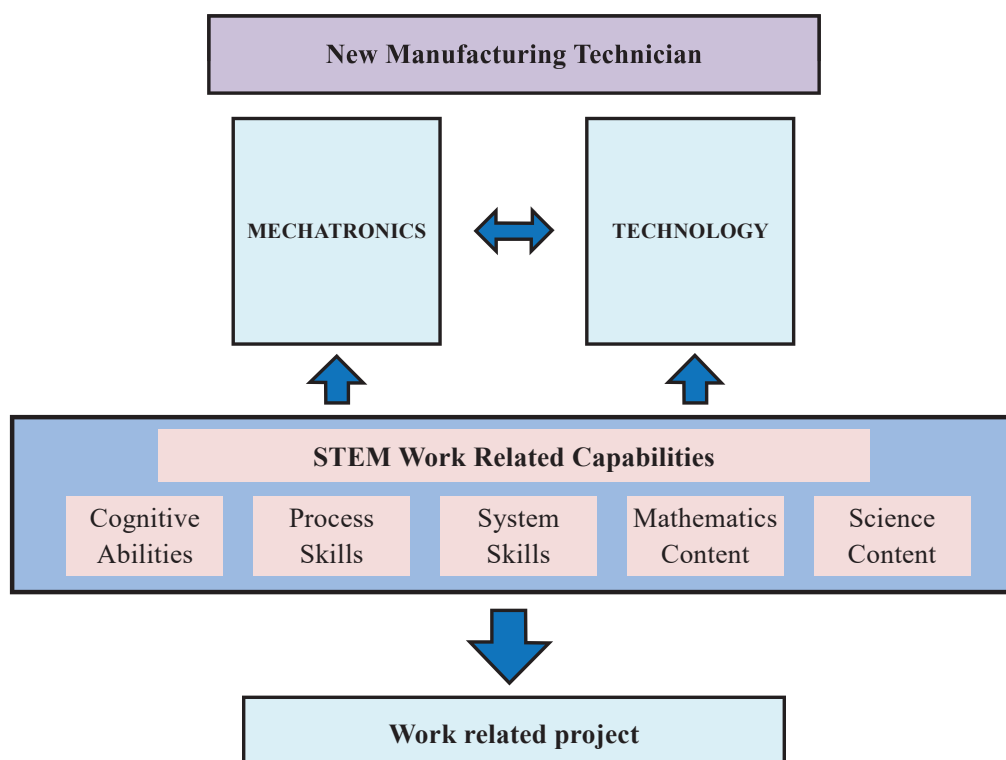
5. PREPARING THE NEXT GENERATION OF TECHNICIANS FOR INDUSTRY 4.0

Preparing the next generation of technicians will require a focus on new skills, new ways of delivering entry level training and new skill development partnerships between training providers and companies in Thailand. The following six recommendations set out a program of activities designed to ensure that there is a ready supply of Industry 4.0 ready technicians.

Recommendation 1 - Provide an entry-level program to produce Industry 4.0 ready technicians

Countries moving to Industry 4.0 are implementing new entry-level technician training programs. It is proposed that the Government of Thailand, through the Office of Vocational Education Commission, establish a similar program. The STEM Through Technology Program, which is detailed in Figure 3 and Appendix A, provides an example of an integrated program in which students acquire the Mechatronics, Technology and STEM competencies required for work. In this program, mathematics and science competencies are viewed as enabling tools that students use to solve practical engineering challenges. In addition, manufacturing technicians need cognitive abilities and system and process skills to analyze and respond to challenges in both the plant and other components of the value chain. These STEM work-related capabilities are embedded in the STEM for Technology Program and are reinforced through the work-related project. The program, which should form an elective in Years 13 -14 in OVEC Colleges, is underpinned by an applied learning teaching methodology. The program: [1] is hands-on and project orientated, [2] uses an integrated delivery model, [3] ensures that STEM competencies, including physics and mathematics, are taught in a work context, [4] focuses on team based, problem solving activities, [5] emphasises the use of technology, [6] is delivered by a team comprising a technical teacher, a STEM teacher and an industry advisor, and [7] engages all students in a real work project.

FIGURE 3: STEM THROUGH TECHNOLOGY PROGRAM



Recommendation 2 - Provide resources to support the STEM through Technology Program

Adequate resourcing is a precondition for the success of any new program. This is especially important where new technologies and new approaches to teaching and learning are being introduced, as is the case with the proposed STEM through Technology Program [see recommendation 1].

Providers will require an integrated learning space and associated learning and assessment resources that will enable students to engage in individual research, team problem-solving, practical design, construction and testing tasks, and online video conferencing. New technologies must be provided that allow groups and individuals to engage in working with integrated and automated systems relevant to manufacturing. The proposed STEM through Technology Program will use an integrated delivery model that may be new to many OVEC teachers. In an integrated learning environment there is less emphasis on direct teaching and much greater attention is given to self-directed learning. Teachers are likely to need professional development and mentor support to implement this new approach.

Industry will be a critical resource in this program. Providers will need strong links with local companies to support the program. It is envisaged that companies will participate in the program design and delivery, act as a major source of ideas for the work-related project, and provide opportunities for students to undertake structured work experience.

Recommendation 3 - Select OVEC schools to trial the STEM through Technology Program

The STEM through Technology Program should only be offered in OVEC schools that are located in key manufacturing regions in Thailand. Within selected schools only students who are intent on pursuing technical careers in manufacturing industry should engage in the program.

Recommendation 4 - Build the capability of teachers and trainers

Vocational teachers have a critical role to play in building the Industry 4.0 readiness of students. However they face major challenges. These include: their own lack of knowledge of manufacturing industry and Industry 4.0, the inadequate STEM skills of students, the poor image of vocational training, and the limited confidence which industry has in provider based technician-training programs.

Addressing these constraints and developing the capability of vocational teachers requires joint work by teachers, manufacturing companies and government. Teachers must maintain current knowledge of manufacturing technologies and work practices, visit local companies to understand their skill needs, and participate in Industry 4.0 related professional development. Manufacturing companies must provide work experience opportunities for teachers, invest in the skills of workplace trainers, and support curriculum enhancement initiatives directed at improving the industry relevance of technician training programs. Government must invest in program development and teacher capability building in relation to Industry 4.0 awareness, STEM, teachers' technical and teaching competence, and industry-school collaboration. As part of this, the Thai Government should leverage its relationships in ASEAN and the broader region to secure international study and work opportunities for vocational teachers in Industry 4.0 focused companies and institutions so that they can acquire the technical and instructional competencies needed for Industry 4.0 implementation.

Recommendation 5 - Establish a new training partnership to develop technician skills

The vocational training system, including both private and public providers, cannot provide all the skills that technicians require for Industry 4.0. However, the system should ensure that all graduate manufacturing technicians have the skill set embedded in the proposed STEM through Technology Program. This includes: [1] an awareness of modern manufacturing, [2] foundation skills in mechatronics and technology and [3] a core set of the STEM work related competencies [see recommendation 1].

This will require a new training partnership between industry and the vocational training system. In this partnership, the training system should ensure the Industry 4.0 readiness of all graduate manufacturing technicians and companies should provide the graduates with specialized skills training and ongoing skills development. Such a partnership would build industry confidence in the outputs of the vocational system, enable companies to focus their training efforts on higher-level skill development and ensure that scarce training resources are effectively targeted.

Case Study 4: CHEVRON – Getting the right mix in private and public investment in skills

CHEVRON [Thailand] is a major natural gas and crude oil producer. The company directly employs about 1,600 people or 25% of its workforce with the remaining 75% being engaged through direct contracts and sub contract arrangements. CHEVRON [Thailand] employs a small, highly skilled group of technicians. In selecting these staff the company places a high value on the technician's awareness of occupational health and safety, work attitude, technical competency, and ability to learn, particularly in relation to technology. The petroleum / natural gas sector is capital intensive and training costs are seen as a relatively small contributor to the company's overall cost of operations. This enables the company to fully fund the skills development of its technicians.

This has led CHEVRON [Thailand] to question whether government should fund specialized skills development in the petroleum / natural gas sector for the technician level workforce or focus its scarce resources on providing young people with broad, industry relevant, entry-level technician competencies that can be built on through in-company training.

Recommendation 6 - Build awareness of technician careers in manufacturing industry

Public perceptions of manufacturing industry in Thailand are often negative and there is little awareness of the range of creative, high-skilled and technology-driven jobs in manufacturing companies. These perceptions have an adverse impact on the ability of manufacturing companies to attract both skilled workers and new entrants. The adoption of Industry 4.0 will increase demand for people in manufacturing companies who are IT savvy and have high level technical and STEM skills. Attention must be paid to building awareness of the career opportunities for technicians in manufacturing industry and in taking steps to address negative, limited and out-of-date perceptions of the sector.

A public awareness campaign should be developed that targets four core audiences: learners, parents and families, career advisors, and teachers. This audience specific campaign should provide information on Industry 4.0, the work of manufacturing technicians, the entry level training options for technicians, and career progression. The program should draw on experience from other countries, including the USA [Dream It! Do It!], the UK, [Make it in Great Britain] and Australia [Young Engineers Australia], to identify successful strategies for promoting technician careers in manufacturing.

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APPENDIX A - OVERVIEW OF THE STEM THROUGH TECHNOLOGY PROGRAM

MECHATRONICS [80 hours]				
Technical Skills and Knowledge				
Units	Content			
Drivers of change in Thai manufacturing	• Industry 4.0 • Product quality	• Competitiveness • Reduction of waste	• Cost reduction • Environmental impact	
Mechatronics awareness	• Definition of mechatronics	• Mechatronics components	• Mechatronics examples • Functions of mechatronics system	
Units used in manufacturing	• Metric units • Manufacturing cycle time	• Metric prefixes for small and large numbers • Throughput	• Cost per unit • Yield • Rejects	
Precision instruments and measurement	• Vernier callipers • Micrometer • Temperature gauges	• Multimeters • Pressure gauges	• Dual Oscilloscope • Flow meters, types and uses	
Electricity and electronics	• Voltage, current, resistance in a manufacturing plant • Inductance, capacitance use in industry	• Electricity generation • Digital Techniques • Electronics for Industry	• Electric motors and generators • Transformers • Electric circuits • Electric drives • Fault finding tasks	
Fluid power in manufacturing	• Hydraulic actuators • Hydraulic pumps	• Hydraulic control valves	• Hydraulics use in manufacturing	
	• Pneumatic system • Compressors • Directional control valves	• Pneumatic cylinders • Pressure control valves	• Pneumatics applications in manufacturing	
Robotics in manufacturing	• Development of robotics • Types and applications of industrial robots	• The 4D’s of robotics • Robotic components	• Classification of robots • Advantages of robots	
Sensors and vision systems	• Types of sensors • Operation of sensors	• Use of sensors in an automated plant • Types of vision systems	• Use of vision systems in an automated plant	
STEM Work Related Capabilities				
Cognitive Abilities	Process Skills	System Skills	Science Content	Mathematics Content
• Logical reasoning • Mathematical reasoning • Visualization Problem solving • Creativity	• Critical thinking • Collaboration • Active listening • Negotiation • Persuasion • Presentation and reporting • Information sharing • Team orientation	• Judgement and decision making • Systems analysis	• Heat transfer • Pascals Principle • Boyles Law • Charles Law • Basic electricity • Force, weight, mass, pressure, work and energy • Diffusion and dispersion • Electromagnetism • Magnetic induction	• Metric units of length, area, volume • Rotational measurement • Prefixes of metric units • Ratios and proportions • Percentage • Fractions and decimals • Geometric calculations • Trigonometric calculations • Equations

TECHNOLOGY [80 hours]				
Technical Skills and Knowledge				
Units	Content			
Business software applications	• Technical reports • File storage and manipulation	• Technical presentations	• Gantt chart development and interpretation	
Digital communication devices and methods	• Computers • Laptops • Tablets • Cell Phones • Search engines • Social media	• YouTube • Email • Short Messaging System • Instant Messaging • Multimedia Messaging System • Forums	• Weblogs • Wikis • Video conferencing • Virtual learning environment	
Data storage and analysis	• Data storage devices • iCloud • Internet of Things	• Interpreting digital data - simulation screens, sensors, safety alarms & production outputs	• Analyzing data and determining response	
Quality monitoring technology	• Quality systems	• Monitoring technology	• Data representation • Interpreting quality data	
PLC introduction	• PLC hardware • PLC software	• Digital inputs, • Digital outputs	• Safety practices	
Industrial programming	• Ladder logic • Ladder notation	• Basic ladder programming • Latch logic	• Relating ladder logic to real industrial applications	
	• Timer representation	• Ladder diagram with timer • Delay on timer	• Delay off timer • Applications in industry	
	• Counter representation	• Ladder diagram with counter • Counting up	• Counting down • Application in industry	
PLC - Wiring	• PLC power supply	• Wiring inputs to PLC	• Wiring outputs to PLC	
STEM Work Related Capabilities				
Cognitive Abilities	Process Skills	System Skills	Science Content	Mathematics Content
• Logical reasoning • Mathematical reasoning • Visualization Problem solving • Creativity	• Critical thinking • Collaboration • Active listening • Negotiation • Persuasion • Presentation and reporting • Information sharing • Team orientation	• Judgement and decision making • Systems analysis	• Basic electricity • Electric circuits • Circuit protection • Magnetic induction • Optics • Lasers	• Boolean expressions • Units and unit conversion • Graphical representations and interpretation • Use of parenthesis • Developing formulae • Statistics

WORK RELATED PROJECT [40 hours]	
Students undertake a team based capstone project that requires students to complete a real work task that involves: • using hydraulic and pneumatic actuators • employing at least three types of sensors as inputs to a PLC • wiring a PLC to inputs and outputs [motor] • PLC programming that includes a timer and counter	• using measuring devices to test input and output signal levels • connecting and fault-finding the system • writing a technical report on the system development and operation using a word processing package • preparing and presenting an electronic presentation on the project.

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