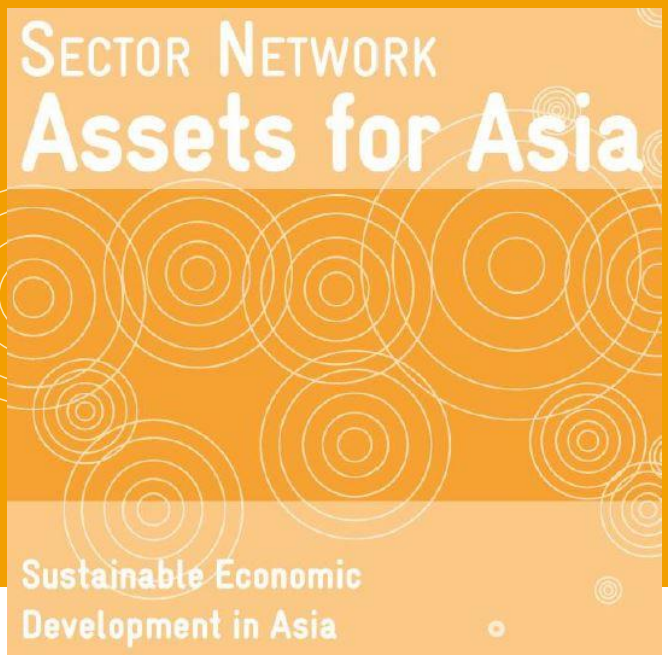
Innovate for the Future of Learning

- An assessment on the Effects of Digitalization and the COVID-19 Pandemic on the Practice of in-company Training



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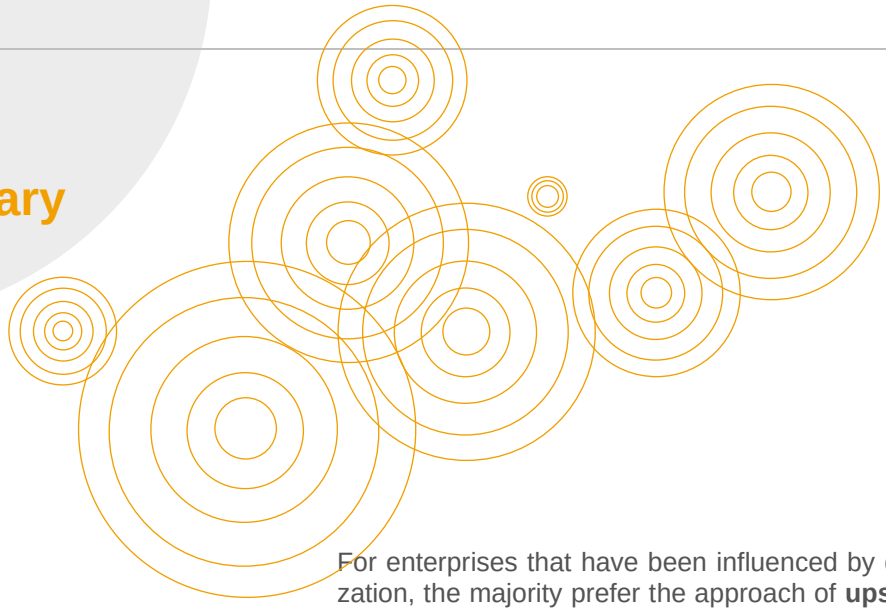
Executive Summary



Digitalization is having significant impacts on global labour market. Industry's demand for workers' skills is therefore undergoing constant change. COVID-19 pandemic is making the scenario much more complicated.

Existing research has revealed a rather complicated picture concerning the impact of digitalization on the labour market. Despite disparities, consensus indicates that **professional competencies** concerning digitalization (such as knowledge on information and communication technology, algorithms, automation, ability for software development and security, data analysis, general systems theory) as well as some **transferable skills** (such as problem solving, teamwork, collaborative work, initiative, communication, innovation, adaptability, flexibility and self-management) are necessary to fulfil works in the context of digital transformation.

Both China and ASEAN countries are making progress in the digital transformation of industries despite variations in its degree. For the majority of the manufacturing enterprises in the regions, **digitalization is largely a development process** where its definitive influence on the shop floor workers are yet to be explored.

Empirical investigation in this study demonstrates that the degree of digitalization in Chinese and ASEAN companies vary considerably. And the resulting impact on **competence requirements of shop floor workers is rather moderate**. For some companies, impact on shopfloor workers is only notable in the sense that their tasks change evidently; for most, the **impact is more prominent on the engineers i**nstead of the shop floor workers, whose tasks remain largely the same. The findings of the questionnaires and interviews are consistent with the empirical investigation that - in both China and ASEAN - digitalization has **not led to serious skill challenges on shop floor workers**.

For enterprises that have been influenced by digitalization, the majority prefer the approach of **upskilling existing workers** to other measures to cope with the challenges. They have applied various skill upgrading strategies, such as developing online **micro-courses**, teaching more relevant theoretical knowledge (on intelligent manufacturing equipment, etc.), establishing **stronger cooperation with college**s etc. New training methods (e-learning, blended training, face-to-face training, flipped classroom) and technologies (for instance simulation, digital labs, remote coaching) being applied in both China and ASEAN have been effective, but not without challenges. For instance, lack of understanding of the methods and technologies, lack of preparedness of the trainers for the new methods etc. The traditional way of apprenticeship remains the most effective method of training for some companies, due to factors such as safety and the protection of intellectual property.

Some **innovative approaches** are applied by both Chinese and Thai company. For instance, companies having difficulties finding qualified research personnel have **strengthened cooperation with universities and colleges**. By financing and conducting **joint research projects**, the postgraduate students help the companies as "external brains" to tackle technical problems and promote innovation.

Besides increased competence requirements for shop floor workers, the empirical investigation has also verified the potential **skills-displacing** (i.e. some tasks are replaced) or **skill-degrading** (i.e. low skilled work remains or even increases) effects revealed by some the literature. This means digitalization does not necessarily lead to an increase on the level of skill requirements for workforces. Thus, the **incentive for improvement of vocational training** for shop floor workers is missing and these companies have done very little in this regard.

Interviews with Chinese governmental agencies demonstrates that governments at different levels have taken measures to foster the digital transformation of the enterprises, such as **diagnosis of degree of digitalization**, **financial supports**, **business**

solution plans, manager training as well as supports in **apprenticeship program. Industrial parks**, which has been a common practice to attract investments and promote productivity in China also conducted various programs and activities to foster the industrial transformation and upgrading.

The study has drawn the following recommendation for TVET stakeholders.

- Skill upgrading strategies should consider the development stage of the corresponding industry and company.

- Vocational schools should design adjustable and flexible education program, so that it can be adaptive and better prepare students for the unforeseeable technological change.

- Government should provide supports for enterprises striving for digital transformation, especially for SMEs which may have grave difficulties (due to lack of finance or competent workforces) in applying digital transformation and could be in a vulnerable situation when digitalization happens.

The findings of this investigation could offer the following implications for future GIZ projects.

- In order to better understand the reality, and to improve the appropriateness of the project, preliminary researches should be done before planning and carrying out projects if possible.

- The project should develop customized programs to cope with partners of different industries and developmental phases.

- Mutual communications and visits among partners at different stages of development of digitalization could contribute to the better understanding of each other and therefore form a more systematic and whole view of the subject matter.

- To tackle some of the difficulties encountered by enterprises, some support measures and activities could be carried out, for instance the improvement of training of the trainers, the development of training guidelines or handbooks relevant to training methods and technologies, or even the provisions of training equipment if necessary and possible.

Chapter 1 Introduction

1.1 Background

Rapid technological development such as digitalization is having significant impacts on our lives as well as the labour market. Industry's demand for workers' skills is therefore undergoing constant change. Meanwhile, globalization and regional integration has made communication, interaction and mutual learning between different regions increasingly important and necessary. COVID-19 pandemic is making the scenario much more complicated.

ASEAN and China have developed ever stronger economic relationships in the past decades, now they are among the largest trading partners to each other. Therefore, it is of great value to deepen the understanding between China and ASEAN in relation to issues such as labour market requirements, in-company training as well as vocational education practices.

Thus, it is meaningful to investigate the changing practice of re-skilling and up-skilling of workers in the context of constant change and development of manufacturing in China and ASEAN with consideration to the specific challenges imposed by the COVID-19 pandemic.

Against this background, this research is conducted, with the aim of gaining more insights and understanding of the ongoing developments of labour market skill requirements and the corresponding actions taken by industry so deal with these changes.

1.2 Research Objectives

Under the influence of digitalization, industries are undergoing changes in various forms. With the spread of COVID-19 pandemic, the changes could have even more influence on the labour market. This research aims to shed some light on the changing practice of skill development of workers in both China and ASEAN under the influence of digitalization, with the focus on the manufacturing industry.

The research focusses on traditional hot spots of advanced manufacturing in selected industrial cities in China and ASEAN. These areas see advances in digitalization and the provision of a qualified workforce key to sustain social stability as well as an opportunity for further investment and economic development.

Based on the research results gained from literature review and empirical analysis, this study endeavors to provide some recommendation for TVET stakeholders and some suggestions/ implications for GIZ concerning future TVET programs.

Based on the above mentioned research objectives, the investigation attempts to answer the following questions.

1. What are the impacts of digitalization on the skill requirements of shop floor workers in manufacturing companies[1] in China and ASEAN?

2. With the influence of digitalization, what are the current issues and developmental trends in training in the selected industries in both China and the selected ASEAN country?

3. To what extent do intra-company and inter-company training centers already carry out skills upgrading for technology change such as digitalization? To what extent they provide re-skilling and up-skilling of the existing workforce?

4. Which innovative technologies are applied in training programs (simulation, digital labs, remote coaching, etc.)? What role do private (Chinese and foreign) providers of teaching and learning technology play in the promotion of innovative approaches? A particular focus may highlight the role of German Industry 4.0 training providers in China and how

[1] Shop floor worker in this report refers to all the workers who work on the shop floor instead of offices. They include skilled workers (workers who certain level of vocational knowledge and skills; they normally have some official vocational education training and possess a vocational certificate) as well as unskilled workers who do not have vocational skills and have normally received only general basic education.

similar approaches are being adapted in comparable sector in the ASEAN region.

5. Which mix of training methods (face-to-face, e-learning, blended learning, flipped classroom, etc.) is applied and with what success? How has the training practice changed with COVID-19?

6. What recommendation can be drawn from the above research results for TVET stakeholders? What suggestions and implications can be drawn for GIZ concerning future TVET programs?

1.3 Methodology

Desk research was carried out to obtain basic information and understanding about the nature of digitalization and its influence on the skill requirements and vocational trainings in manufacturing industries. General relevant information was gathered, but the emphasis was put on information concerning China and ASEAN.

Due to the lack of empirical ecidence on the impact of digitalization on vocational training in China and ASEAN, some empirical methods were cairred out to obtain more first-hand information.

Firstly, online questionnaires were developed and applied, which were distributed via social- network and other online means. With its reliability and validity of the questionnaire be tested, the questionnaire could provide some first-hand quantitative data.

Secondly, Interviews were also implemented to gain in-depth and comprehensive understanding of the issues investigated. Interviews were mainly carried out with the human resource department of the company, as well as the relevant government officials. Field trips are carried out in combination with workshops in selective pilot cities of LP4.0 project. Some of the interviews in China and all interviews with ASEAN companies were conducted in online form.

Chapter 2 Technological change and its influence

Technological change does not influence vocational training directly, it is realized and achieved through a logic chain of events: technological change lead to industry's change in business and production, the accumulation of which can affect the structure of labour market; meanwhile, the changed business and production modes and methods result in the change of work content of workers, which bring about the changed requirements for workers' knowledge and skills; eventually, the transformation of skill requirements make enterprises change their vocational training practices. In this chapter, the above mentioned aspects are discussed, with supports from existing literature.

2.1 The nature and characteristics of digitalization and its impact on business and production

In this report, we only investigate digitalization in its direct reference to manufacturing industry, in this sense, it very often relates to or is replaceable with the concept of "Industry 4.0", which generally refers to the revolution in manufacturing industry where factories integrate production machines, wireless connectivity and sensors and link these to a system platform ecosystem that can oversee the whole production line process and execute decisions autonomously. This transformation includes elements such as big data, autonomously operating systems, cloud computing, social media, mobile and self-learning systems (IAB 2015).

Industry 4.0 is not an isolated event that takes place on its own, but rather a continuation of last several industrial revolutions; its development is more of an evolutionary process than a revolution. It can be understood as a rigorous implementation of the knowledge and technologies from the 3rd Industrial Revolution, while fundamentally rethinking the functionality of production facilities, leading to changes in the work environment as well (IAB 2015).

Under the influence of digitalization, firms are increasing their application of intelligent and digital technologies to improve productivity. Meanwhile, new platform-based business forms are emerging, creating value by establishing network effects between customers, producers, and providers, facilitating interaction in a multilateral model. Compared to traditional businesses, digital platforms achieve faster scale up and at lower cost while constantly spawning new service segments, large databases, and activity forms. (World Bank,2019)

With the transformation of business and production modes and methods, which was brought by, jobs are redefined. The changing shape of the business inevitably affects the changing nature of work, which is now defined in new ways, including new work organization, work patterns and work models. Increasingly, people can complete work tasks from home without having to travel to a fixed location. A good example is the change that comes with the rise of platform economy, which has more short-term tasks than ever before, therefore the work of many workers become more fragmented, while its mobility increases.

2.2 The impact of digitalization on labour market

New technologies such as digitalization are profoundly influencing the labour market, changing industry's demand for skills. But how exactly would industry's requirements for workers' knowledge and skills change due to technological advances? Previous researches have indicated that, with the impact of technological change, different scenarios of labour market could emerge.

The first scenario, which is also the most widely discussed scenario, can be summarized as the Skill-Biased Technological Change argument, which indicates that technological progress is skill-biased, leading to an increase in high-skilled workers and higher wages while low-skilled workers are gradually replaced. It is therefore biased in favor of high-skilled workers. The corresponding explanation is related to the theory of skill-biased technological change.

Algorithms for big data are now rapidly entering domains reliant upon pattern recognition and can readily substitute for labour in a wide range of non-routine cognitive tasks (Brynjolfsson and McAfee, 2011). In

addition, advanced robots are gaining enhanced senses and dexterity, allowing them to perform a broader scope of manual tasks. This is likely to change the nature of work across industries and occupations.

The most obvious change is the replacement of machines with people. Some researchers examined how susceptible jobs are to computerization, illustrating that around 47% of total U.S. employment was in the high-risk category, which include most workers in transportation and logistics occupations, together with the bulk of office and administrative support workers, and labour in production occupations. (Frey & Osborne, 2017).

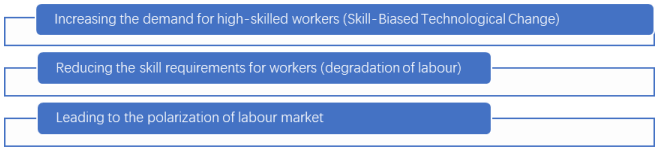
The second possible scenario is the degradation of labour. The theoretical analysis was represented by the American sociologist Braverman, who argued that, the separation of concept and execution through scientific management in modern enterprises had deepened the division of labour in the manufacturing process and led to the degradation of labour, therefore reducing the number of skilled workers.

In this situation, it was management rather than workers plays a decisive role in the production process; the general tendency in the development of the labour process is to transfer the full knowledge of the production process to management itself and the skills and techniques to machines and tools. As a result, workers would gradually become "unskilled" people who do not possess higher skills and techniques (Braverman 1974, pp103-112).

This scenario can also be observed in the reality of Chinese production. In many factories, each assembly line produces one or a few products simultaneously, and workers at each station were required to perform only one or a few simple operations, and to repeat these actions for more than 12 hours. Even under the current circumstances of technological changes, decrease on the requirements of operating workers' competences are very common. (Xu 2019).

Contradictory it might seem, the above mentioned two scenarios may take place simultaneously, which lead to the third possible scenario, which can be summarized as the polarization of labour market, where the impact of the technological change on labour market is bipolar, the reduction of jobs at the medium end of the skill spectrum coincides with an increase in jobs at the high and low ends of the skill spectrum.

In summary, new technologies such as digitalization are profoundly influencing the labour market, changing industry's demand for skills. Previous researches have indicated that, with the impact of technological change, different scenarios of labour market could emerge: under the Skill-Biased Technological Change scenario, the requirements for workers' competences would increase; under the "degradation of labour" scenario caused by the increasing separation of concept and execution, the requirements for workers' competences may decrease; under the "polarization of labour market" scenario, the reduction of jobs at the medium end of the skill spectrum coincides with an increase in jobs at the high and low ends of the skill spectrum. Under different scenarios, industry's skill requirements for workforces may vary substantially, which could lead to different strategies of skill development on the company level.



Graphic 1 Three possible scenarios of digitalization's impact on labour market

2.3 Industries' changing skill requirements under digitalization

With the transformation of business and production, as well as the change of labour market that is brought by technological change such as digitalization, industries' skill requirements have also changed correspondingly.

There've been a relatively large amount of researches studying the skill requirements in the context of digitalization. Based on literature review, some scholars have summarized the major categories of competencies required for the Industry 4.0 workforces as follows: technical competencies (state-of-the-art knowledge, technical skills, process understanding etc.), methodological competencies (creativity, entrepreneurial thinking, problem-solving, decision making etc.), social competencies (intercultural skills, language skills, networking skills etc.) and personal competencies (flexibility, ambiguity tolerance, ability to work under pressure etc.); they also developed a scale describing the required levels of each competencies (Hecklau, Galeitzke, Flachs & Kohl 2016).

A recent study attempts to identify what competencies are identified in the literature as necessary for Industry 4.0 by conducting a scientific mapping of literature related to the qualification of professionals for industry 4.0. The conceptual map developed showed that the main competencies needed include skills: (leadership, strategic vision of knowledge, self-organization, giving and receiving feedback, proactivity, creativity, problem solving, inter-disciplinarity, teamwork, collabourative

work, initiative, communication, innovation, adaptability, flexibility and self-management) and knowledge of contemporary fields (information and communication technology, algorithms, automation, software development and security, data analysis, general systems theory and sustainable development theory) (Kipper etc 2021).

An investigation of industry representatives and experts carried out by Universities of the Future indicated that the competencies required for industry 4.0 consists of mainly two sets of competencies: (1) discipline-specific knowledge on engineering, business and design; (2) transferable skills, which includes ability for continuous learning, system thinking, business thinking, technological literacy, soft skills and problem-solving skills; based on this, the scholars developed a transferable skills framework for industry 4.0 (Universities of the Future 2019).

The literature review above indicates that digital transformation could lead to changes of skills requirements on workforce. Despite some disparities in concrete competencies among the literature, a certain degree of consensus exists in the sense that professional knowledge concerning the latest technologies as well as some transferable competencies, such as the ability to learn, entrepreneurial thinking, problem-solving and flexibility, are necessary to fulfill works in the context of digitalization.

Chapter 3 Status quo of application of digitalization in China and ASEAN and its implications

What is the status quo of the application of digitalization in manufacturing in China and ASEAN? To what extent is this crucial technological change taking place in the region? What differences are there between China and ASEAN? What are the implications of these changes and differences for vocational training? In this chapter, we attempt to answer these questions.

3.1 Status Quo of application of digitalization in general

As everyday life of billions of people is becoming increasingly digitalized due to the widespread of smart phones and social media etc., the depth and degree of digital transformation in the manufacturing process varies significantly across the globe.

Taking Industry 4.0 for example. In Germany, where the concept of Industry 4.0 was initially invented, around half of the companies are already using technologies of the 4th industrial revolution, but only 5% of the production and only 8% of the office and communication equipment can be attributed to these technologies; however, in general, the trend towards 4.0 technologies is increasing significantly (Arntz, Gregory, Jansen, and Zierahn 2016).

In the Asia Pacific region, investigation carried out by IDC and CISCO indicates a complicated image of digitalization of SMEs: the vast majority (84%) of SMBs are struggling to execute their digitalization goals, and slightly more than half of the SMBs are starting to create a digital plan or carry out digital efforts on a tactical level, while 31% of SMBs are still reactive to market changes and have made hardly any efforts to transform digitally; SMBs in the region have accelerated their digitalization in recent years, with 16% of SMBs overcoming critical challenges and reaching rather advanced maturity stages of digitalization in 2020; (IDC& CISCO 2021).

According to this study, about 70% of SMBs in Asia Pacific are accelerating their digitalization in response to COVID-19, with more than half of the SMBs expecting that over 1/5 of their business will be digitalized by 2021 (IDC& CISCO 2021).

In 2020, Singapore, Japan, and New Zealand continue to lead, with no change in their ranking in digital maturity compared to 2019; mainland China, Taiwan, and Thailand have surpassed Korea, Hong Kong, and Malaysia, respectively; Indonesia and Vietnam have also made notable progress (IDC& CISCO 2021).

Despite differences in the industrial development, both ASEAN and some of the major Asia-Pacific countries (China, India, Australia etc.) have reacted to digitalization in their respective policy space, with or without a specific I4.0 strategy; (ILO 2019, p.36)

3.2 Status quo of digital transformation of manufacturing in China

In China, industries have been very active in transforming to a higher level of efficiency and productivity, and the Chinese government, which regards innovation as the major source of modernization, has also set ambitious goals for the next decades. In March 2021, China's 14th five-year plan listed the development of seven key "frontier technologies" as the nation's top policy priority: artificial intelligence (AI), quantum information, integrated circuits or semiconductors, brain science, genomics and biotechnology, clinical medicine and health, deep space, deep earth, deep sea and polar research.

Manufacturing contributed 40 percent of China's GDP in 2017. Maintaining this key sector means China's 'Made in China 2025' Industrial Internet of Things (IoT) strategy focuses most on manufacturing than other areas. China has always been willing to make big infrastructure investments to improve its industry's competitiveness. Accenture predicts China's IoT investments could add $196 billion to cumulative GDP in manufacturing industry alone over the next 15 years.

Policies are being introduced across China to encourage factories to conduct "machine replacement". For example, in Guangdong, the Dongguan municipal government has set up a special fund for "machine replacement", funding 200 million yuan each year since 2014 to support enterprises in implementing "machine replacement", with a maximum subsidy of 15% of the total amount of equipment. The Foshan municipal government has formulated the "Foshan Implementation

Plan for Supporting Enterprises to Promote Machine Replacement" in 2015, funding 53 million yuan each year for this project; enterprises purchasing complete sets of automated production lines and production system transformation can receive a maximum subsidy of 1 million yuan. In 2018, the Guangdong provincial government work Report proposed adding about 20,000 sets of applied robots, promoting the digital transformation of 3,000 industrial enterprises. Meanwhile, more than 8,000 industrial enterprises will be guided to implement technological transformation. (Chen Binkai & Ma Yanlai, 2021)

New concepts are not merely appearing in policy documents; industries are currently undergoing profound changes as well. In some industrial sectors and cities in China, robots and other automated equipment become the main protagonists of production, and the composition of the production floor has changed from mostly general operators to a small number of skilled workers. At Foxconn's Kunshan factory in China, where there were around 110,000 workers in 2013, only around 50,000 remained in 2015 after the transition to production using mainly industrial robots. The overall demand for operative workers at the factory has decreased while the demand for high-skilled employees has increased. These high-skilled workers do not just have a single skill but are the complex talents who can operate programming and have the ability to understand and apply the industrial internet. (Xu Hui, 2019)

However, the impact of digitalization on the manufacturing industry is limited, especially among the SMBs. An empirical investigation with about 100 small and middle sized companies demonstrates the following findings: (1) the penetration rate of artificial intelligence and big data applications is rather low: more than two-thirds of the interviewed companies have not yet used artificial intelligence or big data in their production and business activities; (2) penetration rate of smart manufacturing is low as well: less than 18% of surveyed manufacturing companies are building smart production lines, smart workshops and smart factories; (3) the interviewed companies indicated that the main obstacles to digital transformation are high costs and tight funding: 35% of the interviewed companies reported that the biggest obstacle to digital transformation is that service providers charge too much; and 30% of the interviewed companies said that the biggest obstacle to digital transformation is the shortage of funds (Xi, Hu & Xu, 2020).

It is estimated that, by 2030, up to 220 million Chinese workers, or 30% of all the workforce, may need to transition between occupations; demand for skilled professionals may rise by 28%, and for frontline services labour by 23%, while demand declines for manufacturing workers by 27%. In a forecasted midpoint automation scenario, about 516 billion hours of work, or an average of 87 days per worker, may be displaced and need to be redeployed by 2030. This would lead to substantial change of skill requirements as well. The demand for physical and manual skills and basic cognitive skills could fall by 18% and 11%, respectively; while the demand for social and emotional skills and technological skills may rise by 18% and 51%, respectively (McKinsey 2021).

3.3 Status quo of digital transformation of manufacturing in ASEAN

For ASEAN countries, the potential of digitalization gives rise to a commitment "to upgrade their export-oriented industrial sectors from a labour-intensive, low value-added base to capital and skills-intensive, higher value-added manufacturing production that fosters development of a supporting high-tech services sector as well" (ILO 2019, 36).

Despite the optimistic long-term vision, some ASEAN members are facing difficult situations in human resource development. The "global human capital index" developed by World Economic Forum indicates that the ASEAN countries have only partly developed their human capital and are neglecting or wasting between 43 to 27% of their talent (WEF 2017). Some ASEAN countries are experiencing shortages of skilled labour, and the trends indicate that by 2025 more than half the high-skilled jobs in Cambodia, Indonesia, the Lao People's Democratic Republic, the Philippines, Thailand, and Viet Nam—about 25.6 million jobs—may be filled by workers without sufficient qualifications (ILO and ADB 2014).

More importantly, more challenges may come with digitalization process, for the workforces in the region. Investigation has revealed that approximately 56% of all employment in the ASEAN-5 (Cambodia, Indonesia, the Philippines, Thailand and Viet Nam) is at high risk of displacement due to technological change over the next decade or two. Across these ASEAN-5 countries, prominent industries with high capacity for automation are hotels and restaurants, wholesale and retail trade, as well as construction and manufacturing. Industries with low automation risk across the ASEAN-5 include education and training, human health and social work (Chang and Huynh 2016).

Prominent occupations in certain countries face extreme risks of automation. For example, in Cambodia, where garment production dominates the manufactur-

ing sector, close to half a million sewing machine operators face a high automation risk. In Thailand, automation risk is particularly acute for approximately 1 million shop sales assistants. In Indonesia, about 1.7 million office clerks are highly vulnerable to automation. In each of the ASEAN-5, women are more likely than men to be employed in an occupation at high risk of automation. Moreover, less educated workers and employees earning lower wages face higher automation risk. (Chang and Huynh 2016)

The governments in ASEAN are taking measures to deal with the challenges mentioned above. At the 36th ASEAN Summit on 26 June 2020, Heads of State adopted the "Declaration on Human Resources Development for the Changing World of Work", where all ASEAN countries recognize Human Resource Development (HRD) as a key priority of future policy-making in the region. According to the Master Plan on ASEAN Connectivity 2025, through the increase of efficiency, the emergence of new products, services and digital public goods, digital transformation could potentially unleash up to $625 billion by 2030 (8% of ASEAN's projected GDP at the time) (ASEAN 2016).

3.4 Interim summary and its implication for the investigation in the next stage

Both China and ASEAN countries are making progress in the digital transformation of industries. In China, both central and some provincial government policies have given digital transformation of industries high priority. Through various forms of subsidises, central as well as some provincial and local governments have been supporting the digital transformation of enterprises.

However, existing research demonstrates that, there're considerable internal differences in terms of the degree of digitalization among manufacturing companies in both China and ASEAN. For most of the manufacturing enterprises in the region, digitalization is largely a development process which has shown mixed influence on the shop floor workers.

In China, despite the raid technological development, the penetration rate of artificial intelligence and big data applications in manufacturing is rather low, as well as that of smart manufacturing, especially for SMEs and they are still facing considerable difficulties, such as high costs and tight funding. In some ASEAN countries, while digitalization brings new growth opportunities, it also brings risks of job replacement, which could lead to serious unemployment in certain industrial sectors.

Digitalization and tech advancement may lead to different labour market results, for instance the increase of demands for high-skilled workers, the polarization of labour market. It is anticipated that in China and ASEAN, we are more likely to observe the former.

Digital transformation has led to changes of skills requirements on workforce. Despite some disparities in literature, a certain degree of consensus exists in the sense that some professional competencies concerning digitalization as well as some transferable skills are necessary to fulfil works in the context of industry 4.0.

This reality has significant implications for the analysis of in-company training in the next stage, especially for the empirical investigation and the comparison between China and ASEAN. When taking into consideration of the different labour market scenarios under the influence of technological change, the implications can be even more intrinsically complicated and meaningful.

Firstly, the internal variations within China/ASEAN as well as the differences between them in terms of digitalization make it difficult to make scientifically solid and representative comparisons between them. It is therefore necessary to choose companies that are at different stages of digitalization as the target of comparison and analysis, to enhance the comparability.

Secondly, as literature indicates, the possibility of degradation of labour and polarization of labour market exists; thus, it is meaningful to take this possibility into consideration while investigating the impacts of digitalization on vocational training. With this in sight, we should also consider the relationship between technology and skills as well as the role of individual in a more digitalised work environment shall be reflected during the investigation.

Digitalization in China and ASEAN

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However, in China, the penetration rate of artificial intelligence and big data applications in manufacturing is rather low, as well as that of smart manufacturing, especially for SMEs and they are still facing considerable difficulties, such as high costs and tight funding. In some ASEAN countries, digitalization could not only bring new growth opportunities, but also mean risks of job replacement, which could lead to serious unemployment in certain industrial sectors.

Chapter 4 In-company training in manufacturing industry

4.1 Contemporary issues in training in manufacturing companies

4.1.1 Developmental trends overseas

Influenced by the digitalization process, companies around the globe are upgrading their vocational training to cope with the challenges presented. Here a practice in Germany is introduced.

In Germany, the JOBSTARTER plus project “A 4.0 – cooperate training for Industry 4.0” is a good example of such kind to support small and medium-sized enterprises (SMEs) in the metal and electrical industry in West Thuringia, in order to adapt training to the requirements of digitized production. The project developed a process with which companies could assess their potential for 4.0 production; it also trains trainers in methodological and didactic terms together with the company training associations, and introducing new teaching and learning methods, are prepared, tested them and advised the training staff pedagogically at the workplace (BMBF 2017).

The project activities include the following points: information and advice on methodical and didactic further training for trainers on the subject of industry 4.0, in order to minimize acceptance problems with regard to digitization; development and testing of learning- and experimentation-locations as inter-company demonstration possibilities for industry 4.0; successful monitoring and support of the learning process within the company to ensure that the introduction of digitalization elements. At the same time, the project supports the introduction of industry 4.0 production systems that are already used in training; supporting the companies which carry out trainings and vocational schools in the use of digital media for training marketing; transfer and networking with Thuringian initiatives in the field of industry 4.0.

A growing amount of literature on new digital technologies and technological change points out the importance of lifelong learning in general and employer-provided training in particular. However, evidence on how company training has changed in the context of recent technological change is still scarce, especially for regions in East Asia and Southeast Asia.

4.1.2 Anticipation and prediction of researchers concerning corporate training

In China, many scholars have anticipated and predicted the developmental trends of company training against the background of digitalization. Some scholars anticipated that training methods would undergo revolutionary change, including the following points:

1. Mobile learning would make training more convenient and efficient, and makes on-demand learning possible, and learning can happen anytime and anywhere.

2. Virtualized and socialized learning would become an important means of future learning.

3. Training and learning through role-playing and simulated training, socialized learning and blended learning using online social media tools would be widely applied.

4. Fragmented micro-learning would become a mainstream learning method in the future; it would be an important feature of learning to divide learning into tiny modules and deliver core content on demand (Wang Ying, Ning Fuwang, Li Xiang, 2016).

Some scholars have designed training systems and culture for the enterprises in the digital age, which comprises three different layers:

1. On basic level, a training carrier which contains actual training project and fragmented interactive e-courses;

2. On intermediate level, a task-based and people-oriented learning system, in which the design of learning paths and some concrete task-based learning systems are encompassed;

3. On top level, a flexible cultural platform exists which could provide system and cultural support of corporate learning, as well as a community of learning (Zhou Huiyun & Li Hongwen, 2013).

In summary, scholars have anticipated the potential scenarios of vocational training in the age of digitalization. However, these research are largely theoretical prediction without much empirical basis.

4.1.3 Skills upgrading strategies: findings from literature

There've been limited empirical research on how technological change or use of certain technology affect company training.

Using longitudinal data on the training activities of over 3500 establishments in Germany, scholars found out that, firstly, if more employees in a firm use digital technologies, the firm on average provides more training; secondly, independent of employees' skill requirements, a correlation exists between the frequent performance of interactive/cognitive tasks and participation in employer-provided training; thirdly, employees with medium-skilled jobs participated in employer-provided training the most, whereas employees in low-skilled jobs participated the least (Lukowski, Baum & Mohr, 2021).

1. Digital platform's support for digital transformation of SMEs

As one of the biggest e-commerce platforms and digital service providers, Alibaba has supported the digital transformation of many SMEs through various approaches, including training practices. Empirical investigation indicates that the training organized by Alibaba for companies on its platform can be of great value.

The trainings are organized within the framework of two kinds of events: Orange Success Camps and Dream Trips. The Orange Success Camps are events held at the Alibaba headquarters, and some of them focused on learning, where Alibaba invites CBEC (cross-border e-commerce) experts to explain the concept of CBEC. The Dream Trips are field trips led by Alibaba to visit companies that excelled in CBEC; and during the trips entrepreneurs would study the best practices, research their business models, and search for the solutions that could work for their own companies.

From these events, the SMEs learned from Alibaba and other benchmark companies the importance of employee training; some of them even hired management consulting company to offer on-site training for CBEC employees and to help introducing a more sophisticated CBEC management system. For some of the entrepreneurs, these events help them the gain a better understanding of organizational culture in a digital setting. Even a concrete expression that is strongly advocated by Alibaba during the events, "one man can walk fast, but a group can walk long", could leave the participants deep impressions; together with other cases and learning materials, the entrepreneurs can understand the Alibaba digital ecosystem better (Li, Su, Zhang & Mao, 2018).

2. Supports from external consulting company

In China, with the rapid development of digital economy, increasing amount of small and medium-sized enterprises have set about on the path of digital transformation; but due to the lack of digital technologies and knowledge, they need assistance from professional service agencies. The differences in knowledge base and behaviour patterns between SMEs and professional service organizations make the cooperation between the two parties difficult, hindering the sharing and application of digital knowledge between them, and therefore could have negative impact on the performance of digital transformation.

However, successful example exists and corporate training plays an unneglectable role in it.

According to the investigation, a company producing electrical facilities was seeking consulting services on digital transformation from an external professional consultant company. At the beginning, the consultant and the project leadership team had significant differences in the content of the training course and the QMS (Quality Management System) program, and the QMS program could not be directly promoted in the workshop. During the project, through on-site consultation, workshop visits, and participation in regular meetings, the consultants gradually obtain a deeper understanding of the status of the company's operation and management, which helps them accurately grasp the actual management problems and needs of the company. By analysing the irrationalities in the existing management system and proposing appropriate digital knowledge training programs and production improvement programs that match the needs of the enterprise, the differences in understanding and behaviour patterns between the two parties gradually disappeared, and the sharing of digital knowledge between the two parties' increases. As a result, digital operations were gradually advanced, the implementation of the new digital system was then implemented,

External support is important for digitalization of Chinese companies: evidence from literature

As previous literature indicates, SMEs in China are facing difficulties in digital transformation, such as high costs and tight funding. Thus, external supports could be very important for overcoming the difficulties.

As one of the major digital service provider, Alibaba has supported the digital transformation of many SMEs through various approaches, including training. The trainings are conducted in the form of events and field trips. Events are held at the Alibaba headquarters, where the concept of CBEC (cross-border e-commerce) is explained. Field trips include visit to companies that excelled in CBEC and during the trips entrepreneurs would study the best practices, research their business models, and search for the solutions that could work for their own companies.

For some companies, consulting services offered by external professional consultant company could also be useful. For the successful digital transformation to take place, the consultant company's understanding of the problems and needs of the client company can be crucial, in order for the consultant company to propose appropriate digital knowledge training programs and production improvement programs.

and the corresponding rules and regulations were updated and adjusted; in the middle and late stages of the project, the digital transformation came in place (Hu etc. 2021).

The literature above suggests that, during the process of digital transformation, enterprises may encounter difficulties which may not be easily solved, especially for SMEs and that external help from digital service provider or competent consulting company could be helpful in this regard.

4.2 Developments of corporate training in the context of digital transformation: Findings from questionnaires

The literature review above has provided some useful information on how digital transformation is facilitated by external supports etc. However, there's been very limited description and analysis of how digital transformation is actually influencing the vocational training in companies. Therefore, empirical investigation is carried out to answer this question. Firstly, and online questionnaire is developed and distributed; secondly, interviews are carried out with HR personnel in the relevant companies. In this section, the findings from questionnaires are briefly introduced.

The questionnaires are distributed via online platform (Wechat group etc.) mainly in Taicang and Kunshan of Jiangsu province, where some advanced manufacturing enterprises are located. The respondents are mainly HR managers in the corresponding manufacturing companies. The reason why a proportionally significant amount of German companies are chosen as the main target group is twofold: firstly, based on previous and preliminary communications, it is identified that these German companies are among the most technologically advanced companies in manufacturing in China and are therefore most likely to be influenced by digitalization; secondly, some professional and personal contacts have been established before and therefore the applicability and accessibility of the questionnaires are higher compared to other companies.

Altogether, 59 questionnaires are successfully distributed and collected, all of which are valid. Among them, 5 of them are companies located in ASEAN, the rest are in China. Due to the low sample number and the lack of representativeness it resulted in, a systematic comparison between China and ASEAN is not possible; therefore, the results would be introduced as a whole.

The distribution of all companies in terms of number of employees is as follows: about 13% less than 50, employees, about 15% 51-100, about 35% 100-500, about 24% 500-1000, about 12% more than 1000.

The concrete results of the findings can be found in annex 1.

The findings of questionnaires can be summarized as follows:

- digitalization is having a rather moderate impact on the production and business process as well as the HR structure on average. There are considerable inter-company disparities in terms of the degree of digitalization.
- in the digital age, the ability to learn is regarded as the most important competency, with IT related competencies and problem solving abilities the second and third most important competencies for shop-floor workers.
- To cope with the challenges presented by digitalization, the majority of the companies prioritise reskilling their current employees as the main approach, compared to enhancing apprenticeship cooperation with vocational schools. The vast majority chose increasing on-the-job training and online training as the measure to tackle the problems arising from digitalization.
- some new training methods and technologies are applied by the companies, such as blended training, e-learning and remote coaching correspondingly, but over half of the companies regard these methods and technologies not very effective and difficult to implement. Many of the investigated HR personnel chose the options “the training methods are not fully understood” and “because the training technologies are not mastered” as the reasons for the difficulties in effectiveness. The reasons for the implementation difficulties are mainly the lack of qualified training personnel, guidance on methods and lack of facilities.
- Covid-19 pandemic has made trainings more difficult for many companies, it has also increased online training and the application of multiple training methods.

4.3 Skills upgrading strategies in the context of technological change: interview findings

To better understand the impact of technological change on vocational training, some semi-structured interviews are carried out with representatives from companies in China and ASEAN. Altogether 14 interviews were conducted, among which 11 companies are located in China, 2 in Thailand and 1 in Vietnam. 8 of the 11 interviews in China were conducted in a face-to-face manner, the rest of the interviews in both China and ASEAN were conducted via online platform. Among the Chinese companies interviewed, some were barely influenced by digitalization, therefore their results were not presented here. The results for all the other interviews are demonstrated in the annex 2 and 3.

Briefly speaking, the interviews demonstrate that, in both China and ASEAN, companies have applied various skill upgrading strategies to cope with the digital transformation, including developing online micro-courses, teaching more relevant theoretical knowledge, establishing stronger cooperation with colleges etc. New training methods and technologies are applied in the training practice in enterprises in both China and ASEAN.

However, due to factors such as safety and the protection of intellectual property, the traditional way of apprenticeship remains the most effective method of training for some companies. Difficulties in applying the new training methods and techniques include lack of understanding of the methods and technologies, lack of preparedness of the trainers for the new methods etc.

It is important to mention that, to a certain extent, besides the possibility of increased competence requirements for shop floor workers, the empirical investigation has also verified the possibility of skills-displacing or skill-degrading technological change that is revealed by some the literature: in some cases, technological change such as digitalization does not necessarily lead to an increase on the level of skill requirements for workforces and for some companies, the shop floor workforces have carried out more or less the same jobs as before the digital transformation. Under this circumstance, the incentive for improvement of vocational training is missing and these companies have done very little in this regard.

4.4 Findings of additional empirical investigation with other stakeholders

Additionally, some information was gathered via interviews with other relevant stakeholders in the digital transformation of manufacturing companies in China, such as government agencies, industrial parks and training providers.

Governments at different levels have been supportive in digitalizing and modernizing the manufacturing industry. One official of the bureau of economy and information technology at a local government indicates that the city government has a rather comprehensive program in supporting the digital transformation of manufacturing companies. A combination of different approaches is applied: firstly, the local government would provide the diagnosis service to companies that fits some basic requirements in size and number of employees, which could estimate the degree of digitalization of the companies and therefore help the enterprises developing appropriate strategies of digitalization; secondly, industries' demands for digitalization would be collected and analysed by the government, which together with the diagnosis would form a basic picture of digitalization on the local level; thirdly, enterprises that meet the standards set by the government2 can apply for the supports in promoting or establishing a certain number of digital/smart factories, which include financial supports, business solution plans as well as supports in the training of managers, engineers and technicians etc.

Both the central and some provincial governments such as Guangdong, Hunan, Jiangsu and Shanghai have been supporting cooperation between industry and vocational schools, for instance the "modern apprenticeship program". The schools shall apply for the support program together with the enterprises, stating in a standard form what the program aims to do, what problems can be solved from this program and how the skilled workers would be trained. If the program gets granted, government will provide scientific guidance as well as financial supports, which can be used to buy relevant facilities, reward the trainers or improve curriculum.

In many cities across China, industrial parks have been established to attract investments and facilitate the development of industries as well as industrial chain. Nowadays, measures have been taken by local governments to foster the industrial transformation and upgrading in these industrial parks. In one of these parks, a management committee consisting of local government officials has been formed to facilitate all the business activities. To facilitate the digital transformation, this committee has been conducting company visits on a regular basis to obtain better understanding of the practices, wishes and difficulties of the companies located in the parks in terms of digitalization; based on the relevant information, the committee makes constant efforts to help the enterprises by offering various services, such as assisting their search for appropriate workforces, introducing relevant experts to the companies, providing funds, help establishing cooperation with vocational schools, etc. Additionally, external high quality vocational education resources were also introduced to the park, with several agencies with advanced professional know-how in vocational education now located in the park. The committee has successfully organized training for the enterprises in the industrial park, helping the managers in these companies better understand the digital transformation and how it influences the production process. Forums were organized to facilitate dialogue among different parties involved in the industrial upgrading.

An online interview with a training provider near Shanghai reveals that: the training program that is related to digital transformation of manufacturing and Industry 4.0 includes mainly two parts: (1) general introduction and promotion of the concept and ideas of Industry 4.0 for the clients who are interested; (2) based on the Industry 4.0 facilities of FESTO, presenting and demonstrating of concrete operation under the current technological background, which includes MPS, CP-Lab/CP-Factory, pneumatical and electro-pneumatical equipment etc.

4.5 Summary of the empirical findings

There's been rather limited previous empirical studies on how digitalization of industries affect vocational training in workplace in China and ASEAN. The majority of the literature in the Chinese language is anticipating and predicting the developmental trends under the digital setting, instead of empirical investigation.

As limited literature illustrates, E-commerce Platform companies such as Alibaba as well as professional service agencies can play important roles in supporting the digital transformation of SMEs in China; however, financial and organizational difficulties still exist on a very wide range.

The empirical findings from questionnaire and interview demonstrate that considerable divergence exists concerning the degree of digitalization for enterprises in both China and ASEAN and that in general, digitalization is having moderate impact on the competence requirements of shop floor workers in general. Differences exist in terms of the impact of digitalization; for some companies, digitalization is having significant

[2] Normally it includes standard concerning sector, size, degree of digitalization, but it varies among regions. For instance, a 2019 policy in Suzhou suggests that the advanced manufacturing companies that meet one of the criteria can apply for different amounts of subsides: investment over 20 million Yuan in the past three years; sales surpassing 1 or 3 or 5 billion for the first time; carrying out important national innovation projects etc.

impact, where workers' tasks change evidently; for some, the impact of digitalization is more prominent on the engineers, because it's engineers' task to design the manufacturing environment and the shop floor workers do not have to fulfil very complex tasks. No clear difference between China and ASEAN on the aspects mentioned above can be observed; however, this comparison is not representative due to the limited sample.

Interviews demonstrate that, in both China and ASEAN, digitalization has not led to serious challenges to the companies in terms of skill requirements on shop floor workers, which is in accordance to the findings of the questionnaires that digitalization is having moderate impact. The interviewed companies have applied various skill upgrading strategies to cope with the digital transformation, including developing online micro-courses, teaching more relevant theoretical knowledge, establishing stronger cooperation with colleges etc.

As empirical findings indicate, new training methods and technologies are applied in the training practice in enterprises in both China and ASEAN.

However, due to factors such as safety and the protection of intellectual property, some companies still regard the traditional way of apprenticeship the most effective method of training. Difficulties in applying the new training methods and techniques include lack of understanding of the methods and technologies, lack of preparedness of the trainers for the new methods etc.

It is important to mention that, to a certain extent, besides the possibility of increased competence requirements for shop floor workers, the empirical investigation has also verified the possibility of skills-displacing or skill-degrading technological change that is revealed by some the literature: in some cases, technological change such as digitalization does not necessarily lead to an increase on the level of skill requirements for workforces and for some companies, the shop floor workforces have carried out more or less the same jobs as before the digital transformation. Under this circumstance, the incentive for improvement of vocational training is missing and these companies have done very little in this regard.

Interviews with other relevant stakeholders in the digital transformation of manufacturing companies in China have demonstrated that government at different levels have taken measures in this respect, such as diagnosis of degree of digitalization, financial supports, business solution plans, manager training as well as supports in apprenticeship program etc. Meanwhile, industrial parks were established to foster the industrial transformation and upgrading, which also combines various activities to support the digital transformation.

Impact of digitalization and various measures to cope with it

Empirical investigation indicates that digitalization has brought about considerable change to the skill requirements of enterprises in China and ASEAN, most evident changes include the increase of recruitment standard for technicians and shop floor workers, while the increase of number of engineers/R&D staff less evident.

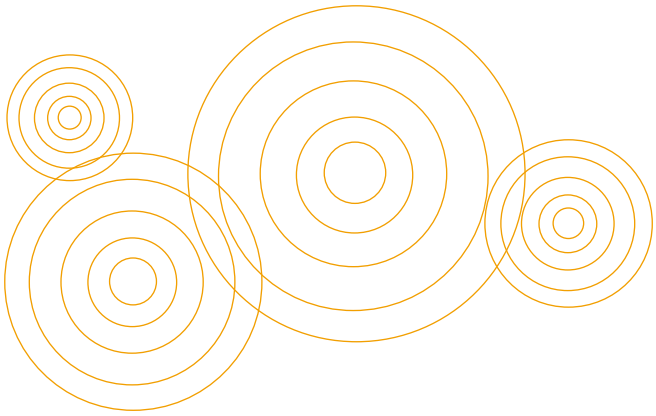
The most important competencies under the influence of digitalization are the ability to learn, IT knowledge and competence as well as problem solving ability, according to the questionnaire survey of companies in China and ASEAN.

To cope with the challenges presented by digitalization, the majority of the companies prioritize reskilling their current employees as the main approach, compared to other measures such as enhancing apprenticeship co-operation with vocational schools.

New training methods and technologies are applied by the companies in both China and ASEAN, such as blended training, e-learning and remote coaching. Meanwhile, due to factors such as safety and the protection of intellectual property, some companies still regard the traditional way of apprenticeship the most effective method of training. Additionally, difficulties in applying the new training methods and techniques include lack of understanding of the methods and technologies, lack of preparedness of the trainers for the new methods etc.

In China, government at different levels have taken measures to support the companies in their digital transformation, such as diagnosis of degree of digitalization, financial supports, business solution plans, manager training as well as supports in apprenticeship program etc. In fostering the industrial upgrading, industrial parks could serve as a good instrument which combines various activities to support the digital transformation.

Covid-19 pandemic has made trainings more difficult for many companies, but it has also increased online training and the application of multiple training methods, which presents opportunities for innovation as well.



Chapter 5 Conclusions and recommendation

5.1 Conclusions

Digitalization is having profound impact on the world we live in and it's also gradually changing the business and production in manufacturing companies.

The existing research has revealed a rather complicated picture concerning the impact of technological change such as digitalization on the labour market. Despite some disparities among the literature, a certain degree of consensus exists in the sense that some professional competencies concerning digitalization as well as some transferable skills are necessary to fulfil works in the context of digitalization.

Both China and ASEAN countries are making progress in the digital transformation of industries, meanwhile, considerable internal differences exist in terms of the degree of digitalization among manufacturing companies in both China and ASEAN. For the majority of the manufacturing enterprises in the region, digitalization is largely a development process its influence on the shop floor workers are yet to be investigated. In China, central as well as some provincial and local governments have been supporting the digital transformation of enterprises by means of subsidises and other methods.

Due to the limited sample of investigation, scientifically solid conclusion cannot be made concerning the causality relation between enterprise characteristics or government policy and the degree of digitalization. However, at least in China, the various policy measures should have some impact on the digitalization transformation of manufacturing enterprises, especially when the difficulties indicated in the literature review are taken into consideration. Both financial supports (subsidise etc.) and professional supports (diagnosis, guidance, counselling etc.) could provide enterprises with assistance that they urgently need.

The empirical investigation of this study demonstrate that in general, digitalization is having moderate impact on the competence requirements of shop floor workers in both China and ASEAN. Differences exist in terms of the impact of digitalization, but no clear difference between China and ASEAN on the aspects mentioned above can be observed; however, this comparison is not representative due to the limited sample.

Among different aspects of digitalization, the application of ICT and industrial software seem to have more impacts on the business and production of enterprises. The most common consequences of increased digitalization on the workplace are two folds, firstly, work content has become more complicated for work-

ers and technicians, which lead to increased competence requirements; secondly, decrease in the number of shop floor workers also takes place.

For the enterprises that have been influenced by digitalization, the most common practices are upskilling of existing workforces, with recruiting new employees and apprentices from vocational schools as the second and third most common practices. Other common practices include the application of online training, the training of technicians and workers by the suppliers of the facilities, the enhanced cooperation between enterprise and vocational schools.

Despite these commonalities, the enterprises have applied a wide range of strategies to cope with the challenges brought by digitalization. Some companies have developed and applied more individualized training contents and approaches; some have developed online micro-courses and real-time live courses; some have implemented job rotation for apprentices and workers; some have applied a form of flipped classroom.

The interviews have revealed some very interesting measures taken by companies in ASEAN. To cope with the challenges brought by digitalization, one of the two Thai companies interviewed has established cross-department teams, which also helps promote inter-department learning.

The only Vietnamese company interviewed has applied very advanced method such as competence assessment and skill mapping to determine the worker's position as well as the content of training.

Surprisingly some innovative approach is applied by both Chinese and Thai company, namely the cooperation with universities and colleges with the aim of making good use of the "external brains" and tackling technical problems, when it is difficult to hire such highly qualified research personnel as full time employees.

5.2 Recommendations for TVET stakeholders

Based on the findings from literature review and the empirical investigation, some recommendation can be drawn for TVET stakeholders, especially the ones that are closely related to the digitalization and its impact on TVET.

Firstly, skill upgrading strategies should take into account the development stage of the corresponding industry and company. Considerable disparities exist among the companies in terms of degree of digitalization. The appropriate strategies for skill upgrading could differ correspondingly. TVET stakeholders shall be aware of this and develop suitable measures and programs accordingly.

Secondly, vocational schools should be able to adjust its education program for students to better prepare them for the unforeseeable technological change yet to come. Given the importance of theoretical knowledge indicated by various literature and also mentioned by some interviewees, for students in manufacturing related subjects, teaching and learning of more theoretical knowledge could be necessary to help students understand the context of digitalization and therefore solve the problems encountered better in the future workplace.

Thirdly, government should provide supports for enterprises striving for digital transformation, especially for SMEs which may have grave difficulties in applying digital transformation and could be in a vulnerable situation when digitalization happens. The various measures taken by different levels of Chinese governments can be value of reference for ASEAN countries, for instance the subsidises for digital transformation as well as the establishment of industrial park where resources can be concentrated, but local circumstances shall be taken into consideration if policy borrowing is about to take place. Additionally, support measures could be provided to enhance the training of in-company trainers on new training methods and technologies.

5.3 Implications for GIZ project (LP 4.0 & RECOTVET)

The findings and conclusion mentioned above could offer some implications for future GIZ projects.

Firstly, in order to better understand the reality, and to improve the appropriateness of the project, preliminary researches should be done before planning and carrying out projects if possible. In the field of digitalization, should there be any promoting programs, labour market situations, degree of digitalization in industries, relevant government policies etc. shall be investigated.

Secondly, the project should develop customized programs to cope with partners of different industries and developmental phases. The empirical investigation reveals that enterprises have developed quite individualized and innovative measures to cope with digitalization, which normally takes the specialities into account, it is therefore necessary to develop and implement more customized programs if possible.

Thirdly, mutual communications and visits among partners at different stages of development of digitalization could contribute to the better understanding of each other and therefore form a more systematic and whole view of the subject matter.

Fourthly, to tackle some of the difficulties encountered by enterprises, some support measures and activities could be carried out, for instance the improvement of training of the trainers, the development of training guidelines or handbooks relevant to training methods and technologies, or even the provisions of training equipment if necessary and possible.

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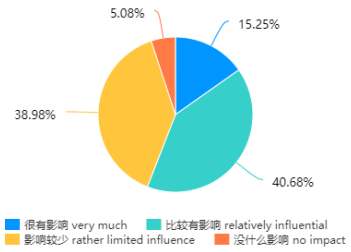
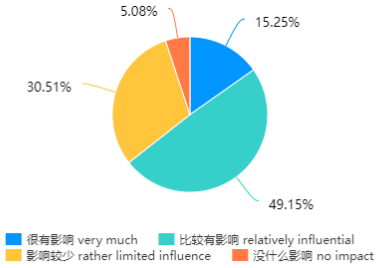
Annex 1 Findings from questionnaires

3.2.1 Digitalization and its impact on the company

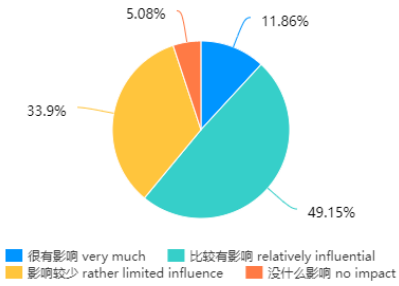
The findings from questionnaire indicate that digitalization-related technologies such as automation and human machine interface, ITC, system engineering and new industrial software are having moderate impact in general. In terms of the impact on the production and business process of the company, overall only about 14% of the respondents regard these technological changes very influential and about 47% relatively influential, about 34% believe that these have rather limited influence, and about 5% think that these have no impact at all (see graphic 1).



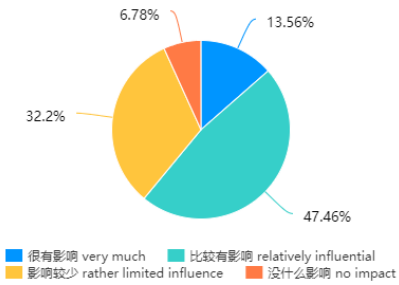
automation and human machine interface



information and communication technology



system engineering



new industrial software

Graphic 1: how technological change has affected the production and business process of the company in the past few years

As for the concrete impact in terms of HR structure and recruitment standard, about 62% of the respondents indicate that the recruitment standard for technicians has increased, about 42% think that the recruitment standard for shop floor workers has increased, about 39% indicate that more engineers/R&D staff are recruited, less than 31% of the respondents say that the number/percentage of shop floor workers has declined due to digital transformation.

The respondents regard the ability to learn, IT knowledge and competence as well as problem solving ability as the most important competences for shop floor workers under the circumstance of digitalization.

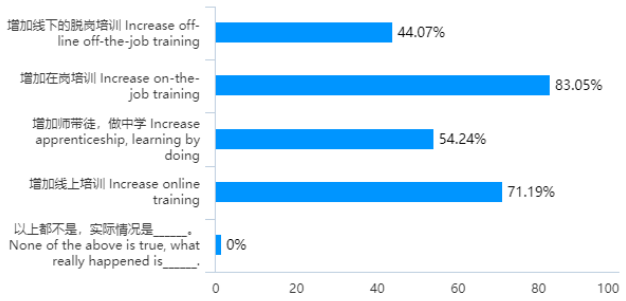
3.2.2 Vocational training under the influence of technological change

Under the influence of technological change, vocational training has undergone certain changes. To cope with the challenges presented, reskilling the current employees to increase their abilities is regarded as the most important measure, and recruiting employees with higher education and skills from labour market is considered as the second option, whereas measures such as enhancing apprenticeship cooperation with colleges or recruiting new staff from colleges of higher level are not given high priority (see table 1).

Table 1 Company's measures to improve the competences of its personnel under the influence of technological change (ranking)

Options	Scores[3]
Reskill the current employees to increase their abilities	3.56
Recruit employees with higher education and skills from labour market	2.46
Enhance apprenticeship cooperation with colleges/schools	2.02
Recruit new staff from schools/colleges of higher level	1.97

In terms of change of training mode under the technological change mentioned above, enterprises' priority in training is to increase on-the-job training (over 83%), whereas increasing online training is the second option (over 70%), apprenticeship and off-the-job training are considered as the third and fourth options (about 54% and 44% respectively) (see graphic 2).



Graphic 2: Change of training method under the influence of technological change

Referring to the change of training method, e-learning is slightly preferred compared to blended training and face-to-face training, whereas flipped classroom is clearly not applied by the majority of the companies (see table 2).

Table 2: New training method applied by company to cope with technological change (ranking)

Options	Scores
e-learning	3
blended training	2.78
face-to-face training	2.78
flipped classroom	1.44

When it comes to innovative training technologies, the vast majority of the companies have applied remote coaching (almost 80%), whereas considerable companies have chosen simulation and digital labs (about 61% and 47% respectively) (see table 3).

Table 3: Innovative technologies that are applied in training programs to cope with technological change

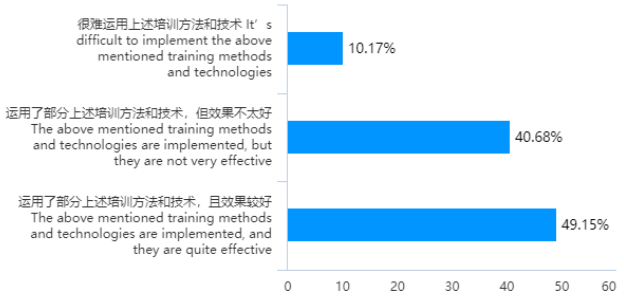
Options	Percentage
Simulation	61.02%
Digital labs	47.46%

[3] The average comprehensive score of the options of the ranking questions is automatically calculated by the questionnaire system based on the ranking of the options by all respondents. It reflects the comprehensive ranking of the options. The higher the score, the higher the comprehensive ranking. The calculation method is: option average comprehensive score = (Σ frequency × weight)/number of people filled in this question

The weight is determined by where the options are arranged. For example, there are 3 options involved in sorting, the weight of the first position in the row is 3, the weight of the second position is 2, and the weight of the third position is 1.

Remote coaching	79.66%
other	1.69%

Slightly less than half of the companies have applied the training methods and technologies mentioned above and regard them effective, and about 40% have applied the methods and technologies but consider them not effective, whereas about 10% think it's difficult to implement the methods and technologies (see graphic 3).



Graphic 3: Implementation of the above mentioned training methods and technologies

The reasons of the difficulties in the implementation of the methods and technologies include mainly lack of facilities and equipment, lack of qualified training personnel and the inclination of the staff to more traditional way of training.

As for the lack of effectiveness of the new training methods and technologies indicated by about 41% of the respondents, the reasons are rather multi-fold: about 58% of the respondents think that the training methods are not fully understood, some indicate that training technologies are not mastered, or the trainers are not familiar with the new methods, whereas more than 1/3 chose the option "it's been a very short time that the methods and technologies are implemented" as the reason.

Table 3: Why is it not so effective to implement the above mentioned training methods and technologies (multiple choice)?

Options	Percentage
Because the traditional way of training is more effective	29.17%
Because the training methods are not fully understood	58.33%
Because the training technologies are not mastered	41.67%
Because it's been a very short time that the methods and technologies are implemented	33.33%
Because the trainers are not familiar with the new methods and technologies	25%
Because the learners are not used to the new methods and technologies	33.33%

3.2.3 Impact of COVID-19 on training

Answers of the questionnaire demonstrate that the Covid-19 pandemic is having evident impact on vocational training. About 3/4 of the respondents note that online training has increased, and about 39% indicate that offline training decrease and training has become more difficult; for 47% of the respondents, more training methods are applied to tackle the issue; about 37% point out that more innovative technologies are applied.

Table 4: Change of training practice under the influence of COVID-19

Options	Percentage
Generally speaking, training has become more difficult	38.98%
Training effect gets worse	13.56%
Online training increases	74.58%
Offline training decreases	38.98%
More training methods are applied	47.46%
More innovative technologies are applied	37.29%

Annex 2 Main findings from interviews

- **Case study of Company A (China)**

Company A is a German machinery company in the automobile industrial supply chain, producing springs and other car components in Taicang, near Shanghai.

1. Degree/stage of digitalization and its influence

The company has adopted digital technologies in the manufacturing and is therefore in on a rather advanced stage of digitalization. In one of the factories, after applying smart factory technologies, the operating tasks became easier, and the manual positions have decreased; meanwhile, the maintenance and repairing positions have even higher requirements than before, because the complexity of these tasks has increased.

Even in factories where more "traditional" automation is taking place, the production and division of workers has changed. In one of the factories, after installing mechanical arms, some of the sorting tasks, which were performed by workers, are now carried out by mechanical arms. While the original 10 sorting jobs disappeared, the demand for skilled workers who carry out the maintenance and repairing work has increased.

To cope with this change of post assignments, the company has taken two approaches: firstly, reskilling the existing workers with certain competence basis; secondly, recruiting vocational college graduates with relevant technical background.

2. Skill upgrading strategies

To reskill the existing workers for the changed work contents, the company has updated the training for the workers inside the company while sending some of the workers to the German headquarter for more intensive training and learning on the job.

The reskilling training is updated in two ways: both in content as well as in methods.

In terms of content updating, firstly, the brief introduction of relevant content on automation, smart factory and Industry 4.0 are integrated to the existing training materials, so the workers can learn the knowledge in advance; secondly, the more individualized training contents are provided, in accordance with the changing tasks on the job position, such as the setting and maintenance of mechanical program, knowledge and skills concerning robots, etc.

In terms of the updating the methods of training, several changes are prominent. (1) The number of trainee has become more streamlined. In the past, one trainer may provide training for quite a few trainees; now it is almost one-to-one or one-to-two. (2) In the past, employees often would start operating after simply watching the trainer's operation; now the trainees have to learn some theoretical knowledge first, especially for automation or intelligent manufacturing equipment. Grasping the Know-how, and possessing a certain understanding of the functions, interface and operation of the equipment before practical training is increasingly common. (3) The training used to be carried out in a fixed time or coordinated time; but now with much of the training content updated in the company internet, employees can enter the online training system to learn knowledge and watch videos anytime and anywhere, or even take the exam online flexibly. (4) Training documents, such as work guidance and checklists used to be posted on-site, but they are now in the computer system; employees must complete the corresponding check on the computer interface before operation.

Under the circumstance that a completely new production line is established, which only happens once in a few years, a team of core members are sent to Germany for training and learning. The team normally consists of 1 production line manager, 2 maintenance supervisors (machine + electricity) and 3-5 skilled worker.

3. Additional remarks

The production manager emphasizes that, for the essential professional skills and knowledge under the latest technologies, offline training remains the main approach of training, because some of these skills cannot be easily learned without the real working environment.

Some skilled workers who carry out training mission are aware of the new methods such as flipped classroom, but regard them difficult to implement in the working settings.

- **Case study of Company B (China)**

German machinery company, producing balancing machine as well as filling and testing systems, in Shanghai

1. Degree/stage of digitalization and its influence

The company is technologically very advanced but has made very limited progress in terms of digitalizing its manufacturing. In the past few years, no revolutionarily new technological developments have taken place in the company. However, new technologies are constantly applied in the production process. In recent years, in order to better meet the needs of customers in the electrical automobile industries, new products and technical solutions were developed.

However, the recruitment requirements of this company are relatively high, and there are currently no positions with low technical content; all workers should possess the ability to understand technical drawings and to carry out certain assembly operation independently. New employees need to receive training on professional know-hows, working principles, professional theoretical knowledge, and knowledge on core components, etc.

In order to promote digital transformation, the company established a number of technical teams composed of “engineers, technicians, and apprentices”, which would solve the problems encountered in the process, in order to reduce costs, increase efficiency and forward process innovation.

2. Skill upgrading strategies

The company has a systematic way of updating and adjusting training contents to meet the latest skill requirements. Every divisions of the company all have an annual training plan. According to technical updates and customer requirements, new contents are added into the plan. A training menu with relevant information based on the plan is then provided to employees at the end of the year, so that employees can have a preview and understanding of the training program for the second year; they can choose courses according to their positions and work needs. After submitting for approval, the budget will be reviewed and the corresponding contents will be included in his/her annual training plan, which is updated every year.

Besides this system, some concrete measures are also taken to meet the changes and challenges in recent years.

External training providers and supplier can play an important role in providing training. To cope with some of the latest technological developments, some of the electrical and test workers participate in the industrial automation course on Industry 4.0 developed by the Bavarian training company and Festo. Since Siemens is the provider of certain plc and industrial software, it also provides training on the related subject in the form of chargeable training courses. The quality of the training is normally good.

In response to customers’ changing requirements, such as automobile OEMs, which require on-site qualifications (safety management etc.), the company have sent some employees to participate in external courses and exams to obtain the required certificates.

Technological changes have relatively little impact on the training methods, but the pandemic has. During the pandemic, in order to maintain the corporate training to a certain degree, various online training methods are applied.

Firstly, online courses, which covers a rather complete theoretical content, such as “basic theory of dynamic balancing” are developed and implemented. Secondly, online micro-courses are also developed by engineers and technicians, with the aim of teaching concrete knowledge points or solving small theoretical problems. Thirdly, learning from the current trend in several internet giants, some popular engineers and technicians start the form of real-time live courses as a method of training.

3. Additional remarks

Professional skills are normally not provided online, because these skills often involve operation on site and they are usually very interactive, and the online training won't be as effective.

What is equally important is this, to prevent the core technical know-hows from being stolen, trainings relating to the core technical procedures and methods are not uploaded to internet, not even the intranet. These trainings are usually carried out in the form of small-scale offline training; even for some online training contents, the viewing of online courses also has strict permission settings according to different categories. Obviously, safety and the protection of intellectual property plays a central role in this respect, which somehow impedes the use of online training methods.

Local government subsidizes the training of 16-35 year-old Shanghai residents, so the company's costs are reduced.

- **Case study of Company C (China)**

Chinese electrical company, producing electric micro switches and related products, in Shanghai

1. Degree/stage of digitalization and its influence

The company is technologically advanced but has barely adopted any digitalization technologies in its production yet. A recent technological improvements made on production is the application of automation equipment as well as related software since 4 years ago. The gradual replacement of operation workers by robotic arms has led to the reduction of assembly workers for about 50% during the past few years. The skill requirements for workers did not change dramatically, but the demand for maintenance and repairing workers has increased.

2. Skill upgrading strategies

To cope with the challenges of new technologies, as well as to improve the competitiveness of the company, various skill upgrading strategies are applied in recent years.

The company has a rather strict requirement of long-term employees. They have to participate in training of 120 hours and pass the exam to get a work license; the exam contains theoretical and practical contents.

As mentioned earlier, digital transformation and other technological developments often lead to higher skill requirements of the workforces. In order to further enhance the skills levels of the employees, job rotation for apprentices and some workers was recently implemented. After a certain period of rotation, the worker/apprentice would be assessed and given a chance to decide which position he/she prefers to stay.

A stronger cooperation with colleges and universities are also pushed forward. Although it's difficult to attract graduates from the elite universities, the company has found other ways to make use of the talents: they offer scholarship to some of the senior students and carry out small joint research projects which is normally closely related to their bachelor graduation project. Through these small projects carried out jointly by engineers, technicians, elite university students as well as their supervisors, some technical obstacles were successfully removed. Some students were even hired as a consultant after their graduation project at the company. The human resource manager refers to these students as "external brain", because they can contribute their intelligence to the company without being an official employee.

During the pandemic, online training is substantially strengthened. Some training contents, which used to be taught offline, are now recorded in advance and then uploaded to the intranet, where trainees can watch very easily. Even a form of flipped classroom is applied: the workers are required to learn the uploaded content in advance; then they were provided with some assistance if they encountered difficulties; afterward, they need to take the test.

- **Case study of Company D (China)**

German company producing electric tools, such as electric drill, angle grinder, in Chengdu.

1. Degree/stage of digitalization and its influence

Striving to achieve smart factory of industry 4.0 standard, the company in Southwest China has been applying several new technologies and management instruments to modernize its production and business. The company is on a rather advanced stage of digitalization in manufacturing.

Through the application of new technologies, such as using standardized MES production execution system, RFID radio frequency identification applications, AGV automatic guided vehicles, real-time data analysis and seamless connection between warehouses and production lines, the production is become more efficient,

operations and supply chains become more transparent, and the better use of resources is realized.

In the past few years, due to the technological advancement, the factory's production capacity has increased by 5-6 times, but the number of workers has not increased. Meanwhile, contrary to the common understanding, the factory's requirements for shop floor operators have even decreased, because part of the manual tasks are now completed by the machine, and only some the rest of the simple tasks, such as loading and unloading processes are completed by the operating workers.

The recruitment requirement for operational workers are still lower-secondary school graduates, while the technicians should have at least vocational school certificates in mechanical and electrical domains. Although sensors are installed on the production line and relevant data is continuously collected, only technicians understand what the data means, workers do not actually understand the process, and their tasks have not changed.

Under this circumstance, the knowledge structure of engineers has changed. In the past, engineers need to master the tools and methods for statistics and calculation of industrial data, and diagnose the source of the problem; after the digitization, the system can directly display where the problem is. To solve problems, engineers need better IT-related capabilities.

2. Skill upgrading strategies

Maintenance technicians are mainly trained by the company with its rather sophisticated training system. In the past, they also recruited experienced technicians who have worked in the same industry; currently they company plans to recruit students who graduated from school which is working with AHK to integrate the German certificate and education standard to the education program; the company is currently participating in the school's education process, take students as interns in the company.

The company has a comprehensive internal training system. However, 30% of the training is conducted by external personnel, which happened under two circumstances: either the particularly professional and theoretical content, which may be very difficult to learn in the working setting, or the introduction of some new mindset from outside, mainly for management and engineers.

3.Additional remarks

When asked about the change of skill requirements on shop floor workers, the CEO of the company clearly indicates that their skill requirements have not changed and the reasons for this is as follows: because the engineers have designed the entire system in the way that the workers still do the relatively simple tasks since the digital transformation, and it's not easy to change the competence of shop floor workers dramatically on a large scale.

This, together with some findings from questionnaire, verifies the notion revealed in the literature, namely technological change is not necessarily skill-biased, it could also replace skills without upgrading the skill requirements. For enterprises, the most economic option may not be upgrading the technology of facilities and skill requirements of workforces simultaneously. It means that, at least for shop floor workers, technological change does not always lead to the change of skill requirements and vocational training.

- **Case study of Company E (China)**

Chinese company producing electric components, such as electromagnetic wires, in Shenyang.

1. Degree/stage of digitalization and its influence

Through the installation of a digital ERP (Enterprise Resource Planning) system as well as some other innovations on production, such as online detection device and visible detection tools, the company is undergoing some technological transformation. However, it is difficult to judge, to what extent the company has realized the digitalization of production because the research team was unable to visit the company.

The installation of ERP system is a process which can last for a couple of months, during which time the content and procedure of work is transformed for both office and shop floor workers. During a certain period of time, the traditional manual system and the new ERP system have to be operated simultaneously, because the ERP system was not completely functioning and business needs to run as normal. This not only generated extra costs, but also leads to additional work contents for the workers, who need to do more scan and check works. The traditional operation work is not so difficult for the workers, but the application of new ERP system is a challenge for some of the workers.

It is estimated that in the near future the changes of posts and contents of the workers would change even more dramatically. A substantial decrease of shop

floor workers as much as 50% and an increase for the qualification requirements for them are expected.

2. Skill upgrading strategies

The changed working contents brought by the installation ERP system is posing challenges for the factory, which face the difficulty of unstable workforces regularly.

The main strategy is to upskill the existing workers. Due to the difficult economic situation of Northeast China, it was not very easy to recruit highly qualified workers from the labour market, so they have to find a solution within the company. The majority of the upskilling training is carried out by the factory technicians and manager. With new systems and technologies are applied, the training time has become longer and training frequency has increased.

When applying new machines and facilities, it was normally the provider of these machines offer training to the workers on how to use them. Sometimes, remote coaching and online video training is applied due to pandemic situation.

To tackle the problem of lack of innovation, the company has cooperated with local universities to “borrow” the engineering talents there. Cooperative research projects between the company and local universities were designed and implemented, where doctor and master candidates can conduct studies with the facilities of the factory, solving the production problems while finishing their doctor-/ master-thesis.

It is meaningful to point out the significance of the mind-set of the company owner, which plays important role to drive the digital transformation of the company prepare early enough for the COVID-19 pandemic. To a certain extent, it can be regarded as a starting point to prepare new job profiles of company which leads to new way and methods of training. Normally, the family-owned company could be a burden regarding the change, however, in this case the company owner foresees changes in advance.

- **Case study of Company F (Thailand)**

Thai company producing automobile components in Bangkok.

1. Degree/stage of digitalization and its influence

The company has been constantly upgrading its production in the past 5 or 6 years. Robotic arms are applied in production, as a result, the number of staff has decreased substantially. For one of the production site, in the past, about 20-30 people with relatively low skills were recruited and trained in the academy, now only 5-6 people were recruited and the training time has also become shorter. Some of the low skilled workers may switch to unskilled positions, such as packaging, if they could not meet the new job requirements.

For the majority of the skilled workers, the work content has changed with digitalization as well. The work become more complicated. Some workers are still working in the same position, but with higher skills. For one of the production site, in the past, they just need to carry out simple operation; now they need to check the program and function of the machines regularly. New tasks also emerge, such as programming robots to carry out different tasks.

2. Skill upgrading strategies

There are mainly two ways to challenges brought by the digitalization process: firstly, skill upgrading training for existing workers; secondly, recruiting new employees with higher diploma level (college).

Skill upgrading training include two parts: classroom training of theoretical knowledge, and practical training of practical know-how.

To determine the training program and content, competence assessment of the workers is carried out, based on which, a skill mapping can be reached for each worker.

For managers and supervisors, innovative training methods such as blended learning are applied, whereas for shop floor workers, on-the-job remains the main method due to the relatively senior age of the workers, while web-based training on QC and 5S, and simulation technology are also implemented, which helps improving the understanding of theoretical knowledge.

Recruiting new employees are a useful instrument to cope with the challenges brought by digitalization. Cooperating with VET school in various forms, including apprenticeship, is implemented as well. During the process, the enterprise also develop curriculum together with schools. However, managing the apprentices could be challenging for the company, due to the difficulties in disciplining the students.

- **Case study of Company G (Thailand)**

Thai brewery company located in Bangkok.

1. Degree/stage of digitalization and its influence

The production of beer and other related products does not change much in the past few years. Some production became more automatized and ICT was increasingly applied in the business and management.

The management's basic philosophy in applying new technologies is that they do not leave any worker behind, instead, they try to prepare them for the changes. Important strategy to cope with the challenges is to let people at different branches of the company to have a shared vision of the company and to understand each other. The operation people should know more about the whole company, its objectives, logistics and sales etc., vice versa.

2. Skill upgrading strategies

The company mainly has two kinds of training, firstly, basic skills training which are carried out by HR department, secondly, specific skills training provided by KM team such as in-company trainers and the agile team.

In coping with challenges brought by digitalization as well as the increasing competition in the beer market, the management of the company thinks that it is necessary to change the mind-set of training, students should be at the centre of training; workers' different interests and backgrounds should be taken into consideration. If possible, a more individualized way of training should be implemented.

Additionally, cross-department teams were established in order to solve problems and promote inter-department learning, which helps to reduce misunderstanding among departments.

Methods such as problem-based training is widely implemented. Digital platform is regarded as an important way to achieve the above mentioned training objectives.

The company also cooperates with vocational school in the form of apprenticeship program, which was attached great importance by the management.

- **Case study of Company H (Vietnam)**

Vietnamese company producing metal construction components, in Hanoi.

1. Degree/stage of digitalization and its influence

The company has been applying industrial software and management system and buying new machines in the past few years.

The new machines have led to changes in production process. Number of workers have decreased and the content of work has changed as well. For instance, to bend certain steel component, it used to require two workers and two supporters, now it only requires one worker and one supporter, and it takes less time and less workload, the workers just need to check the machine instead of doing manual work anymore. Productivity is also increased during the process.

When new machines are implemented, workers are required to know how to operate the machines. Very often, technical English/Japanese is required, so the workers should learn the basic English/Japanese technical vocabulary that is required to carry out the basic operation and maintenance.

2. Skill upgrading strategies

Upskilling existing workers and recruiting graduates from vocational schools are the main approaches to cope with the changes.

When applying new machines, normally the suppliers of the machines would train the workers and engineers. The procedure is as follows, firstly, engineers and technicians get trained; secondly, they train the workers, the workers with more experiences would help them with the training.

Normally, in-company trainers carry out the majority of the ordinary training; in case of lack of trainer, the engineers and technicians also participate in training the workers. Trainers can determine the mode of training according to the content. Normally, theoretical training is conducted first, then practical training. The training for new beginners could last for one month. Online training is provided; Microsoft teams are applied for training of engineers.

The HR department and trainers apply the appropriate training methods according to the content. For theoretical knowledge, online training and other new methods are very useful, which also reduces the cost. For training of practical skills, face-to-face manner is much more effective.

Meanwhile, VET school graduates are recruited and apprenticeship and training program is carried out together with VET schools.

The company thinks highly of the school graduates, because they have good theoretical knowledge, they are young and eager to learn. GIZ is also supporting the relevant programs.

During the pandemic, the workers are required to stay in factory according to government policy to cope with the pandemic, so online training is not so necessary.

Annex 3 Summary of interview findings

	Degree/stage of digitalization and its influence	Skills upgrading strategies	Additional remarks
A In China, German invested, machinery	The company has adopted digital technologies in the manufacturing and is therefore in on a rather advanced stage of digitalization. Smart factory technologies are applied in some factories. Operating tasks became easier, manual positions decreased, complexity of maintenance and repairing increased.	More individualized training contents and approach are developed; Theoretical knowledge is getting more important; Online training system and documents are developed.	Offline training remains the main approach of training, due to lack of effectiveness without the real working environment.
B In China, German invested, machinery	The company is technologically very advanced but has made very limited progress in terms of digitalizing its manufacturing. There's no revolutionarily new technological developments, but new technologies are constantly applied. Technical teams composed of "engineers, technicians, and apprentices" are established to promote digital transformation and solve problems.	The company has a systematic way of updating and adjusting training contents, training menu for each division is updated regularly. External training providers and supplier can play an important role; online micro-courses are developed; real-time live courses are applied.	Because of safety and the protection of intellectual property, trainings related to the essential technical procedures and methods are mainly carried out offline.
C In China, Chinese private invested, electrical	Technologically advanced but has barely adopted any digitalization technologies in its production yet. The gradual replacement of operation workers by robotic arms has led to the reduction of assembly workers for about 50%. The demand for maintenance and repairing workers has increased.	Job rotation for apprentices and some workers are implemented. A stronger cooperation with colleges are established to make good use of the "external brains" and tackle technical problems. A form of flipped classroom is applied.	During the pandemic, online training is substantially strengthened.
D In China, German invested, electrical	On a rather advanced stage of digitalization in manufacturing. New technologies: standardized MES production execution system, RFID radio frequency identification applications, automatic guided vehicles, real-time data analysis and	The company has a comprehensive internal training system. Recruiting graduates from vocational school working with AHK to integrate	Technological change is not necessarily skill-biased, it could also replace skills without upgrading the skill requirements; it does not always lead to the change of skill requirements and vocational training.

	seamless connection between warehouses and production lines. The factory's requirements for shop floor operators have even decreased, because part of the manual tasks are now completed by the machine.	the German certificate and education standard. Some 30% of the training is conducted by external personnel, for the very professional contents etc.	
E In China, Chinese private invested, electrical	Digital ERP system was established, online detection device and visible detection tools are applied. Additional work contents for the workers, application of new ERP system is a challenge for some; in the near future substantial decrease of shop floor workers as much as 50% and an increase for the qualification requirements for them are expected.	Upskilling the existing workers, mainly carried out by the factory technicians and engineers. Training time become longer and training frequency has increased.	
F In Thailand, Thai company, automobile components	Robotic arms are applied in production. Number of staff decreased substantially. Some low skilled workers switch to unskilled positions. Work become more complicated for the majority of the skilled workers. New tasks emerge, such as programming robots.	Skill upgrading training for existing workers and recruiting new employees with college level. Skill upgrading training include two parts: classroom training of theoretical knowledge, and practical training of practical know-how. Competence assessment and skill mapping of workers are conducted for each worker. Web-based training on QC and 5S, and simulation technology are implemented. Cooperating with VET school in various forms, including apprenticeship. Developing curriculum together with schools.	For shop floor workers, on-the-job remains the main method due to the relatively senior age of the workers. Managing the apprentices could be challenging for the company, due to the difficulties in disciplining the students.
G	Production does not change much in the past few years. Some became more automatized	Changing of the mind-set of training, with students at the centre; workers'	Mind-set of the company owner, which plays important role to drive the

In Thailand, Thai company, brewery	and ICT was increasingly applied in the business and management. Letting people at different branches of the company to have a shared vision of the company and to understand each other.	different interests and backgrounds being taken into consideration and more individualized way of training. Cross-department teams established in order to solve problems and promote inter-department learning. Problem-based training and digital platform is applied in training. Cooperating with vocational school in the form of apprenticeship program.	digital transformation of the company prepare early enough for the COVID-19 pandemic.
H In Vietnam, Vietnamese company, construction steel	Applying industrial software and management system; buying new machines. Number of workers decreased, content of work changed as well. Workers are required to know how to operate the machines. Very often, technical English/Japanese is required.	Suppliers of the machines train the workers and engineers. For theoretical knowledge, online training and other new methods are applied widely. For training of practical skills, mainly in face-to-face manner. Recruiting VET school graduates, apprenticeship program implemented.	During the pandemic, the workers are required to stay in factory according to government policy to cope with the pandemic, so online training is not so necessary.

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