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Navigating Industry 4.0: Bridging Skills and Collaboration for Workforce Transformation - A Case Study in Vietnam

Vo Thi Nhu Uyen[1], Pham Xuan Thu[2], Phung Le Khanh[3]

[1]Hanoi University of Industry, Vietnam, https://orcid.org/0000-0003-0402-3202

[2]National Institute for Vocational Education and Training, Vietnam, https://orcid.org/0000-0002-0818-1024

[3]National Institute for Vocational Education and Training, Vietnam

Abstract: ***Industry 4.0 will bring extensive changes in the nature of work. While automation is likely to displace workers, new occupations will be created, which means the workers must be trained in new competencies and skills for production practices at the enterprises and the labor market in the globalization context. In addition, adequate collaboration between enterprises and vocational education institutions would lead to provision of relevant practical skills for industrialization. This article presents the survey results on Updating new skills-new technologies in training programs: A case study in Vietnam under the impact of the 4th industrial revolution and the level of combination between enterprises and vocational education institutes in training programs with 3 groups of occupations: 1-Information technology, electronics and telecommunications; 2-Electricity, electronics; Automation; 3-Agriculture, forestry and fishery. The questionnaire survey was conducted in two forms: online and in person at 700 enterprises, 50 TVET institutes and 7, 000 employees in 22 localities in Vietnam. The survey results are the basis for vocational training management agencies to make policies for vocational education so as to improve the quality of human resources, in line with Industry 4.0.***

Keywords: New skills, New technologies, Industry 4.0, Training programs, Enterprises

1. Introduction

Industry 4.0 spurred many debates and discussions on how education sectors and industries can cope with the rapid pace of technological advancements and the implications for workforce and industry. In this regard, innovators have been pursuing development of learning technology solutions that could help (Kim, P., 2020).

Industry 4.0 is probably a threat to employment, especially to non-technical workers if they do not apply new skills and new technologies. Some skills that are not considered important in today's context may become the core skills of most occupations in the 21st century (World Economic Forum, 2019).

The employment impact of Industry 4.0 has the most effects on the workforce. The unemployment rate of those with a low level of education remains persistently high, and that this vulnerable group of workers is likely to be hit hardest, while workers with higher education are more characterized by a declining unemployment rate. The advancement of technology, which can all lead to the creation of new jobs (Szabó-Szentgróti, G., Végvári, B., & Varga, J., 2021).

The window of opportunity to reskill and upskill workers has become shorter in the newly constrained labour market. This applies to workers who are likely to stay in their roles as well as those who risk losing their roles due to rising recession-related unemployment and can no longer expect to retrain at work. For those workers set to remain in their roles, the share of core skills that will change in the next five years is 40%, and 50% of all employees will need reskilling (World Economic Forum, 2020).

Groups of occupations that employees need to be trained and updated on new knowledge and skills such as: Information technology; Electronics and Telecommunications; Electricity, electronics; Automation; Processing Industry; Hi-tech agriculture, forestry; Automotive industry, agricultural mechanic, medical equipment; Transportation and logistics services; Tourism services (hotels, restaurants. . .); Textile, leather, shoes; New/renewable energies (Frey, C. B. and M. A. Osborne, 2015; Melanie Arntz, Terry Gregory, Ulrich Zierahn, 2016; (World Economic Forum, 2019; Truong Le Tien, 2019).

There are two key trends on Industry 4.0 impact on jobs and skills. First, alarmist views on technology-induced job losses have been revised to a more optimistic outlook predicting a net increase in jobs. However, new jobs may emerge in different industries and require workers to learn new skills. The second key trend is that new jobs are more likely to demand higher-level cognitive skills and entail non routine tasks that are unlikely to be replaced by automation. Such changes in the nature of work will require continuous learning, which in turn can be bolstered by building the ability and willingness to unlearn and relearn. This survey provides new skills-new technologies for TVET institutions to change/update training programs (Sungsup Ra, Unika Shrestha, Sameer Khatiwada, Seung Won Yoon & Kibum Kwon, 2019).

Occupations and their skill requirements are not set in stone. Occupations can be re-designed to pair uniquely human skills with the productivity gains from technology to boost demand for jobs. Educational institutions will need to provide supports to educators as they are asked to teach these new skills. This could require significant retooling of teacher education or faculty incentives in educational

institutions. As education systems offer more flexible and adaptive pathways for learners, employers will also need to learn how to identify and develop talent. The college degree has long been an imperfect signal for employment readiness and this is likely to become even more complex (Pearson, 2020).

Industry 4.0 creates many opportunities for Vietnam in economic development and national competitiveness improvement. The technological innovation and improvement of management and production models probably help Vietnamese enterprises increase productivity, reduce production costs and improve product quality. Besides, Vietnam may also take advantage of the opportunities to develop digital services and technology platforms, create many new jobs and strengthen the competitiveness of the service industry. However, Vietnam needs to focus on training and developing human resources, especially in the fields of information technology, data science and technological innovation (Ministry of Science and Technology, 2018).

The main issues or challenges for TVET in this transformation require elevating learning and reskilling. We need to elevate our training systems to be able to train a highly skilled workforce that is required to support IR 4.0. This involves training new, more highly skilled workers or upskilling those already in industry. A number of industries and jobs may also become obsolete in the near future. These displaced workers will need to be reskilled to do other jobs that are still in demand (McKee, S., Gauch, D., 2020).

Depending on the implementation level of Industry 4.0 in companies, vocational education and training for the workforce is highly relevant and the vocational education system has to respond to the needs and expectations of these changes in the work world. Successful responses of the vocational system to the demands of Industry 4.0 have to focus on curriculum development and training of both skilled and highly skilled workers (Georg Spöttl & Lars Windelband, 2021).

The enterprises must regularly update and research the labor market to learn about the skills and capacity demand of workers for mostly meeting the production requirements. In addition, they ought to invest in capacity and skills training for employees to help them develop their careers, enhance work performance and better meet the job requirements (Anh D. T. N, Tham N. T. T, Hiep P. D, 2023).

Cooperation between university and enterprises would be meaningful, effective and sustainable. It is undeniable that Industrial Revolution 4.0 will provide fresh opportunities. The first change will be human resources across all sectors, including in the training sector, to meet the new requirements of the industrial sector. Workers need to be equipped with new skills, in addition to their professional expertise, to solve other job-related issues (Pham H. T., 2020).

Collaboration with the industries and the education institutions are the major rising concern in many developing countries (Md. Abu Raihan, 2014). Collaboration between schools and enterprises in vocational education and training is a challenge in many countries (Hiim. H, 2023). The partnership between the enterprises and vocational education institutes is essential to create a quality training environment and meet the requirements of the labor market in globalization context. The enterprises can provide information about the skill and competencies requirements of the employees to the vocational education institutes, then the institutes possibly design appropriate training programs and help the employees acquire the skills needed to work in a modern manufacturing environment. As a consequence, the vocational education institutes are expected to continuously research, update and develop training programs in line with the requirements of the enterprises and labor market. Also, the training programs are tailored to the reality of production, helping workers learn the necessary skills to work effectively (Pham Do Nhat Tien., 2020).

General education as well as vocational education have a critical role to play in making employees industry ready. They lay the foundation for skill development, which is critical for economic growth and social development of a country. Wth the advancement in technology and gradual implementation of Industry 4.0 solutions, the skill requirement in industry is going to change significantly. It is very important to understand what changes Industry 4.0 will bring in the current manufacturing setup, what the new tasks that an employee would have to do will be, how it is going to be different from what he or she has been doing and what additional skills would be required to carry out those tasks successfully. Though skills demand at an aggregate industry level is expected to evolve as mentioned above. Cognitive abilities, system skills and complex problem solving skills are the top three skills expected to be high in demand and will continue to remain important (Whitepaper Summary, 2016).

Industry 4.0 will certainly have major distributional impacts through shifts in countries' economic structures, within-industry changes in firm composition and within-firm changes in business models and processes resulting in changes in occupational structures, and in the task content of occupations. Ultimately, there will be consequences in terms of skills demand and the return on skills (Asian Development Bank, 2021).

Vocational schools and enterprises collaboration is necessary to improve the quality of vocational training in Vietnam. In vocational training, the vocational schools focus on training professional ethics, labor discipline, industrial behavior, and basic professional knowledge and skills for learners. And enterprises participate in training advanced professional competency in accordance with the requirements of companies by job positions; developing professional ethics, labor discipline and industrial behavior for learners in accordance with the characteristics of production. This collaboration add the policy support of state management agencies will ensure benefits for learners, vocational schools and enterprises, and contribute to develop local human resources in the current context (Bui Van Hong and Nguyen Thi Luong, 2020).

The labor productivity in Vietnam is low (JICA, 2022). In order to proactively seize opportunities and minimize the negative impacts of the 4th Industrial Revolution on socio-economic development, the identification of occupations, vocational skills and new training models in the field of vocational education is to adapt to the requirements of the Fourth Industrial Revolution, contributing to renovation and quality improvement of vocational education in the way of opening, diversity and flexibility for the lifelong learning needs of the people. (Prime Minister, 2017, 2021).

2. Methods and Materials

Survey purpose

This survey aims to identify training demand on New Skills-New technologies in training programs of vocational education institutes and the degree of collaboration between the enterprises and vocational education institutes. The survey results are the basis for policy making on vocational training associated with training and retraining so as to improve the quality of human resources for the requirements of Industry 4.0 in Vietnam.

Survey method

- The survey uses qualitative and quantitative methods, combined with questionnaires.
- The quantitative methods are used to collect the data on the number of employees, names, numbers of new skills and the level of meeting the enterprises' needs, etc.
- The qualitative methods (face-to-face interviews at the enterprises, online or telephone interviews) are used to gather the information on trends, level of skill application in the future as well as the development plans of vocational education institutes.

Sample:

- The survey was conducted at 700 enterprises with 100 or more employees.
- 7, 000 employees working in these enterprises were surveyed and their employment positions are affected by Industry 4.0 in Vietnam.
- 50 colleges were randomly chosen for the survey and their training programs contain 3 fields mentioned above

Survey scope

The survey was carried out in the provinces and municipalities in four key economic regions of Vietnam, which are identified by the Government as the key areas affecting and supporting the development of other regions across the country, including: Northern key economic region (Hanoi, Hung Yen, Hai Duong, Hai Phong, Quang Ninh, Bac Ninh, Vinh). Phuc); Central key economic region (Thua Thien-Hue, Da Nang, Quang Ngai); Southern key economic region (Ho Chi Minh City, Binh Duong, Ba Ria-Vung Tau, Dong Nai); Mekong Delta key economic region (Can Tho City) and some provinces having TVET institutes (Nghe An, Ha Tinh, Khanh Hoa, Dak Lak and Lam Dong).

Survey content

- Regarding the vocational education institutes: identifying training plans for new occupations and new vocational skills; the degree of collaboration with the enterprises;
- Regarding the enterprises: the training demand to update and improve new skills-new technologies; the degree of collaboration with TVET institutes;
- Regarding the employees: the training demand to update and improve new skills-new technologies

Respondents:

- 700 enterprises: (i) Operating in the information technology industry; electronics and telecommunications; electricity, electronics; agriculture, forestry and fishery; (ii) Having 100 or more employees, being small and medium-sized (including state-owned enterprises, non-state enterprises and foreign-invested enterprises).
- 7000 employees working at the above-mentioned enterprises and their positions are heavily impacted by the fourth industrial revolution.
- 50 colleges randomly selected and having training programs in the information technology industry; electronics and telecommunications; electricity, electronics; agriculture, forestry and fishery;

Limits of the Study:

- Temporal limits: The study was conducted during a short time (2 months), in 3 groups of occupation
- Spatial limits: This study was conducted in Vietnam.
- Human limits: This study targets a wide range of space (22 localities) and some subjects (700 enterprises, 50 vocational education institutes and 7.000 workers).

3. Results /Findings

3.1 Survey result at vocational education institutes

New skills/New technologies to be updated to training programs for Information technology; Electronics and Telecommunications; Electricity, electronics; Automation

Apart from the general skills that need to be updated in the program, including: digital transformation skills, technology application of 4.0 IR, adaptive skills; start-up skills, foreign languages, informatics, communication, teamwork, organizational and management skills, systems thinking and analysis, each profession have new skills/new technologies needed to update as show in Table 1.

Table 1: New skills, new technologies to to be updated for Information technology; Electronics and Telecommunications; Electricity, electronics; Automation

Occupation	New skills, new technologies to be updated
Electricity-Electronics	Artificial Intelligence
	Modern electrical and electronic systems
Residential electricity	Installing, establishing connections to control electrical devices by wireless devices (using wifi, bluetooth)
	Smart building control
	Installing civil smart electricity (smartphone)

Automation technology	Installing, testing and operating intelligent automation control systems with internet connection, following technical requirements
	Developing artificial intelligence (AI)
	Automation; industrial robots
Industrial electricity	Intelligent control of electricity
	Programmable logic controller (PLC); process automation of production
	Modern electrical and electronic systems
	Internet of Things (IOT) technology, smart sensors, smart electrical devices
	Skills of software installation and drawing on CADe-simu; skills of using hantex electronic measuring devices, setting up and programming the logo soft comfort v7
	Installing smart inverter; programming smart home connection
	PLC automation
	Advanced PLC for data digitization
	Designing and operating industrial communication and control
	Installing industrial intelligent electrical equipment, skills in using electronic measuring equipment hantex, osciloscope.
	Automation; industrial robots, intelligent building control
Graphic design	3D printing technology
Computer network administration	Development of the internet of things (IOT)
	Increasing the use of mobile communication, designing web interfaces for mobile phones in many industries; enhance the ability of digitization in connecting to the internet and big data; enhance the ability of information and network security
	Technology design and programming
	Signal processing and communication
Industrial electronics	Intelligent control of electricity
	Developing artificial intelligence (AI)
	Installing, maintaining and operating communication networks; Installing, maintaining monitoring system; programming for automation systems; programming for flexible production systems; programming for embedded systems
	Microcontroller programming; PLC programming; programming; industrial communication system monitoring
	Advancing smart home system in microcontroller, approaching virtual practice model in many modules
	Internet of Things (IoT) Technology
	Automation; industrial robots, intelligent building control
	Accessing to virtual practice model in many modules; connecting MI In PLC, IOT device (keysight); Installing, connecting intelligent devices in industry
Automation	Robot technology
	Connecting and operating controllers with peripherals
	Controlling and monitoring engineering
Industrial robots	Object-oriented programming, human-machine communication, voice control
	Developing artificial intelligence (AI)
	Robot technology
Database Administration	Safe Process Operation; data security in the system, backup and restore data
Website	Website 3.0 Application
Multimedia graphics	3D graphics, 3D drawing
Air conditioning	Central air conditioning system
	Skill in pairing devices of different brands and intelligent control
	Repairing electronic circuits
Mechatronics	Data security, network system operation and maintenance work
	Internet of Things (IOT) technology, smart sensors, learning machine (AI)
	Developing artificial intelligence (AI)
	Connecting wireless control for simulating the system on fluidsim, interaction between people and objects
	Controlling and monitoring engineering
	Industrial robotics engineering
	Installing smart sensors
	Programming and operating flexible production systems; Robot control programming, Programming, monitoring industrial communication systems
Installation and control engineering in industry	Intelligent inverter System of cranes, lifting and lowering, elevators; Programming and monitoring industrial communication systems
Computer repair and assembly engineering	Technology maintenance and installation
	Skill in using error reporting and automatic repair devices
	Electronic and computer engineering
	Computer simulation, interactive video
Computer programming, IT	Security of data in the system, backup and recovery of data; Website design and administration
	3D graphics, cloud computing
	Programming and analyzing data
	IoT, network security

	Developing artificial intelligence (AI); developing robotics and internet of things technology; applying virtual reality software
Information technology (software application)	Developing artificial intelligence (AI); applying Virtual reality (VR) and Austrian reality (AR) software

New skills/New technologies to be updated to training programs for agriculture-forestry-fishery

Apart from the general skills that need to be updated in the program, including: digital transformation skills, technology application of 4.0 IR, communication, teamwork; start-up skills, adaptive skills, thinking, initiative, creativity, each occupation has new skills/new technologies needed to update, as shown in Table 2.

Table 2: New skills/New technologies to be updated to training programs for agriculture-forestry – fishery

Occupation	New skills, new technologies to be updated
Management and exploitation of irrigation works	Applying science and technology, digital technology to the management, exploitation and operation of irrigation works
Silviculture	Measurement by new GPS
Bonsai gardening	Landscape design on software
Processing and designing carpentry products	Engraving with CNC technology
Plant tissue culture	Sampling technique Plant tissue culture (in vitro)
Krill farming and processing	Applying science and technology for krill farming and processing Farming and processing krill according to MSC standard Quality management, production process supervision and geographical indication development
Cultivation	Management and operation of equipment in high-tech agricultural production
Seafood processing	Application of science and technology to seafood processing and IPC computers in weighing and controlling errors Operation, maintenance and repair of refrigeration and packaging equipment
Operation and repair of electric pumping stations	Installing, establishing connections to control electrical devices by wireless devices Applying science and technology, digital technology to the management and operation of electric pumping stations
Crop science	Quality management of agricultural products and traceability, Management and operation of equipment in high-tech agricultural production
Plant protection	Application of modern biotechnology, modern tissue culture techniques, modern molecular techniques, modern genetic engineering Sensors for rapid detection of pesticides
Shrimp farming	Applying technology to shrimp farming: biofloc system, Ras shrimp farming, CPF-Combine version 2, Copefloc shrimp farming, super-intensive Raceway shrimp farming…
Animal husbandry	Sample testing process: blood, specimen. . . Operating testing machines: blood, urine. . . Implementing rapid tests Reading test results Application of test results to treatment regimens. Operating ultrasound and X-ray machines. Reading ultrasound and X-ray results. Application of results to treatment regimens.
Krill farming and processing	Applying science and technology for krill farming and processing Farming and processing krill according to MSC standard Quality management, production process supervision and geographical indication development

Degree of collaboration with the enterprises

All vocational training institutes collaborate with the enterprises. However, the combination degree and form vary between the institutes. The most common form of collaboration with the enterprises is taking on the trainees to practice on site (100%), followed by providing information on the recruitment and training demand of the enterprises (92%), as shown in Table 3.

Table 3: Degree of collaboration with the enterprises

Collaboration form	Percentage of enterprises collaborating (%)	Occupation/New skills/New technologies
Developing training programs and textbooks	84, 00	Mechatronics, welding technology, mobile robot profession, industrial electricity, industry 4.0, robot application in industry
Developing outcome standards, training field list, training equipment list	78, 00	Mechatronics, welding technology, mobile robot profession, industrial electricity, industry 4.0, robot application in industry
Taking on the trainees to practice on site	100, 00	Industry 4.0, industrial robot application, industrial electricity, mechatronics, digital skills and internet connection. . .
Assessing learning outcomes of learners at vocational education institutes	84, 00	Mobile robot
Retraining workers at vocational education institutes	82, 00	Digital skills and internet connection
Providing trainers for vocational education institutes	64, 00	
Taking on the teachers to visit and work at the enterprises	82, 00	Application of robots in industry, industrial electricity, mechatronics
Provide information about their training and recruitment needs	92, 00	
Coordination of training with the enterprises	88, 00	Industrial robot application, industrial electricity, mechatronics, digital skills and internet connection. . .
Supporting in providing facilities and equipment, scholarships to students of vocational education institutes	88, 00	
Cost sharing in the training activities	64, 00	

3.2 Survey result at enterprises

Workers and occupations affected by Industry 4.0

The percentage of workers that their jobs are affected by Industry 4.0 is 25.9%. And the occupations most affected by Industry 4.0 include Industrial electricity; Computer programming; Electricity-Electronics; Industrial electronics; Automation; Multimedia graphics. . . . ., as shown in Table 4.

Table 4: 20 occupations with the most number of workers affected by Industry 4.0 Unit: %

Occupation	No technical qualification	3-Month certificate	Elementary degree	Intermediate degree	Associate degree	Total
Industrial electricity	6, 6	40, 0	36, 0	10, 7	6, 7	100, 0
Computer programming		66, 3	25, 0	8, 7		100, 0
Electricity-Electronics	4, 6	52, 3	33, 7	4, 7	4, 7	100, 0
Industrial electronics	10, 4	37, 3	28, 4	11, 9	11, 9	100, 0
Automation	9, 1	43, 6	25, 5	12, 7	9, 1	100, 0
Multimedia graphics		64, 6	31, 3	4, 2		100, 0
Welding		29, 3	48, 8	12, 2	9, 8	100, 0
Website		55, 6	33, 3	5, 6	5, 6	100, 0
Graphic design		69, 2	30, 8			100, 0
Food processing	20, 8	33, 3	16, 7	8, 3	20, 8	100, 0
Computer network administration	8, 3	20, 8	37, 5	16, 7	16, 7	100, 0
Database Administration	14, 3	38, 1	28, 6	9, 5	9, 5	100, 0
Residential electricity	4, 8	52, 4	42, 9			100, 0
Mechanical engineering	15, 8	36, 8	15, 8	15, 8	15, 8	100, 0
Air conditioning		44, 4	44, 4		11, 1	100, 0
Industrial robots		37, 5	37, 5	25, 0		100, 0
Installation and control engineering in industry	12, 5	37, 5	12, 5		37, 5	100, 0
Computer repair and assembly engineering	12, 5	56, 3	31, 3			100, 0
Automation technology		50, 0	50, 0			100, 0
Average	5, 8	46, 8	31, 7	8, 7	7, 0	100, 0

New skills/New technologies to be updated to training programs (by enterprises)

700 enterprises (79.3% of enterprises are non-state, 14.6% of enterprises are foreign-invested and 6.1% of enterprises are state-owned) were surveyed, the result demonstrated that: To meet the requirements of enterprises, workers must have common skills such as: Digital transformation, technology 4.0 application in the production process, foreign languages, informatics, initiative, creativity, communication, teamwork, thinking ability, general analysis ability; Persuasion, negotiation and marketing skills.

In addition, the employees working in different occupations require particular new skills, detailed in Table 5.

Table 5: New skills/New technologies to be updated to training programs

Occupation	New skills/New technologies to be updated to training programs (by enterprises)
Food processing	Digital agriculture
	Social network
Cultivation, animal husbandry	Biotechnology
	Management and operation of equipment in high-tech agricultural production
Seafood processing	Application of science and technology to seafood processing and IPC computers in weighing and controlling errors Operation, maintenance and repair of refrigeration and packaging equipment
Plant tissue culture	Sampling technique Plant tissue culture (in vitro)
Electricity-Electronics	Artificial Intelligence
	Modern electrical and electronic systems
	Quantum Computing
	Smart automatic production lines
	Smart sensors
Residential electricity	Installing, establishing connections to control electrical devices by wireless devices (using wifi, bluetooth)
	Smart building control
Automation technology	Installing, testing and operating intelligent automation control systems with internet connection, following technical requirements
	Developing artificial intelligence (AI)
	Automation; industrial robots
Industrial electricity	Intelligent control of electricity
	Programmable logic controller (PLC); process automation of production
	Modern electrical and electronic systems
	Internet of Things (IOT), smart sensors, smart electrical devices
	Skills of software installation and drawing on CADe-simu; skills of using hantex electronic measuring devices
	Installing smart inverter; programming smart home connection
	PLC automation
	Advanced PLC for data digitization
	Designing and operating industrial communication and control
	Automation; industrial robots, intelligent building control
Graphic design	3D printing technology
Welding	High-tech welding
	Welding robot
	AGV (Autonomous Guided Vehicles)
Computer network administration	Development of the internet of things (IOT)
	Increasing the use of mobile communication, designing web interfaces for mobile phones in many industries; enhance the ability of digitization in connecting to the internet and big data; enhance the ability of information and network security
	Technology design and programming
	Cloud security
	Signal processing and communication
Industrial electronics	Intelligent control of electricity
	Developing artificial intelligence (AI)
	Installing, maintaining and operating communication networks; Installing, maintaining monitoring system; programming for automation systems; programming for flexible production systems; programming for embedded systems
	Microcontroller programming; PLC programming; programming; industrial communication system monitoring
	Advancing smart home system in microcontroller, approaching virtual practice model in many modules
	Internet of Things (IoT) Technology
	Automation; industrial robots, intelligent building control
Automation	Robot technology
	Connecting and operating controllers with peripherals
	Controlling and monitoring engineering
Mechanical engineering	Intelligent Manufacturing Systems – IMS
	3D design with big data in mechanical engineering
Database Administration	Safe Process Operation; data security in the system, backup and restore data
	Big data
	Data Center Management
Website	Website 3.0 Application
Multimedia graphics	3D graphics, 3D drawing
Air conditioning	Central air conditioning system
	Skill in pairing devices of different brands and intelligent control
	Repairing electronic circuits
Mechatronics	Data security, network system operation and maintenance work
	Internet of Things (IOT), smart sensors, smart electrical devices
	Developing artificial intelligence (AI)

	Connecting wireless control for simulating the system on fluidsim, interaction between people and objects
	Controlling and monitoring engineering
	Industrial robotics engineering
	Programming and operating flexible production systems; robot control programming
Installation and control engineering in industry	Intelligent inverter
	System of cranes, lifting and lowering, elevators
	Operating scada in the factory's production line
	Operating and maintaining machine vision systems
Computer repair and assembly engineering	Technology maintenance and installation
	Skill in using error reporting and automatic repair devices
	Electronic and computer engineering
	Computer simulation, interactive video
Computer programming, IT	Security of data in the system, backup and recovery of data; Website design and administration
	3D graphics, cloud computing
	Programming and analyzing data
	IoT, network security
	Developing artificial intelligence (AI); developing robotics and internet of things technology; applying virtual reality software
	Blockchain-based data transmission

Degree of collaboration with vocational education institutes

There are 391 out of 700 enterprises that collaborate with TVET institutions (55.86%). The enterprises partner with the institutes to different degrees in different forms. The most common form of combination is taking on the trainees to practice on site, followed by coordinating training with vocational education institutions; Retraining workers at the institutes; coordinating in the development of outcome standards, the list of training fields, the list of training equipment, as shown in Table 6.

Table 6: Collaboration with TVET institutes

Collaboration form	Percentage of enterprises collaborating (%)	New skills/New technologies
Taking on the trainees to practice on site	51, 29	Electricity-Electronics, welding, metal cutting, IT, computer programming, graphic design, refrigeration system installation, CNC machine operation, industrial electricity, computer repair
Developing training programs and textbooks	35, 86	Mechatronic equipment, electrical-electronic equipment, welding, metal cutting, IT, computer programming, graphic design
Developing outcome standards, training field list, training equipment list	42, 00	Mechatronic equipment, electrical-electronic equipment, welding, metal cutting, IT, computer programming, graphic design
Providing information about training and recruitment needs of enterprises	33, 43	Electricity-electronics, welding, metal cutting, industrial electricity, technology engineers
Taking on the teachers to visit and work at the enterprises	35, 71	Mechatronic equipment, electrical-electronic equipment, IT, computer programming
Coordinating in assessing learning outcomes of learners at vocational education institutes	33, 57	Electricity-electronics, welding, metal cutting, automation
Retraining workers at vocational education institutes	42, 29	Mechatronic equipment, electrical-electronic equipment, IT, computer programming, computer repair
Coordination of training with TVET institutes	46, 43	Welding, metal cutting
Providing trainers for vocational education institutes	37, 71	Assembling electrical panels, electricity-electronics, computer repair, industrial electricity, metal cutting, mechanical processing
Supporting in providing facilities and equipment, scholarships to students of vocational education institutes	31, 57	Industrial electricity, metal cutting
Cost sharing in the training activities	23, 14	Metal cutting

3.3 Survey result of workers at enterprises

New skills/New technologies to be learned/updated (by workers)

In order to better meet the job requirements in the context of Industry 4.0, the employees believe that it is necessary to be trained in some new skills, most of which are computer science, foreign languages, and occupational safety and health…. as shown in Table 7.

Table 7: Workers' demand for training in new skills/new technologies

New skills/New technologies	Training demand Number of workers
Informatics	3, 649
Foreign languages	3, 619
Occupational safety and health	3, 613
Knowledge/professional	3, 610
Teamwork	3, 136
Dexterity, endurance, perseverance and precision	3, 111
Communication	3, 090
Ability to perceive and evaluate quality and safety	2, 785
Creative ability, creative mind	2, 772
Ability to Persuade and Negotiate	2, 770
Time management and work coordination	2, 689
Analytical and creative thinking, initiative	2, 675
The ability to guide, advise and explain	2, 667
Complex problem solving skills	2, 624
Human Resource Management Skills	2, 548
Attention to detail, reliability	2, 535
Ability to manage finances and resources	2, 490
Ability to work under pressure and flexibility	2, 482
Critical and analytical thinking	2, 473
Marketing	2, 433
Leadership capacity	2, 380
Learning strategies and active learning	2, 372
Technical debugging skills; product analysis, design and improvement skills	2, 349
Technology maintenance and installation	2, 273
Technology design and programming	2, 257
Environmental Sustainability	2, 233
Ability to analyze and evaluate systems	2, 208
Using, monitoring and controlling technology	2, 120
Reading, writing, active listening and math	2, 093
The ability to reason, solve problems and come up with ideas	2, 079

4. Conclusions

The survey result demonstrated that:

1) Regarding new occupational skills and new technologies (specialized skills) for each profession, the research revealed that 25.9% of employees in the 700 surveyed enterprises are working in occupations affected by Industry 4.0 (Table 4). In which, the industries and occupations that employees are most affected include: Industrial electricity; Computer programming; Electricity-electronics; Industrial electronics; Automation; Multimedia graphics. . . . . The research also identified new skills and new technologies that need to be updated for the workers in each occupation affected by Industry 4.0 (Table 5 and Table 1). However, there is a difference in the definition of new skills under the Industry 4.0 impacts between the TVET institutes and businesses. In order to meet the requirements of using human resources in the enterprises, the vocational training institutes must work with the businesses to find out and agree with enterprises on the name and concept of the new skills, new technologies. In the next step,
2) In addition to the specialized skills mentioned above in each profession, the study shown that there are similarities between vocational education institutes and the businesses in terms of the content of expected additions to the training programs, which is a number of transformation skills (soft skills), basic skills in all the occupations, of vocational education institutes, and in accordance with the enterprises' needs on the general skills for new occupations. TVET institutes intend to add to the training program some general skills for all new occupations that basically are the same with the needs of businesses, including: Digital transformation; technology 4.0 application in the production process, foreign languages, informatics; communication; thinking ability, analysis ability; persuasion and negotiation; marketing; sales; Time management skills…
3) The research also disclosed that there are many forms of collaboration between the vocational training institutes and the enterprises in the training process. The most common form is taking on the trainees to practice on site, followed by coordinating training with vocational education institutes; retraining workers at the institutes; coordinating in the development of outcome standards, the list of training fields, the list of training equipment. However, only 55.86% of enterprises collaborate or participate in skills training, whereas 100% of TVET institutions cooperate with enterprises to provide skills training. As a consequence, there should be solutions to promote the enterprises to work more actively with TVET institutes in the training process in order to meet job requirements in the context of Industry 4.0's impact.

5. Recommendations

In the light of the above results, the researchers recommend:

For the TVET institutes: Updating the training programs and training the learners to use new skills/new technologies

For the state management agencies in vocational education: Making policies on vocational training associated with training and retraining so as to improve the quality of human resources for the requirements of Industry 4.0 in Vietnam.

For the enterprises: Implementing or collaborating with TVET institutes for updating training programs and training for learners to acquire new skills Ethical Approval: (if there is) It is including your ethical approval, documenting the full name of the approving ethical committee, and confirming that informed consent was obtained from all patients/participants for your experiments.

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