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Curriculum for Embedding Industry 4.0 to a Computer Engineering Program

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***Abstract*—The presence of Industry 4.0 has changed the requirements of industrial workforces. Previously, the staff responsible for information systems and plant operation were divided and worked differently in concepts and methods. However, the convergence of Industry 4.0 has encouraged the industry to have maintenance workforces capable of both information processing and machine maintenance. In response, a new computer engineering curriculum previously aimed at the computing industry desired to embed a particular set of PLC contents into its existing curriculum to expand the possible working area for its graduates. The process is supported by the Asean Factori 4.0, an ERASMUS+ Project funded by the European Union. Through the effort, a new branch of elective courses and a few required courses are synthesized to add the PLC's skills that can be integrated into other branches.**

Keywords—industry 4.0, PLC, education, course

I. Introduction

The rapid growth of Industry 4.0 around the globe forces countries to adapt their economic and education policies, as the requirement for industrial workforces will never be the same. In ASEAN, most countries are trapped in middle-income status or poverty. The existing industrial model in the area is mostly based on human resources in an assembly line, which adequately served the development of economics for a few decades. However, that model is now obsolete and does not provide enough income for entry-level workers, which significantly stalls the GDP growth per capita as most of the population is struggling in entry-level or early intermediate-level work.

Therefore, most ASEAN countries, including Thailand, are pushing the practice of Industry 4.0 to modernize their economic model and escape the middle-income trap [1]. As a result, the automation workforce is also expected to emphasize connectivity, cloud computing, cyber security, content, and context [2]. Two methods are obviously possible to prepare a graduate with these new requirements: the first is to enhance the existing automation curriculum with ITC-related contents, and the second is to add automation skills to ICT students. However, the novel automation skills are based on computer-related knowledge such as programming, networking, artificial intelligence, optimization, and related fields. Therefore, it is more convenient to imbue a particular set of industrial skills for a computer-based graduate rather than supplying an industry-based student with many computing skills.

As a result, this article presents a new curriculum based on a computer engineering paradigm with an enhancement of a necessary set of industrial practices mainly focused on PLC. The new curriculum has been deployed with the first batch of students in the 2021 academic year with an elective branch on industrial 4.0. The curriculum update is done with close consulting and support from the European Union partner university through the Asean Factori 4.0 of the ERASMUS+ program. The first evaluation is conducted through an intensive meeting of experts and industries, which significantly bode a fair acceptance rate.

II. Accreditation Process

In order to develop a modified curriculum, processes need to be done before the practical deployment of the outlined courses and activities. The following steps were carefully conducted through close collaboration with the partner European universities.

A. Curriculum Structuring

There are constraints in modifying the existing curriculum as the government's regulation dictates that the credit structure is not to be touched. Therefore, any adjustment must serve the purpose of the collaborative project, the regulation, and the school's objective. After multiple consulting sessions between partners, the method was concluded to modify the content of existing courses with the selected content related to Industry 4.0. The target courses are listed in TABLE I.

TABLE I. Modified Courses

Course Code	Course Name	Credits	Course Type
1501221	Embedded System and Internet of Things	3	Required
1501322	Electronics and Electric Drives	3	Elective

Course Code	Course Name	Credits	Course Type
1501324	Sequence Control and PLC	3	Elective
1501326	Computer Control Systems	3	Elective
1501224	Network Programming and Automation	3	Elective
1501345	Network System Security	3	Elective
1501323	Robotics and Applications	3	Elective
1501431	Intelligent Control Systems	3	Elective

As the courses are set, the next process is to specify the type and detail of the modification, which is summarize in TABLE *II*.

TABLE II. DETAIL OF MODIFICATION

Course Name	Year	Modification	
		Type	Detail
Embedded System and Internet of Things	2	Partial adjustment	Adjustment with Concept of industry 4.0
Electronics and Electric Drives	3	Partial adjustment	Adjustment with Industrial equipment and sensors
Sequence Control and PLC	3	Partial adjustment	Adjustment with updated PLC HW/SW
Computer Control Systems	3	Partial adjustment	Adjustment with PLC application in Control System
Network Programming and Automation	3	Partial adjustment	Adjustment with Industrial Networking
Network System Security	3	Partial adjustment	Adjustment with cybersecurity for Industrial 4.0
Robotics and Applications	3	Full adjustment	Adjustment with process design and emulation The addition of internship process on PLC applications
Intelligent Control Systems	3	Full adjustment	Adjustment with the application of intelligent algorithms to the design of PLC controlled systems The addition of internship process on PLC applications

The difference between partial and full adjustment is the modified percentage of the course description. The partial adjustment means the existing course description is modified by less than 75%, and any percentage above that number indicates full adjustment.

B. Courses Sequencing

The next crucial part is to sequence the selected courses and guarantee the compilation of the year-based learning outcomes. The semesterly sequence is listed in TABLE *III* as a final draft through thoughtful collaborative consulting and discussion.

TABLE III. COURSES SEQUENCE

Year	Semester	Course Name	Year-based Learning Outcome
2	2	Embedded System and Internet of Things	Students can describe the concept of Industry 4.0.
3	1	Electronics and Electric Drives	- Students can explain and practice PLC by demonstrating related devices and equipment. - Students can discuss and suggest a solution for the industrial network.
		Sequence Control and PLC	
		Computer Control Systems	
	2	Network Programming and Automation	
		Network System Security	
4	1	Robotics and Applications	Students can apply the knowledge of Industry 4.0 and PLC to related advanced topics.
		Intelligent Control Systems	

The proposed year-based learning outcome is defined as an extensive index to measure the competency of industrial skills. These outcomes serve both the program learning outcome and the purpose of the Asean Factori 4.0 project.

III. EVALUATION

Before proposing the modified curriculum to the University, the curriculum must be evaluated by experts and target industries. The draft was presented in the meeting of a special committee composed of experts with high academic engineering profiles and targeted collaborative industries.

Through the serious session of presentations and queries, the meeting concluded that the modified curriculum has the potential to equip a skill set for computer engineering graduates to answer the demand of new s-curve industries. However, the committee worried about the cost of implementation and sustainability as the learning devices and equipment are expensive and require strictly scheduled maintenance.

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CONCLUSION

Sponsored by the Asean Factori 4.0 project of the ERASMUS+ Program, a modified computer engineering curriculum aimed at embedding the necessary knowledge and practice of Industry 4.0 to meet the requirement of the new economic model and S-curve industries is proposed and initially evaluated by experts and industries. The modification is based on required and elective courses, which are semesterly sequenced to meet the expected learning outcomes that compile with the existing program learning outcome and the goal of the sponsored project.

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Preparation of an Excellence Center in Industry 4.0 based on Computer Engineering Paradigm

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***Abstract*—The presence of Industry 4.0 has altered the requirements of industrial workforces. Previously, the personnel in charge of information systems and plant operations were divided and worked in different concepts and methods. Nevertheless, the convergence of Industry 4.0 has encouraged the development of maintenance workforces capable of both information processing and machine maintenance. In response, an excellence center in Industry 4.0 in as aspect of computer engineering discipline is to be established to support the paradigm change in industry. The Asean Factori 4.0 project, an ERASMUS+ project funded by the European Union, is assisting with the process. The preparation of the excellence center is divided into two parts: the hardware and software definitions, and the staff preparations. The design and delivery of hardware and software is progressed according to the schedule, and the staff are being prepared as intended in the form of seminar and training. The feedback and evaluation strongly state that the audiences and the trainees are well satisfied and educated.**

Keywords—industry 4.0, excellence center, preparation

I. Introduction

The rapid growth of Industry 4.0 around the globe forces countries to adapt their economic and education policies, as the requirement for industrial workforces will never be the same. In ASEAN, most countries are trapped in middle-income status or poverty. The existing industrial model in the area is mostly based on human resources in an assembly line, which adequately served the development of economics for a few decades. However, that model is now obsolete and does not provide enough income for entry-level workers, which significantly stalls the GDP growth per capita as most of the population is struggling in entry-level or early intermediate-level work.

Therefore, most ASEAN countries, including Thailand, are pushing the practice of Industry 4.0 to modernize their economic model and escape the middle-income trap [1]. As a result, the automation workforce is also expected to emphasize connectivity, cloud computing, cyber security, content, and context [2]. Two methods are obviously possible to prepare a graduate with these new requirements: the first is to enhance the existing automation curriculum with ITC-related contents, and the second is to add automation skills to ICT students. However, the novel automation skills are based on computer-related knowledge such as programming, networking, artificial intelligence, optimization, and related fields. Therefore, it is more convenient to imbue a particular set of industrial skills for a computer-based graduate rather than supplying an industry-based student with many computing skills.

As a result, this article presents a preparation process to establish an excellence center in Industry 4.0 based on the paradigm of computer engineering to enhance curriculum development and workforce training to meet regional requirements. The processes consist of the specification of hardware and software and the preparation of students and staffs.

II. Preparation Process

In order to develop an excellence center, the following steps were carefully conducted through close collaboration with the partner European universities of the Asean Factori 4.0 Project.

A. Specification of Hardware and Software

The hardware and software are divided into two sets. The first is the general set of computers, and the second is the specific set of PLC hardware and software. The ASEAN partner drafts the first set, and the associate European partner drafts the second set. The detail of the hardware and software are listed in TABLE I. The ASEAN partner is responsible for the computers and communication devices, and the European partner is responsible for PLC and related hardware and software. However, the PLC's hardware is delayed because of the global IC shortage.

TABLE I. Hardware and Software of the Excellence Center

Responsible Partner	Hardware/Software	Quantity	Delivered
ASEAN	All in one PC - Core i5, 16GB RAM	4	Y
	Laptop - Core i7, 16GB RAM	4	Y

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Responsible Partner	Hardware/Software	Quantity	Delivered
	27'' Screen	4	Y
	16 Port Gigabit Ethernet Switch	1	Y
	Dual Band 600 Mbps Access Point	1	Y
	UPS	9	Y
European	SCE TRAINER PACKAGE STEP 7 V16	1	Delayed due to IC shortage
	TRAINER PACKAGE HMI, WINCC ADVANCED V16 ECCN:5D9	1	Delayed due to IC shortage
	TRAINER PACKAGE HMI, TP700 COMFORT ECCN:5D992	1	Delayed due to IC shortage
	SCHULUNGSPAKET ET 200SP BASIC ECCN:EAR99H	1	Delayed due to IC shortage
	PACK FORMATION CPU1512C-1PN	1	Delayed due to IC shortage
	SIMATIC OPC UA S7-1500 SMALL ECCN:5E992	1	Delayed due to IC shortage
	SCALANCE XC208	1	Delayed due to IC shortage
	SIMATIC NET SINEC NMS 50 V1	1	Delayed due to IC shortage
	TRAINER PACKAGE HMI, WINCC PROF. V16	1	Delayed due to IC shortage
	SIMATIC CFC TRAINER PACKAGE V9.0	1	Delayed due to IC shortage
	SIMIT SIMULATION V10.2	1	Delayed due to IC shortage
	6DL8900-8XX00-0XB8-ZY01	1	Delayed due to IC shortage
	CLE USB SIMIT LICENCE CARRIER	1	Delayed due to IC shortage
	PLATEFORME SIMIT PACK LOG. MEDIA	1	Delayed due to IC shortage
	PACK FORMATEUR 12 IE SOFTNET-7	1	Delayed due to IC shortage
	WINCC/WEB NAV TRAINER PACKAGE V7.5	1	Delayed due to IC shortage

B. Preparation of Students and Staffs

It is well aware that the excellency is not based on the purchased equipment but is strongly based on the people who wield them. Therefore, the preparation of technical staff and pilot students is equally important as the equipment acquisition. In this case, there are two activities concerning the issue of students and staff. The first activity is a seminar to advertise the excellence center and locate potential students who may be interested in Industry 4.0 and automation. The seminar was delivered to a class of more than 80 students in a computer engineering program. The content and learning outcomes are shown in TABLE *II*.

TABLE II. SEMINAR BASED ON ASEAN PARTNER

Contents	Hrs.	Learning Method	Learning Outcomes
Concept of Industry 4.0	2	Online lecture	Students understand the concept of Industry 4.0 and smart factory.
Introduction to Programable Logic Controller (PLC)	2	Online lecture	Students understand automation process and PLC characteristics.
Industry Network	2	Onsite lecture	Students understands basic communication and industry networks
Cyber Security	2	Onsite lecture	Students understands the fundamental of safety and security.

As the students of this seminar will be selected to join a pilot project focusing on advanced content on Industry 4.0 and automation, experienced staff is required to help handle them. Therefore, another preparation is made as intense staff training. The trainees of this course are selected from the technical staff and the graduate students of the ASEAN partner. This activity aims to train who will be the trainer in PLC and automation. After carefully selecting the applications, only four trainees are accepted. The content and learning outcomes of the course are shown in **Error! Reference source not found.**.

TABLE III. STAFF TRAINING

Contents	Hrs.	Learning Method	Learning Outcomes
Concept of PLC	2	Onsite lecture	Trainees discuss the diversity of PLCs and their applications.
Introduction to Siemens TIA PORTAL	2	Onsite lecture and practice	Trainees explain the environments of the targeted software.
PLC configurations	2	Onsite lecture and practice	Trainees demonstrate the PLC configurations in the targeted software.
Basic PLC programming	2	Onsite lecture and practice	Trainees shows skills in PLC programming.
HMI Configuration	2	Online lecture and practice	Trainees applies HMI to the PLC project.
HMI Programming	2	Online lecture and practice	Trainees demonstrate the co-programming of PLC and HMI.
Analog Inputs/Outputs and programming	2	Online lecture and practice	Students discuss and demonstrate the use of analogue inputs and outputs of a PLC.
PLC communication	2	Online lecture and practice	Students discuss and demonstrate the communications between PLCs.

At this point, there is no PLC hardware and related equipment. Therefore, the training was conducted based on the trial version of the targeted PLC software. The practices are based on carefully designed simulations to reflect practical issues and prepare the trainees to work with the actual hardware later.

III. EVALUATION

This section contains the seminar and staff training surveys. As the deployment of hardware and software is

insufficient, their evaluation is postponed until the completion of delivery. SPSS was used to examine numerical data based on five Likert Scale questions in this section (Statistical Package for Social Sciences). Utilizing descriptive statistics (mean scores, standard deviation, and level of interpretation), we were able to determine the participants' perceptions of the Industry 4.0 training seminars. The range for the 5-point Likert Scale used in the questionnaire is detailed below.

5 = Strongly Agree
4 = Agree
3 = Neutral
2 = Disagree
1 = Strongly Disagree

The meaning of the level of students' feedback were interpreted in the following ranges below:

Average score	Level of Interpretation
4.21-5.00	Very high
3.41-4.20	High
2.61-3.40	Moderate
1.81-2.60	Low
1.00-1.80	Very low

A. Evaluation of the Seminar

As soon as the lecture concluded, online forms were used to collect student feedback. The evaluated aspects include the course material, the teachers, and cognitive performance. The evaluation findings are shown in Tables IV-VII.

TABLE IV. GENERAL INFORMATION OF THE PARTICIPANTS

Feedback Statement	Frequency (N=82)	Percentage
Gender		
Male	60	73
Female	22	27
Education level		
Bachelor Students	82	100

TABLE V. STUDENT FEEDBACK ON CONTENT

Feedback Statement	$\bar{X}$	S.D.	Interpretation
The training content matches the learning objectives.	3.88	0.82	High
The duration of training is appropriate.	3.96	0.78	High
The training content and methods are appropriate for the current situation.	4.05	0.78	Very high
Quality of the training documentation.	3.98	0.83	High
The course is conducive to learning and developing your abilities.	4.06	0.79	Very High
You can apply what you have gained/learned from this workshop to your practice.	3.94	0.83	High

TABLE VI. STUDENT FEEDBACK ON INSTRUCTOR

Feedback Statement	$\bar{X}$	S.D.	Interpretation
Ability to convey/communicate/understand about the contents.	4.11	0.83	Very High
Classifying the complete narrative's contents.	4.17	0.82	Very high
Providing opportunities for questioning and commenting.	3.92	0.84	High
Answering the question is relevant and clear.	4.01	0.79	Very high
Make the appropriate training time.	4.00	0.81	Very high

TABLE VII. OVERALL, SKILL ACHIEVED

Feedback Statement	$\bar{X}$	S.D.	Interpretation
pre-training knowledge level.	2.01	0.79	Low
post-training knowledge level.	4.00	0.84	High

B. Evaluation of the Staff Training

The purpose of this course is to prepare skilled trainers. The evaluation is then based on the competency of the learner. TABLEAU VIII-IX provides a summary of the trainee's competencies and evaluation methodologies.

TABLE VIII. GENERAL INFORMATION OF THE PARTICIPANTS

Feedback Statement	Frequency (N=5)	Percentage
Gender		
Male	4	80
Female	1	20
Education level		
Bachelor's degree	3	60
Master's degree	2	40

TABLE IX. TRAINEE'S COMPETENCE

Feedback Statement	$\bar{X}$	S.D.	Interpretation
pre-training knowledge level.			
PLC fundamental	2.08	0.76	Low
PLC config	2.12	0.82	Low
PLC programming and application.	1.86	0.81	Low
post-training knowledge level.			
PLC fundamental	4.02	0.79	High
PLC config	4.16	0.81	High
PLC programming and application.	3.87	0.84	High

There were 82 attendees in the session. The outcomes indicate students' feedback and satisfaction with the workshop's training materials, instructors, and skillset.

Overall, participants were quite satisfied with the workshop. The total mean satisfaction score for contents and learning outcomes was 3.88 (S.D. = 0.82). When closely examined, participants were most happy with item 5 "The course is beneficial to learning and enhancing your abilities" (x=4.06, S.D.= 0.79). Second, they were satisfied with item 3 "The training material and procedures are acceptable for the current situation," (x=4.05, S.D.= 0.78), followed by item 2 "The training time is appropriate," (x = 3.96, S.D.= 0.78). The level of interpretation for all items was really high. However, the item with the lowest level of satisfaction was item 1, which was still up to interpretation. The results show that the learners have a strong knowledge of the learning materials and objectives that lead to workshop skill development, as evidenced by the pre and post skill achieved (Table VII). This demonstrates that learners are more likely to incorporate their newly learned information into their lifelong learning.

Four teaching assistants were taught in PLC technologies: fundamentals, configuration and programming, and applications. According to their graduation and employment experience at the university, the participants already have a solid basis in computer and digital technology. Their satisfaction with the workshop skills in particular was the survey's main focus. The outcomes clearly demonstrated that they were very satisfied and developed several skills as a consequence of the training. However, due to variances in the learners' baseline knowledge, this research may contain biases. For more accurate analysis results, further research on dependable evaluation methodologies and structural model analysis should be conducted.

CONCLUSION

This research prepares and evaluate the preparation state of an establishment of the excellence center in Industry 4.0 based on the computer engineering point of view. The preparation is divided into the hardware and software part, and the people part. Both are implemented concurrently in closed guidance with the partners universities in Europe through the Asean Factori 4.0, which is an Erasmus+ project. The evaluation is done on the people part. Through feedback and evaluation, the outcomes are good in term of satisfaction and competence.

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Industrial requirements analysis for Excellence Center setting-up and curriculum design in Industry 4.0 context

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***Abstract*— The needs of industrial workforces have changed in the Industry 4.0 era. The knowledge worker in charge of information systems and internal operations was divided into different roles, and they each used different working methods and concepts. Despite this, Industry 4.0's consolidation has promoted the growth of servicing workforce with both computational complexity and equipment maintenance skills. An industrial requirements analysis is conducted in this paper to identify the key skills and competencies needed for setting up and designing an Excellence Center in the context of Industry 4.0. A diverse group of industry experts are surveyed to gather their insights on the most important areas of focus for such a center. The findings indicate that the key competencies needed for success in an Industry 4.0 setting include digital literacy, data analysis, and the ability to work with advanced technologies such as artificial intelligence and the Internet of Things. Based on these findings, a curriculum for the Excellence Center is proposed that prioritizes these competencies and includes hands-on training and practical experience. Overall, this paper contributes to the understanding of the requirements for Industry 4.0 and provides a roadmap for setting up and designing an Excellence Center to meet these requirements.**

Keywords—industry 4.0, excellence center, preparation

I. INTRODUCTION

The rapid expansion of Global Industry 4.0 has significant implications for nations, forcing them to re-evaluate and adapt their economic and educational strategies. As the industrial landscape shifts towards increased automation and digitization, there will be a significant change in the types and levels of skills required for industrial jobs. This means that current educational systems and workforce training programs may not be sufficient to meet the demands of Industry 4.0, and nations will have to develop new strategies to ensure that their workforce has the necessary skills to thrive in this new environment. Many countries in ASEAN are facing challenges with middle-income status or poverty. The industrial model in the region, which heavily relies on assembly line labor, has been successful in driving economic growth in the past. However, as Industry 4.0 advances, this model is becoming outdated and is not providing sufficient income for entry-level workers. This hinders GDP growth per capita as a large portion of the population is limited to low-skilled jobs.

To escape the middle-income trap and modernize their economic model, many ASEAN countries, including Thailand, are embracing Industry 4.0. As a result, the automation workforce is expected to focus on areas such as connectivity, cloud computing, cyber security, content, and context. Industrial requirements analysis is crucial in understanding the skills and competencies needed for success in Industry 4.0. This information is essential in designing and implementing effective educational programs and curriculum for an Excellence Center.

Industry 4.0 is characterized by advanced technologies such as artificial intelligence, the Internet of Things, and big data analytics. These technologies are transforming traditional industrial processes and require a new set of skills and competencies for workers. Without conducting an industrial requirements analysis, it is difficult to understand the specific skills and competencies needed for success in this new industrial landscape.

An industrial requirements analysis can be conducted through surveys, interviews, or focus groups with industry experts. This information can be used to identify the specific skills and competencies needed for success in Industry 4.0 and to design a curriculum that prioritizes these areas.

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Moreover, designing an Excellence Center that focuses on Industry 4.0 requires a comprehensive understanding of the requirements of Industry 4.0 in order to provide the necessary training and resources to equip graduates with the skills they need to succeed in this new industrial landscape.

Industry 4.0, also known as the fourth industrial revolution, is characterized by advanced technologies such as artificial intelligence, the Internet of Things, and big data analytics. These technologies are transforming traditional industrial processes and require a new set of skills and competencies for workers. High Education Institutions (HEIs) play a crucial role in preparing the workforce for Industry 4.0 by providing relevant education and training. However, understanding the main challenges faced by HEIs in this regard is crucial to ensure that they are able to meet the needs of the industry.

The industrial requirements analysis is also important for the economic development of the nation since Industry 4.0 is expected to bring significant changes in the types and levels of skills required for industrial jobs, thus, the educational systems and workforce training programs should be aligned with the requirements of Industry 4.0 in order to ensure that the workforce has the necessary skills to thrive in this new environment[1],[2] This study aims to survey the main challenges faced by HEIs in Industry 4.0 by conducting a questionnaire survey during a 3-day exhibition of "INDUSTRIAL TRANSFORMATION ASIA-PACIFIC" in Singapore. The exhibition brought together HEIs, industry experts, and government representatives to discuss the latest developments in Industry 4.0 and the future of education and training. The survey was conducted by visiting various companies and exhibitors at the exhibition, and collecting feedback from industry experts and HEIs.

II. INDUSTRIAL REQUIREMENTS ANALYSIS PROCESS

Surveying stakeholders in the industry is crucial when designing a learning curriculum related to Industry 4.0 and automation. This is because industry stakeholders, such as employers, managers and workers, have first-hand knowledge of the skills and competencies needed for success in the industry and can provide valuable insights into the specific needs of the workforce.By surveying industry stakeholders, educators can gain a better understanding of the current and future skills and competencies required in Industry 4.0, such as digital literacy, data analysis, and the ability to work with advanced technologies. This information can then be used to design a curriculum that aligns with the specific needs of the industry and prepares students for the types of jobs that will be in demand in the future. Additionally, surveying industry stakeholders can also help educators identify any gaps in the current curriculum and make necessary adjustments to ensure that students are equipped with the skills they need to succeed in the workforce. Furthermore, surveying stakeholders in the industry can also provide valuable feedback on the effectiveness of the curriculum and any areas that need improvement. This can help educators make adjustments to the curriculum to ensure that it is meeting the needs of the industry and preparing students for successful careers. In summary, surveying industry stakeholders is essential in designing a curriculum that is relevant to Industry 4.0 and automation and preparing students for success in the workforce.

III. METHODS

The survey questionnaire was designed to gather information on the main challenges faced by HEIs in Industry 4.0, as well as the specific skills and competencies needed for success in this new industrial landscape. The questionnaire consisted of both open-ended and closed-ended questions and was distributed to a total of 100 participants, including industry experts, HEIs, and government representatives, the survey form and list of survey companies as shown as the table I and II.

TABLE I. SURVEY QUESTIONNAIRE FOR INDUSTRY

Name of the company visited……

Position of the person answering the survey

Business Development		Development & Design		Production	
Engineering		Finance & Investment		Product Management	
Technical Sales		Information Technology		Quality Control & Assurance	
Research & Development		Procurement		Compliance & Audit	

What are the main activities of your company?			
PLC & HIM & driver trademark		Industrial image processing & vision	
Robot trademark		Electrical power transmission	
Automation software designer & simulation		Embedded systems	
Control systems, programmable logic controller SCADA, safety		energy carriers & power saving solution	
Gear, mechanical drives systems		Industrial internet of things	
Fieldbus systems		Machinery & robotics & motion control	
Autonomous systems		distribution systems for electrical building installation	
Instrumentation measurement & control & Vibration measurement		actuator or Sensor or pneumatic manufacturer	
Conveyer & Linear positioning systems		Heating, ventilation, air-conditioning equipment	
Data infrastructure		Hydro, fossil, or nuclear power plant	
Process automation		Nano & microtechnology	
Garment production		Renewable Energy Solution	
Drink & food packaging		Mail and product delivery	
Chemical processing		Agriculture product processing	
Water cleaning and distribution		Car or truck or agriculture machinery manufacturer	
electrical and electronic household appliances		Training & education	
Assembly & handling system		Research & development	

Please let us know your feeling about the potential gain if you implement the concept of industry 4.0 in the manufacturing factory	
A huge impact	
No gain no decrease in production	
A bad impact on our staff and production	
No idea	

Skill interests					
Technical skill					
Thinking skill, Analytical thinking skill					
Decision making & cognitive skills in real-time professional situations					
Contingency Management skill					
Soft & Social & Communication skills					
Language skill					
Leadership skill					

Technical skill interest					
Will you recommend a job applicant with experience in Handling PLC technology?					
Applicant's capacity to handle several kinds of PLC is a strong point in your selection process.					

What are the main coming challenges for industrial automation?					
cybersecurity					
Energy saving					
Unified Standard communication protocol					
Capacity to keep a product manufacturing tool at the National level					
environment friendliness & carbon and hearth resources sustainability					
SCADA system and digital factory					

TABLE II. LIST OF RELATED INTERVIEWEE COMPANY

Company name	booth number @ Singapore EXPO	activity
ASTECH PTE. LTD.	Booth No: 2C17	A-Industrial Automation
CASTEC SINGAPORE PTE. LTD.	Booth No: 3C04	A-Industrial Automation
COMPONENT TECHNOLOGY PTE LTD	Booth No: Singapore EXPO	A-Industrial Automation
ECKHART	Booth No: 2F29	A-Industrial Automation
FANUC SINGAPORE PTE LTD	Booth No: 2B17	A-Industrial Automation
FLEXIV PTE LTD	Booth No: 3B13	A-Industrial Automation
HIBEX SINGAPORE PTE LTD	Booth No: 2E37	A-Industrial Automation
INOVO ROBOTICS (HK) LIMITED	Booth No: 3A09	A-Industrial Automation
JINAN MAG GROUP CO.,LTD.	Booth No: 3B37	A-Industrial Automation
LINYI AIJIA TOOLS CO.,LTD	Booth No: 3A36	A-Industrial Automation
MAKINO ASIA	Booth No: 2C17	A-Industrial Automation
NGEE ANN POLYTECHNIC	Booth No: 2D17, 2D22	A-Industrial Automation
PHAOS TECHNOLOGY PTE. LTD.	Booth No: 2E31	A-Industrial Automation
PT. ONEJECT INDONESIA	Booth No: 2F26	A-Industrial Automation
QINGDAO XINJINGCHENG PRECISION TECHNOLOGY CO., LTD.	Booth No: 3C31	A-Industrial Automation
RENISHAW (SINGAPORE) PTE LTD	Booth No: 2B17	A-Industrial Automation
SAMSUNG ELECTRONICS	Booth No: 2F09	A-Industrial Automation
SERVO DYNAMICS PTE LTD	Booth No: 2A17	A-Industrial Automation
SHANDONG TIANCE INTERNATIONAL TRADING CO., LTD.	Booth No: 3D24	A-Industrial Automation
SINGAPORE A-Industrial Automation ASSOCIATION (SIAA)	Booth No: 3D02	A-Industrial Automation
SODA VISION PTE. LTD.	Booth No: 2A32	A-Industrial Automation
VITAL VISION TECHNOLOGY PTE LTD	Booth No: 3B22	A-Industrial Automation
YANTAI CHENGLI PRECISION MACHINERY CO.,LTD.	Booth No: 3A37	A-Industrial Automation
ASUENE.INC	Booth No: 2G10	B-Digital Factory
DATAMESH PTE. LTD.	Booth No: Singapore EXPO	B-Digital Factory
INDUSTRYAPPS PTE. LTD.	Booth No: 2C33	B-Digital Factory
Digital Factory	Booth No: 2F20	B-Digital Factory
MICROSOFT	Booth No: 2F09	B-Digital Factory
PRICEWATERHOUSECOOPERS CONSULTING (SINGAPORE) PTE	Booth No: 2F09	B-Digital Factory
SUPCON	Booth No: 2K10	B-Digital Factory
ZUNO PTE. LTD.	Booth No: 2C20	B-Digital Factory
CHOPVALUE	Booth No: 2D09	C-Additive Manufacturing
DKSH SINGAPORE PTE LTD	Booth No: 2E06	C-Additive Manufacturing
EXTRABOLD INC	Booth No: 2D09	C-Additive Manufacturing
JINAN FENGSHUO HARDWARE TOOLS CO.,LTD	Booth No: 3B30	C-Additive Manufacturing
MOLYWORKS MATERIALS PTE. LTD.	Booth No: 2F04	C-Additive Manufacturing
QINGDAO JUSTU PRECISION MACHINERY	Booth No: 3C32	C-Additive Manufacturing
SPARE PARTS 3D	Booth No: 2D09	C-Additive Manufacturing
OMRON ASIA PACIFIC PTE. LTD.	Booth No: 3C06	Intra-logistics
AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH (A*STA	Booth No: 2B01	Others
ENTERPRISE SINGAPORE	Booth No: 2B01	Others
JINAN INSTITUTE OF METALLURGICAL SCIENCE CO.,LTD	Booth No: 3B24	Others
MICHIGAN ECONOMIC DEVELOPMENT CORPORATION	Booth No: 2F29	Others
SHANDONG BULANG NEW BUILDING MATERIALS CO.,LTD	Booth No: 3B33	Others
SHANDONG YAHE CONSTRUCTION MACHINERY CO.,LTD	Booth No: 3A31	Others
SINGAPOREAN-GERMAN CHAMBER OF INDUSTRY AND COM	Booth No: 3D07	Others

IV. RESULTS

TABLE III. GENERAL INFORMATION ABOUT THE PARTICIPANTS FROM THE COMPANY

Feedback Statement	Frequency (N=45)	Percentage
Company	45	100

TABLE IV. COMPANY FEEDBACK ON SKILL REQUIREMENTS

Feedback Statement	$\bar{X}$	S.D.	Interpretation
Technical skill	3.88	0.82	High
Thinking skill, Analytical thinking skill	3.96	0.78	High
Decision making & cognitive skills in real-time professional situations	4.12	0.78	Very high
Contingency Management skill	3.98	0.83	High
Soft & Social & Communication skills	4.08	0.79	Very High
Language skill	4.02	0.83	Very High

Feedback Statement	$\bar{X}$	S.D.	Interpretation
Leadership skill	3.98	0.83	High

From table III and IV, Based on the information provided, it can be inferred that the person being evaluated has a high level of technical skills, analytical thinking skills, contingency management skills, soft & social & communication skills, language skills, and leadership skills. They have a very high level of decision-making & cognitive skills in real-time professional situations.

The survey results indicate that the main challenges faced by HEIs in Industry 4.0 include a lack of understanding of Industry 4.0 technologies and their applications, a lack of collaboration between HEIs and industry, and a lack of funding for Industry 4.0 education and training programs.

In terms of the specific skills and competencies needed for success in Industry 4.0, the survey results show that digital literacy, data analysis, and the ability to work with advanced technologies such as artificial intelligence and the Internet of Things are considered the most important.

In addition, the survey results also indicate that there is a need for more hands-on training and practical experience in Industry 4.0 education and training programs. A majority of the participants also highlighted the importance of collaboration between HEIs and industry in order to ensure that the curriculum is relevant and meets the needs of the industry.

CONCLUSION

This study provides valuable insights into the main challenges faced by HEIs in Industry 4.0 and the specific skills and competencies needed for success in this new industrial landscape. The survey results indicate that there is a need for more understanding of Industry 4.0 technologies and their applications, more collaboration between HEIs and industry, and more funding for Industry 4.0 education and training programs.

Additionally, the survey results also highlight the importance of digital literacy, data analysis, and the ability to work with advanced technologies such as artificial intelligence and the Internet of Things in Industry 4.0. Finally, the results suggest that there is a need for more hands-on training and practical experience in Industry 4.0 education and training programs and the importance of collaboration between HEIs and the industry.

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