Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry -MSIE4.0

TASK 1.3 REPORT ANALYSIS WP1 ASSESSMENT NEEDS OF INDUSTRY AND STUDENTS

Chiang Mai University | 17th November 2018

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Revision Sheet

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0.1	23/08/2018	Wichai Chattinnawat	First draft of WP1 Task1.3
0.2	9/10/2018	Wichai Chattinnawat	Second draft of Task1.3 REPORT ANALYSIS with more EU Student added
1	17/11/2018	Wichai Chattinnawat	Final Draft of Task 1.3 REPORT ANALYSIS with conclusion derived from new analysis framework model

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WP1

WP1 is aimed to provide comparative analysis of the actual situation concerning the MSc curricula in Industrial Engineering offered in Thai and EU partner countries universities, the identification of the gaps between the real needs of the industry, the student needs and the actual offered curricula. The recommendations for the new curriculum development, are the most important deliverable working elements for the first year of the project in WP1.

Throughout the entire first year the WP1 will

1) identify the strengths and weaknesses , the common points, the differences and the good practices concerning curricula, teaching methods and tools in Thai and EU universities
2) identify the gap between the needs of industry, for being ready for Thailand 4.0, especially in capacity building, and the competence of MSc graduates from current curricula offered by Thai and EU universities
3) Recommend the specifications and focus areas of the new proposed MSIE curriculum.

The WP1 will be led by CMU close collaboration with UMinho that will co-lead and be the WP1 coordinator for EU partners. All partners will also participate and be responsible for tasks related to their geographical regions.

This analysis working plan is now revised after the approval of PEC the project executive committee-PEC.

WP1-1.3: Assessing needs of industry and student

The comprehensive analysis of needs of industry and students (all partners will conduct a survey with companies assigned in their regions in the list and with the help of the Associated Partners. They will also conduct survey with prospective students in their regions. The outcome of this activity will be classified as following

- Task 1.3.1 Preparing a survey form for identifying the needs of industry for MSIE graduates to support their success in Thailand 4.0 and Industry 4.0
- Task 1.3.2 Preparing a survey form for the needs of prospective students for preparing them for Thailand 4.0 and Industry 4.0
- Task 1.3.3 Conducting survey for companies and organizations in the list
- Task 1.3.4 Conducting survey from students
- Task 1.3.5 Identifying the needs of industry and students

The finding of statistics shows that the total number of program being reviewed is 28. So the total estimation of student population is at least 375 for M.S. students from all 9 partners. Therefore to have minimal 10% error margin of error, the total sampling size to be 385. Then each partner should have at least 40 students for each partner.

The finding of statistics for SME company in Thailand shows that there are more than 30,000 SME. By assuming that the high impact SME in Thailand is at least 1,000, the samplng table of YAMANE indicates that the minimum of 91 companies shall be listed based on the 10% error.

The WP1 leader searches for the first and the new S-curves or new country competitive. The TL researcher decided to focus on only 4 groups of (First S-curve)

1) Next – Generation Automotive
2) Smart Electronics
3) Agriculture and Biotechnolgy
4) Food for the Future.

These classification the first S-curve in Thailand was consulted with CWPL and all partners. The specific names of the companies for all study group in Thailand were created and given to all partners for approval. The total of 95 companies are listed by the following clusters:

Tourism	Seafood Processing	Electronic
Agro Processing	Textile Industry	Construction/Manufacturing
Aerospace	Automotives	Logistic and Transport
Packaging and Commerce	PetroChemical	Automation
IT	Wood/furniture	

1. Demographic Information of Industry and student

This section describe the background of Industry sample participated in the questionnaire assessment. The total estimation of industry sample of at least 91 from various sectors is planned with each partner should have at least 10 companies surveyed by each partner. However the final questionnaire collected consists of 72 companies from Thai and EU universities.

Table 1 List of Industry and Company for Industry Assessment

University	Industry Type	Company Name
AIT	Packaging	Bangkok Glass Public Company Limited
AIT	Electronic	Western Digital (Thailand) Co,Ltd.
Chiang Mai University (CMU)	Aerospace	Zodiac Commercial Inserts Thailand
Chiang Mai University (CMU)	Agro Processing	Four T Co., Ltd.
Chiang Mai University (CMU)	Agro Processing	Betagro
Chiang Mai University (CMU)	Automotives	TSM
Chiang Mai University (CMU)	Automotives	Mitsubishi Corp LT
Chiang Mai University (CMU)	Automotives	Toyota Daihatau Engineering and Manufacturing
Chiang Mai University (CMU)	Electronic	Hoya optics
Chiang Mai University (CMU)	Electronic	Tokyo Coil Engineer (Thailand) Co., Ltd.
Chiang Mai University (CMU)	Electronic	Fujikura Electronics (Thailand) Ltd.
Chiang Mai University (CMU)	Electronic	Schaffner EMC Co., Ltd
Chiang Mai University (CMU)	Logistic and Transport	CP all Distribution
Chiang Mai University (CMU)	Manufacturing	DATAMARS (Thailand) Ltd.
Chiang Mai University (CMU)	Manufacturing	Princess Foods Co.,Ltd.
Chiang Mai University (CMU)	Manufacturing	Siam Wire Netting
Chiang Mai University (CMU)	Manufacturing	Meshtec Internationnal
Chiang Mai University (CMU)	Textile Industry	Performance manufacturing Ltd. (Thailand) - Lamphun
Chiang Mai University (CMU)	Wood/furniture	Suksawad
Khon Kaen University (KKU)	Agro Processing	MitrpholSugar co ltd (by KKU)
Khon Kaen University (KKU)	Electronic	Seagate Technology (by KKU)
Khon Kaen University (KKU)	Electronic	Panasonic Manufacturing (Thailand) Co,Ltd. (by KKU)

University	Industry Type	Company Name
Khon Kaen University (KKU)	Logistic and Transport	Thaibeverage Logistics (by KKU)
Khon Kaen University (KKU)	Manufacturing	CP RAM co th (by KKU)
Khon Kaen University (KKU)	Textile Industry	NK Apparel (by KKU)
King Mongkut's University of Technology North	Automotives	DENSO(Thailand) Co.LTD.
King Mongkut's University of Technology North	Automotives	Thai Summit Harness Co,Ltd.
King Mongkut's University of Technology North	Automotives	Misuibishi Motor Thailand Co, Ltd.
King Mongkut's University of Technology North	Electronic	DKSH Thailand Co,Ltd.
King Mongkut's University of Technology North	Electronic	Segate Technology Thailand
King Mongkut's University of Technology North	Electronic	Ronda Thailand
King Mongkut's University of Technology North	Logistic and Transport	Yusen Logistics (Thailand) Co. Ltd.
King Mongkut's University of Technology North	Logistic and Transport	Grand Home Mart Co,Ltd.
King Mongkut's University of Technology North	Manufacturing	President Bakery Public Company Limited
King Mongkut's University of Technology North	Manufacturing	Triple A Mechanies Co,Ltd.
Prince of Songkla University (PSU)	Agro Processing	Stitrangglove
Prince of Songkla University (PSU)	Agro Processing	APK Furnishing
Prince of Songkla University (PSU)	Manufacturing	Southland Rubber Co.,Ltd
Prince of Songkla University (PSU)	Manufacturing	Wonnatech
Prince of Songkla University (PSU)	Manufacturing	Honda Company
Prince of Songkla University (PSU)	Manufacturing	rubbers innotech co.,ltd
Prince of Songkla University (PSU)	Manufacturing	Juthamarth Marketing Co.,Ltd
Prince of Songkla University (PSU)	Wood/furniture	Xunthai Parawood Co., Ltd.
Thammasat University (TU)	Automotives	Schavakon Co.,Ltd
Thammasat University (TU)	Electronic	Mitsubishi Electric Asia (Thailand) Co.,Ltd.

University	Industry Type	Company Name
Thammasat University (TU)	IT	Symphony Communications
Thammasat University (TU)	Manufacturing	JCY HDD TECHNOLOGY COMPANY LIMITED
Thammasat University (TU)	Manufacturing	The CPAC Roof Tile CO.,Ltd
Thammasat University (TU)	Manufacturing	M&R LABORATORY CO., LTD.
Thammasat University (TU)	Wood/furniture	S.B. Furniture Industry Co.,Ltd
Thammasat University (TU)	Wood/furniture	S.B. Furniture Industry Co.,Ltd
Thammasat University (TU)	Wood/furniture	S.B. Furniture Industry Co.,Ltd
CUT	Automotives	Wielton Group
CUT	Automotives	Nexteer
CUT	Automotives	ZF - PDPQ IT
CUT	Electronic	Electrolux Poland Sp. z o.o.
CUT	Manufacturing	Whirpool Polska
CUT	Manufacturing	KLER
CUT	Wood/furniture	RC DESIGN S. z o.o.
CUT	Wood/furniture	Opakowania Eksportowe
Uminho	Automotives	Bosch Car Multimedia S.A.
UPB	Aerospace	INCD Turbomotoare COMOTI
UPB	Construction	Alumil ROM Industry SA
UPB	Construction	NORD TECH SRL
UPB	Electronic	SC ARCTIC SA
UPB	IT	Vegra Info SRL
UPB	IT	Archibus Solution Center SRL
UPB	IT	BIM Consultant SRL
UPB	Manufacturing	Bekaert Slatina SRL
UPB	Manufacturing	UNISON ENGINE COMPONENTS BUCHAREST SA
UPB	Manufacturing	DUAL MAN SRL
UPB	Manufacturing	Thermoconcept Systems SRL
UPB	PetroChemical	PETROM SA
	Manufacturing	Jeremias

The three biggest sectors found are Manufacturing, Electronics and Automotive respectively consisting of more than 60% of the sample. Hence the analysis can represent the needs of industry in which industry4.0 are directly applied.

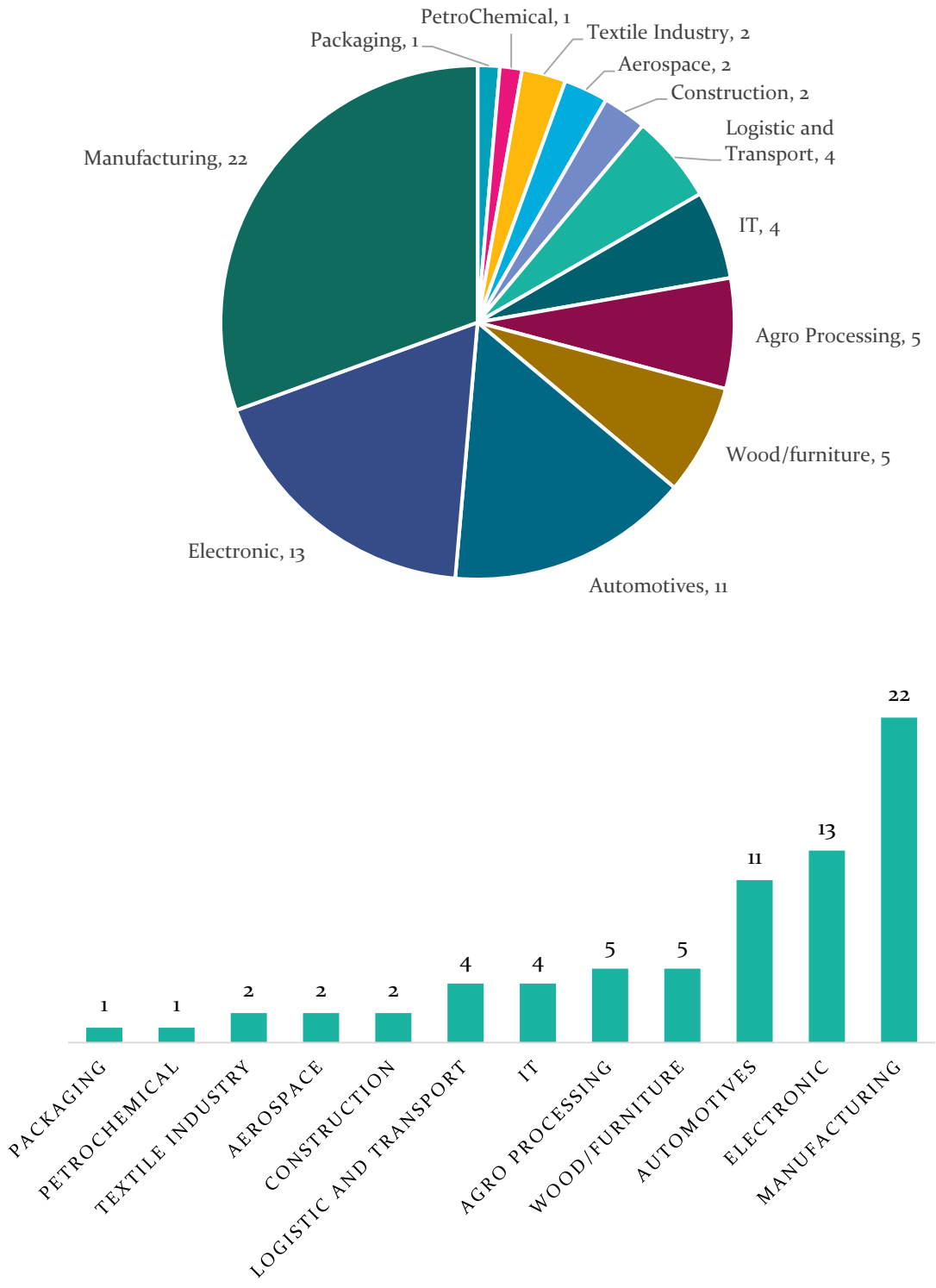


Figure 1 Classification of 72 companies by Sectors

This section describe the background of Students participated in the questionnaire assessment.. The total estimation of student sample of at least 375 for M.S. students from all 9 partners is planned with each partner should have at least 40 students surveyed by each partner. However the final questionnaire collected consists of 450 students from Thai and EU universities with 93% are the master level graduate students with almost equal proportion between newly admitted 1st year students and the 2nd year student.

Table 2 List of Student Assessment

University	No.Student responses	
Chiang Mai University (CMU)	47	10.4%
AIT	43	9.6%
Thammasat University (TU)	23	5.1%
King Mongkut's University of Technology North	67	14.9%
Prince of Songkla University (PSU)	21	4.7%
Khon Kaen University (KKU)	31	6.9%
CUT (Poland/France)	54	12.0%
Uminho (Portugal)	93	20.7%
UPB (Spain/Romania)	71	15.8%
Total	450	

The level of study of the responses can be classified as follows

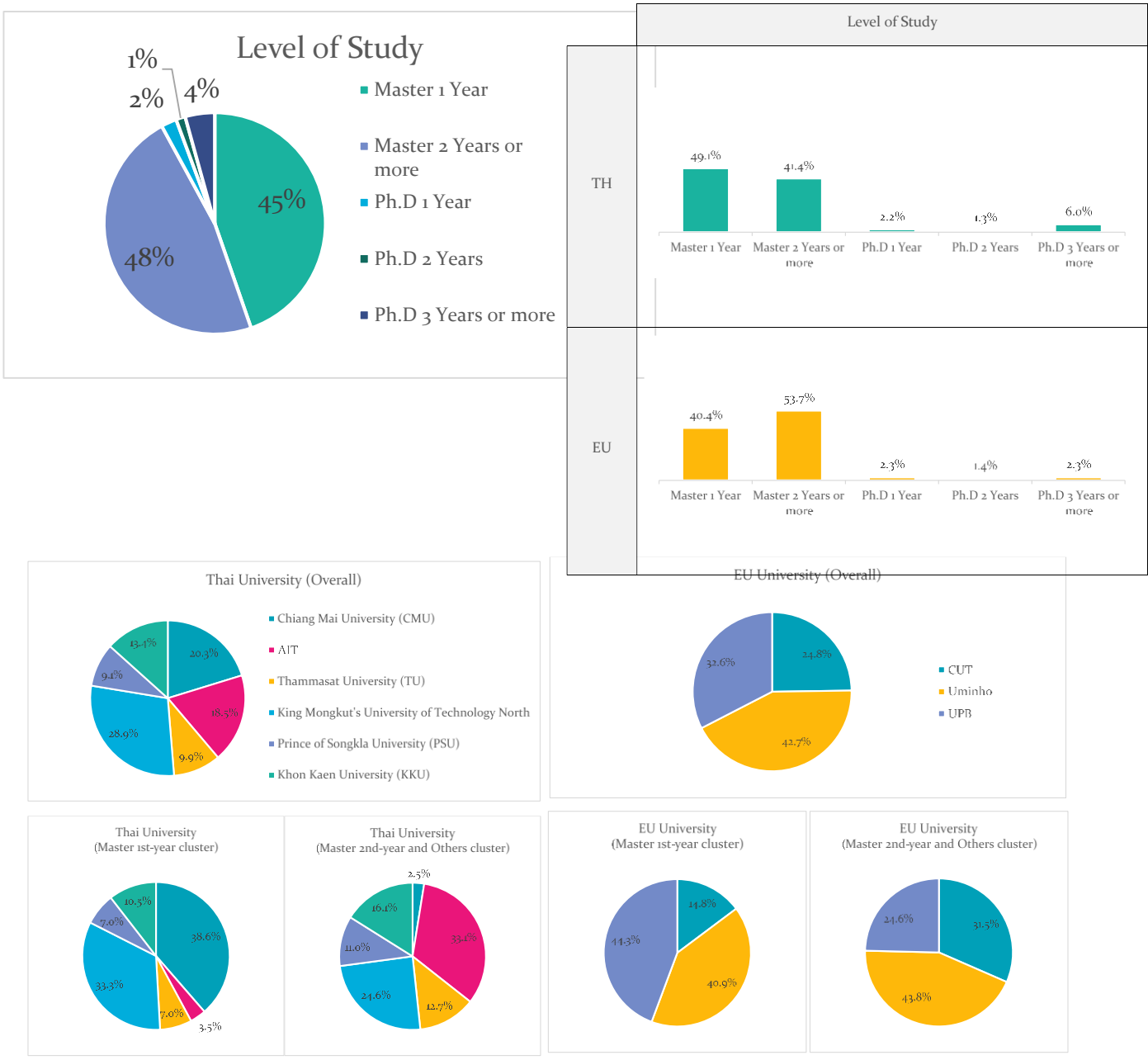


Figure 2 Classification and Level of study of the responses

2. Method of Analysis of Industry and student Needs

This section describe the methodology and rationale of analysis on Industry and student needs. This report will shed light on gap analysis that will be carried out using the content analysis method and the gap analysis framework as follows. The TL will analyze and report the overall finding of the Industry and student needs based on the questionnaire. The complete details of basic statistical and graphical summary report are provided on the appendices 1 and 2. The reader is consulted to refer to those appendices for more details if needed.

The analysis methodology is described schematically as follow

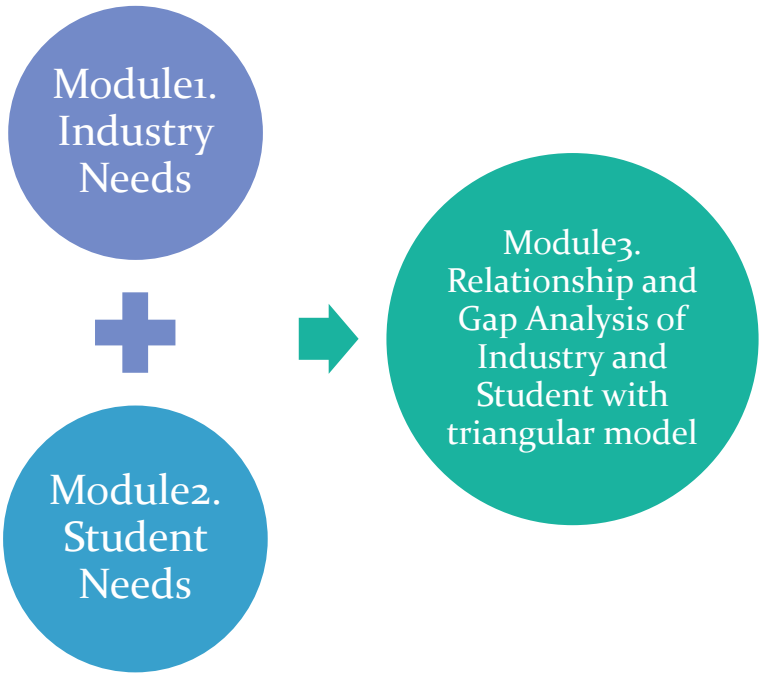


Figure 3 Framework of Industry and Student needs analysis

The analysis and reports will be summarized successively into 3 modules of

1. Industry Needs
2. Student Needs
3. Relationship and Gap Analysis of Industry and Student with triangular model

In order to summarize the finding for each module, the relevance details of the basic statistical and graphical summary from the appendices 1 and 2 will be selected and aggregated to draw conclusion. The reader is consulted to refer to those appendices for more details. The following sections describes the rationale and framework of analysis on each module.

2.1 The need assessment of industry at 2 levels

The analysis of the 1st module on industry need will be summarized according to the questionnaire development framework that assess the current competence of industry at both management and operational perspective. The industry need assessment will be summarized according to the following structure.

Strategy Level

1. What is the existing strategy level of business operation with respect to Industry4.0 concepts?
2. What are the short term plan for business direction and business strategy to gain competitiveness?
3. What are the policy: financial plan, HR plan, of the company toward adopting the industry 4.0?

Adoption Level

4. What is the existing level of manufacturing operation with respect to Industry4.0 concepts?
5. What area of Industry4.0 they need to increase the company competitiveness or competences?
6. What are the current existing usage of the 4 main domains?

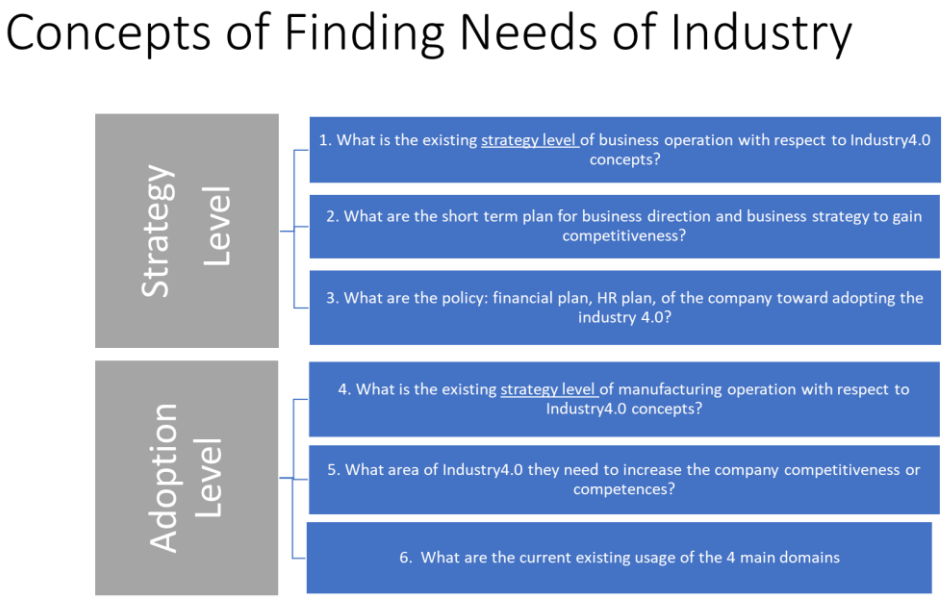


Figure 4 Classification of Industry Need assessment at 2 levels

There are 4 domains of needs analysis that we used as follows

Co-created Design concepts with Smart, Flexible, Integrated Product&Production Development System Innovation

Intelligence Manufacturing System which highlights on self-aware, Self-optimization, Self-configuration

Controlling, Adjusting & Monitoring Process Real Time which determines the contents of i.e., Internet of Things (IOT), Cyber Physical System (CPS), Automation

Integrated Business and Operational Data Management under digital transformation, cloud-based Manufacturing and etc. These four domains and the two level of assessment can be depicted in the following.

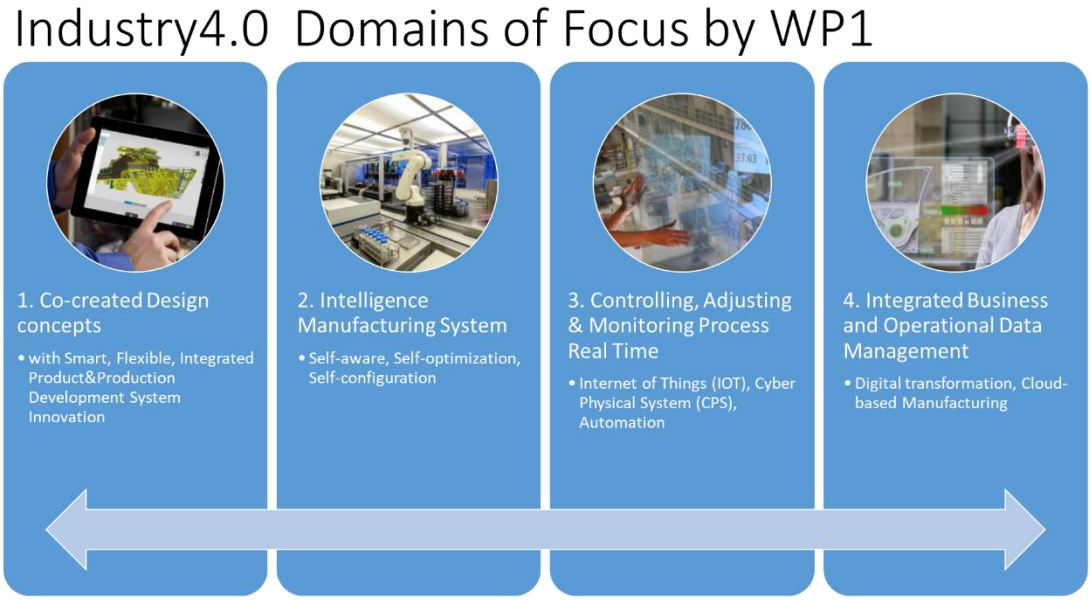


Figure 5 Classification of 4 domains of needs analysis

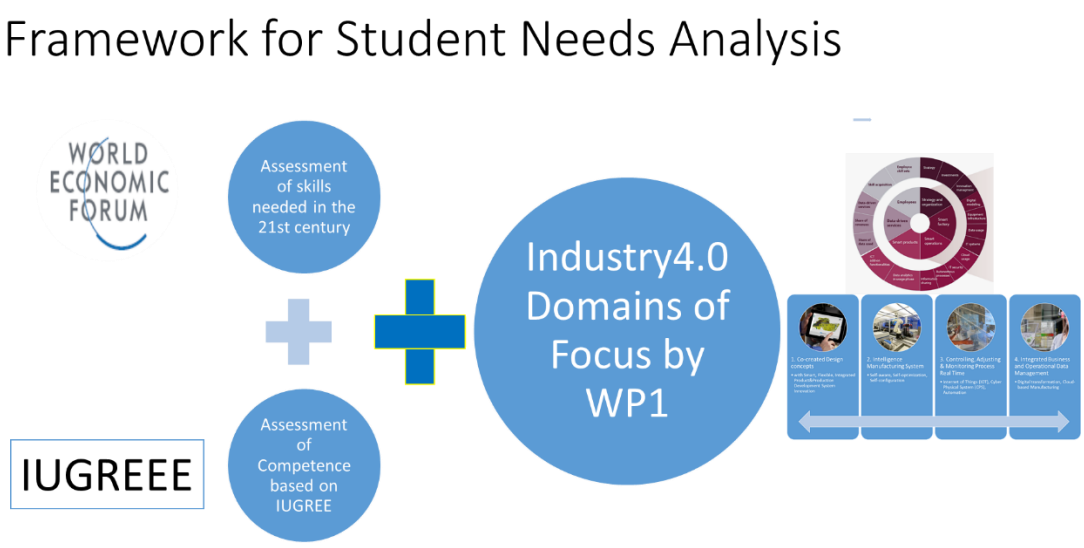
2.2 The need assessment of students at 3 levels

Following the questionnaire development framework of industry need assessment, the TL developed the questionnaire framework of students in correspondent with questioning item of industry. This help assert the assessment whether the student competences are matched with the industry practice on industry 4.0 environment. By having student questioned whether the student are be able to implement the industry 4.0 technology, the results of analysis can be used not only to define the current competence situation but also to suggest the learning outcomes and competence that should be ensured as requirement of the new master curriculum. Hence the 2nd module will reveals student competence with respect to industry at both management skill and operational skill perspective. The student need is summarized according to the following structure.

Part 1: Industry 4.0 Adoption Literacy
1. Business strategy, Business Models
2. Transversal & Domain related Competences: Student as Employee

Part 2 : Industry 4.0 Readiness Competence
1.Smart products & Co-created Design:
-To what extent can student understand the concept that products be controlled with IT, making it possible for them to communicate and interact with higher-level systems along the value chain?
2. Smart factory (Intelligence Manufacturing System):
-To what extent can student understand the concept that digitally integrated and automated production based on cyber-physical systems?
3. Smart operations (Controlling, Adjusting & Monitoring Process Real Time):
-To what extent can student understand the concept that the processes and products in your company digitally modeled and capable of being controlled through ICT systems and algorithms in a virtual world?
4. Data driven services (Integrated Business&Operational Data Management):
-To what extent can student understand the concept that business can offer data-driven services that are possible only through the integration of products, production, and customers?

Part 3 : Character Quality
-To what 21st century skill of Character qualities in terms of Initiative, Adaptability, Leadership, Social and cultural awareness does student possess to teamwork with industry and stakeholders along the vertical and horizontal integration of products, production, and customers throughout the supply chain?



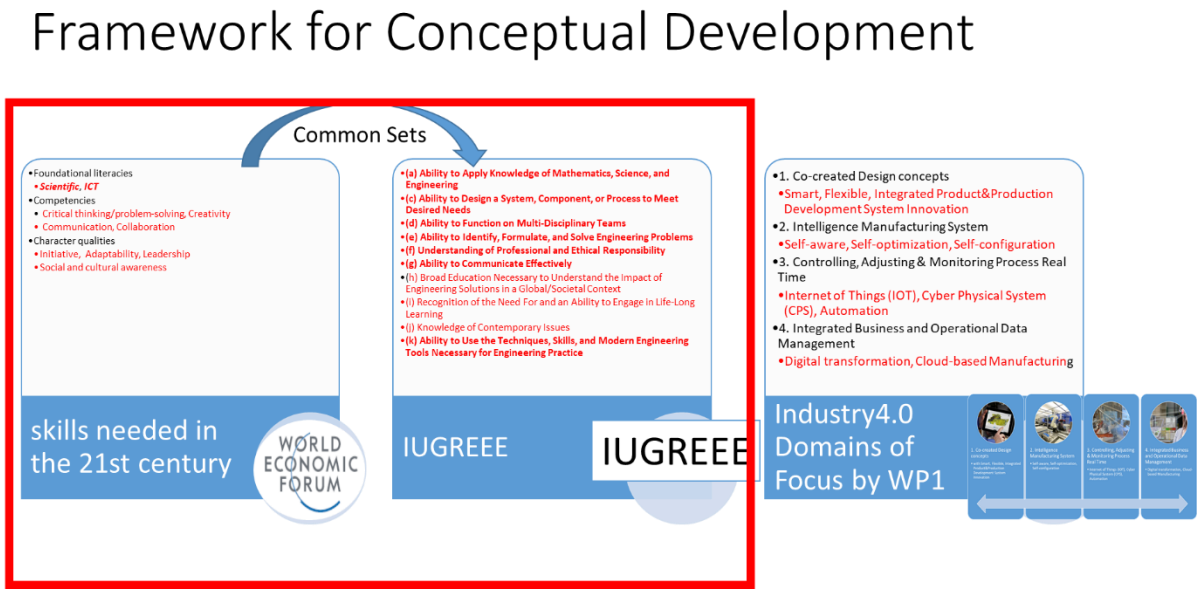


Figure 6 Framework of Student needs analysis

2.3 Relationship and Gap Analysis of Industry and Student with triangular model

In order to summarize the existing situation and the gaps between the current needs of industry and student, the TL and CTL have developed the analysis model by answering the 6 main questions as follows

Q1 What are the conclusion of the Actual competence/need of Industry regarding Industry 4.0

Q2 What are the conclusion of the ideal need of Industry regarding Industry 4.0

Q3 What are the conclusion of the Actual competence/need of students regarding Industry 4.0

Q12 What are the conclusion on the gap between the Actual need of industry vs Ideal of Industry 4.0

Q13 What are the conclusion on the gap between the Actual industry vs current IE student competence

Q23 What are the conclusion on the gap between current IE student competence and ideal Industry4.0 (Please support with statistics, graphs and analysis report)

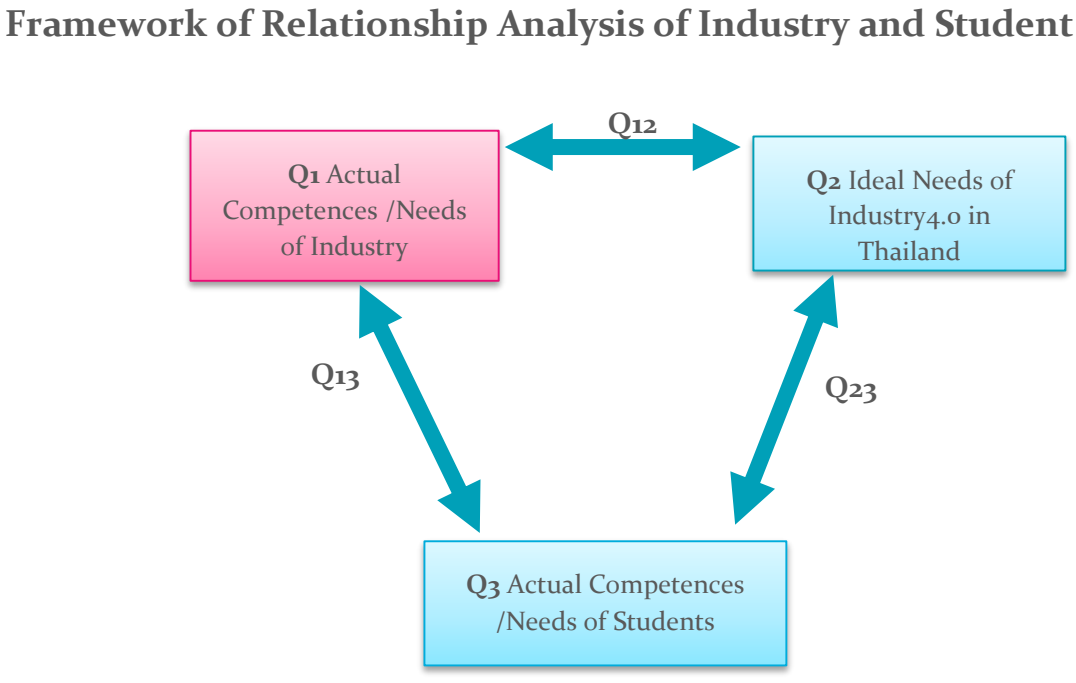


Figure 7 Triangular Analysis Model for Industry and Student needs and Gap

3. Results of Analysis of Industry and Student Needs

This section describe the results and conclusion of the analysis on the 1st module on Industry needs. This report of gap analysis was carried out using the content analysis method and the gap analysis framework as follows.

3.1 The results of 1st Module on Industry Needs

3.1.1 Industry need assessment of at Strategy Level

Industry 4.0 is about more than just improving existing products or processes through the use of digital technologies – it actually offers the opportunity to develop entirely new business models. For this reason, its implementation is of great strategic importance. We examine the current openness toward and the cultural interaction with Industry 4.0 using the following four criteria:

- Implementation status of Industry 4.0 strategy
- Operationalization and review of strategy through a system of indicators
- Investment activity relating to Industry 4.0
- Use of technology and innovation management

- According to the Figure 1 Classification of 72 companies by Sectors, we found that the top 3 clusters of Manufacturing, Electronics and Automotive are the main clusters constitute our sample. The results of analysis will be based not only on the overall samples of 72 companies but also on the comparison between Thai and EU, and among those top 3 clusters. This will helps assuring the consistency of the conclusion on the general recommendation of the competitive factors and the recommendation of M.S. curriculum specification.
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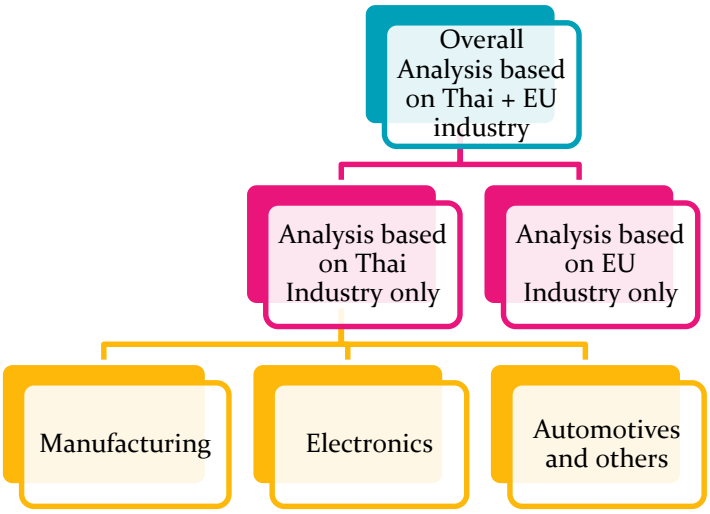

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Figure 8 Structure and Level of Analysis Model for Industry Needs

Finding:

3.1.1 (a) This following results shows the actual business strategic competences analyzed from the industry assessment questionnaire of 72 companies in Thailand and European countries. We found that, at the strategy level, majority of industry with 68% and 90% among Thai and EU industries respectively does not have industry 4.0 business strategy Business Models formulated and implemented whereas almost 50% of the Thai industry cannot and does not yet has the clearly defined approach or indicators to track the implementation status of Industry 4.0 strategy. This corresponds to the results of investment analysis reveal indicating that more than 50% of the Thai industry with respect to clusters does not invest in the research and development of industry 4.0 technology. More than 50% has never or small investment of the industry 4.0 technology even in the production area. This is the same situation occurring that the more than 50% of the industry does not invest of the industry 4.0 technology in area of purchasing, sales, logistics, service.

- Implementation status of Industry 4.0 strategy is very limited.
- Operationalization and review of strategy through a system of indicators is also not common and limited.
- Investment activity relating to Industry 4.0 is very low

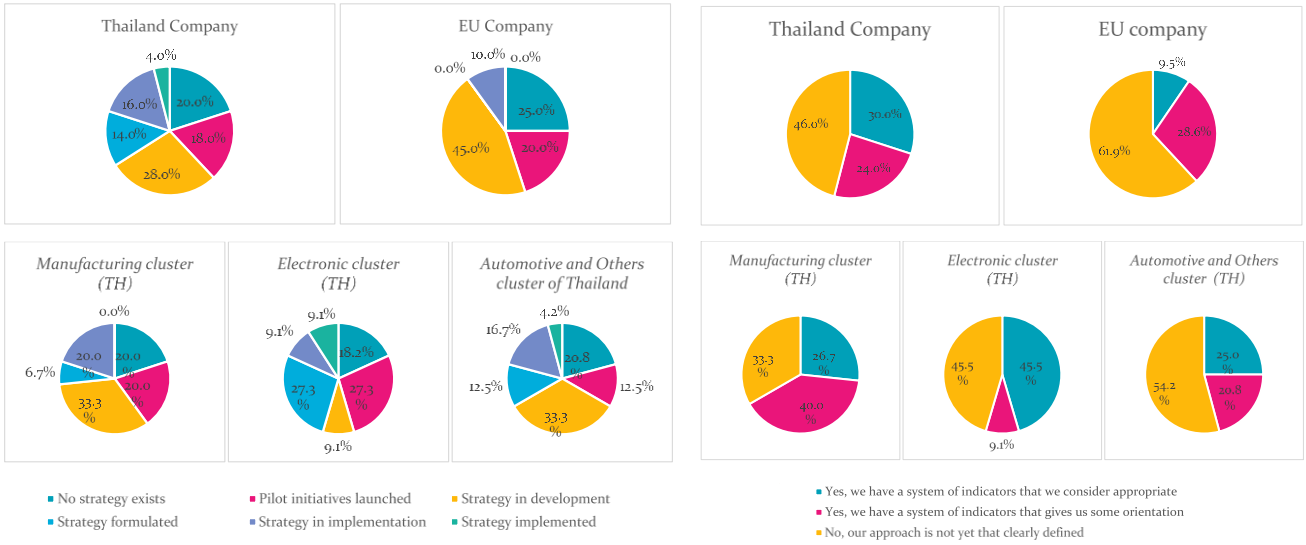
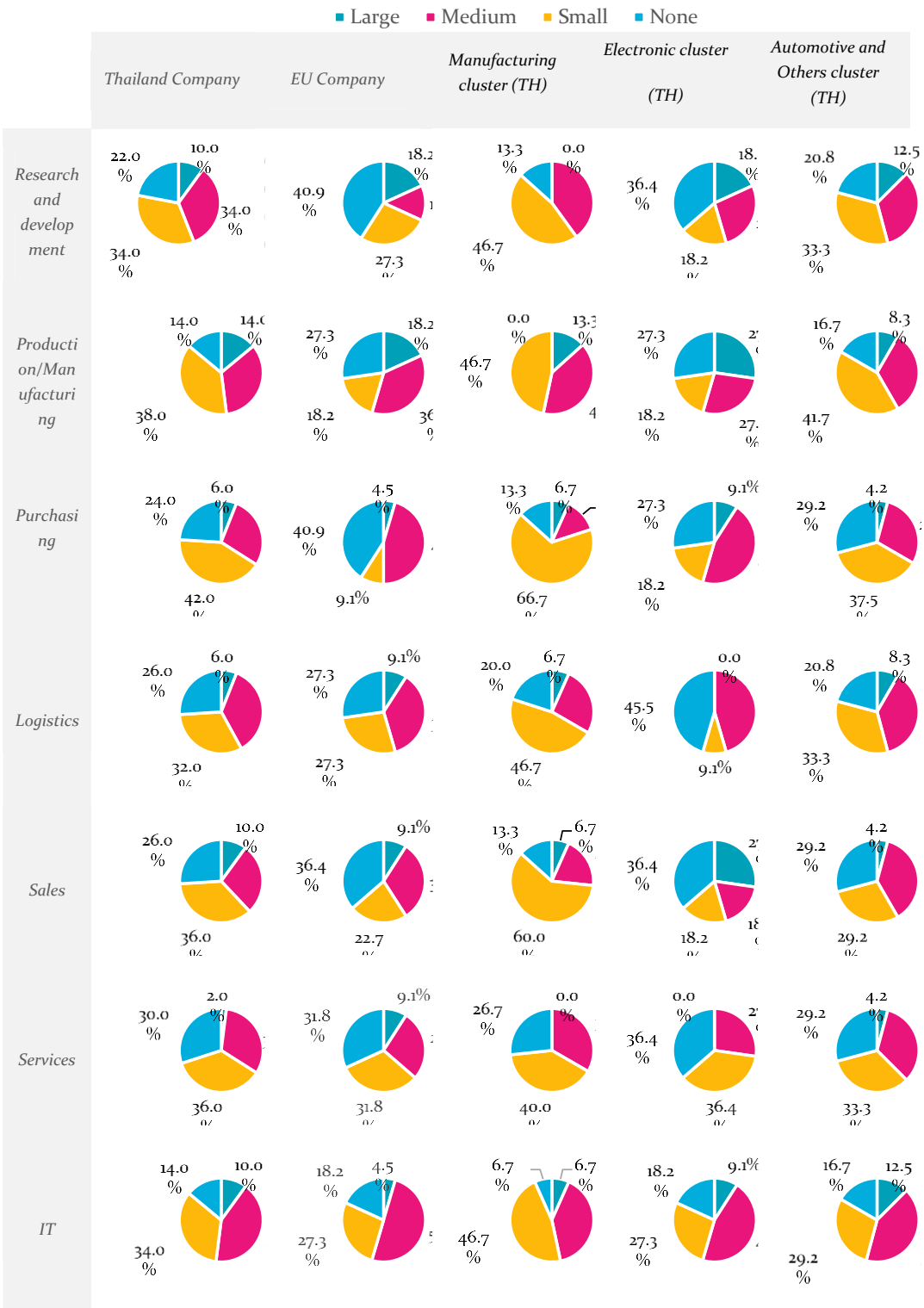


Figure 9 Q1.1,1.2 Strategy formulation and implementation, Use of indicators to track the implementation status of Industry 4.0 strategy

Table 3 Investments in the past 2 years


Large
Medium
Small
None
Thailand Company
EU Company
Manufacturing cluster (TH)
Electronic cluster (TH)
Automotive and Others cluster (TH)
Research and development
Production/Manufacturing
Purchasing
Logistics
Sales
Services
IT

3.1.1(b) We found that the areas of Production technology, IT, and Production technology, and Centralized, in integrative management are the highest target for implementation of the industry4.0. This is the same for industry with all cluster types and regions.

- Use of technology and innovation management is not eminent and supportive.
- This suggested that the strategy planning and adoption need to be emphasized whereas the content of the strategy plan need to be developed and should cover the whole spectrum of supply chain and data-driven business model.

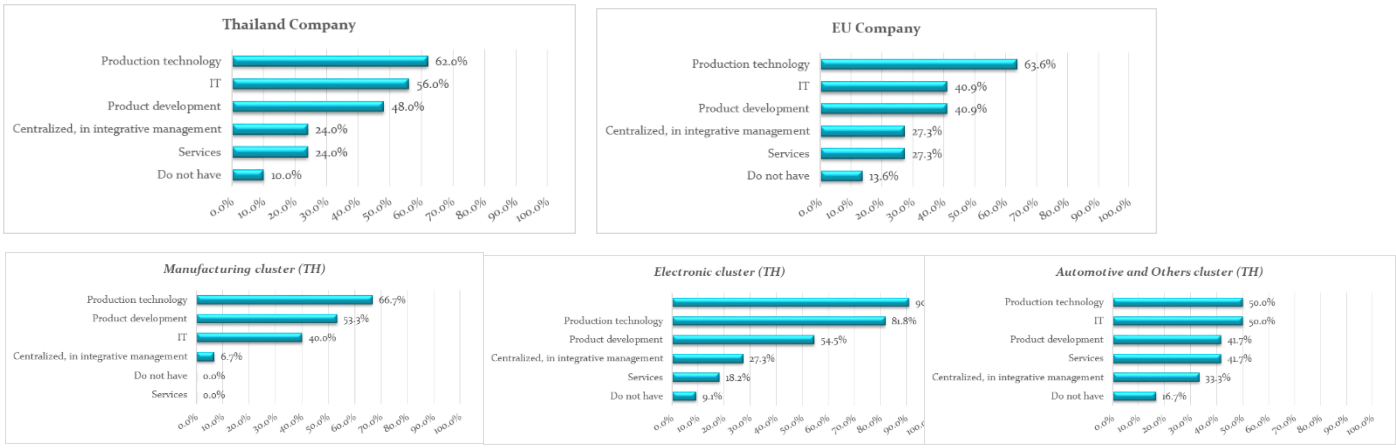


Figure 10 Q1.5 In which areas does your company have systematic technology and innovation management?

3.1.1.(c) We analyzed the perspective on the level of contribution of Industry4.0 that the industry need in order to increase the competitiveness, overall value creation of your products & service shows that almost 70% indicates that (Industry4.0 is relevance to business and we are will need to adopt it in next 1-3 years. However almost 58% of the responses are not currently employing or partly adopted part of Industry4.0. The following illustrates that there exist the differences between the needs and the actual usage of theindustry 4.0 technology.

For manufacturing sector, the highest needs are sensor technology, Mobile end devices and Big data. The highest actual usage are Mobile end devices, sensor technology, and RFID. The highest gap occurs at the Big data technology. This suggests that in order to enhance the business competitiveness of the manufacturing company, the Big data to store and evaluate real-time data needs to be adopted among all manufacturing company.

For Electronics sector, the highest needs are sensor technology, Big data, Mobile end devices and Realtime location. The highest actual usage are sensor technology, Mobile end devices, RFID, and Big data. The highest gap occurs at the M2M and Big data technology. This suggests that in order to enhance the business competitiveness of the electronic company,

the M2M and Big data to store and evaluate real-time data needs to be adopted among all electronics company.

For Automotive sector, the highest needs are RFID and M2M, sensor technology, Big data to store and evaluate real-time data, and Mobile end devices and Realtime location. The highest actual usage are Mobile end devices, RFID, sensor technology and the Embedded IT. The highest gap occurs at the Realtime location and Big data technology. This suggests that in order to enhance the business competitiveness of the automotive company, the Realtime location and Big data to store and evaluate real-time data needs to be adopted among all automotive company.

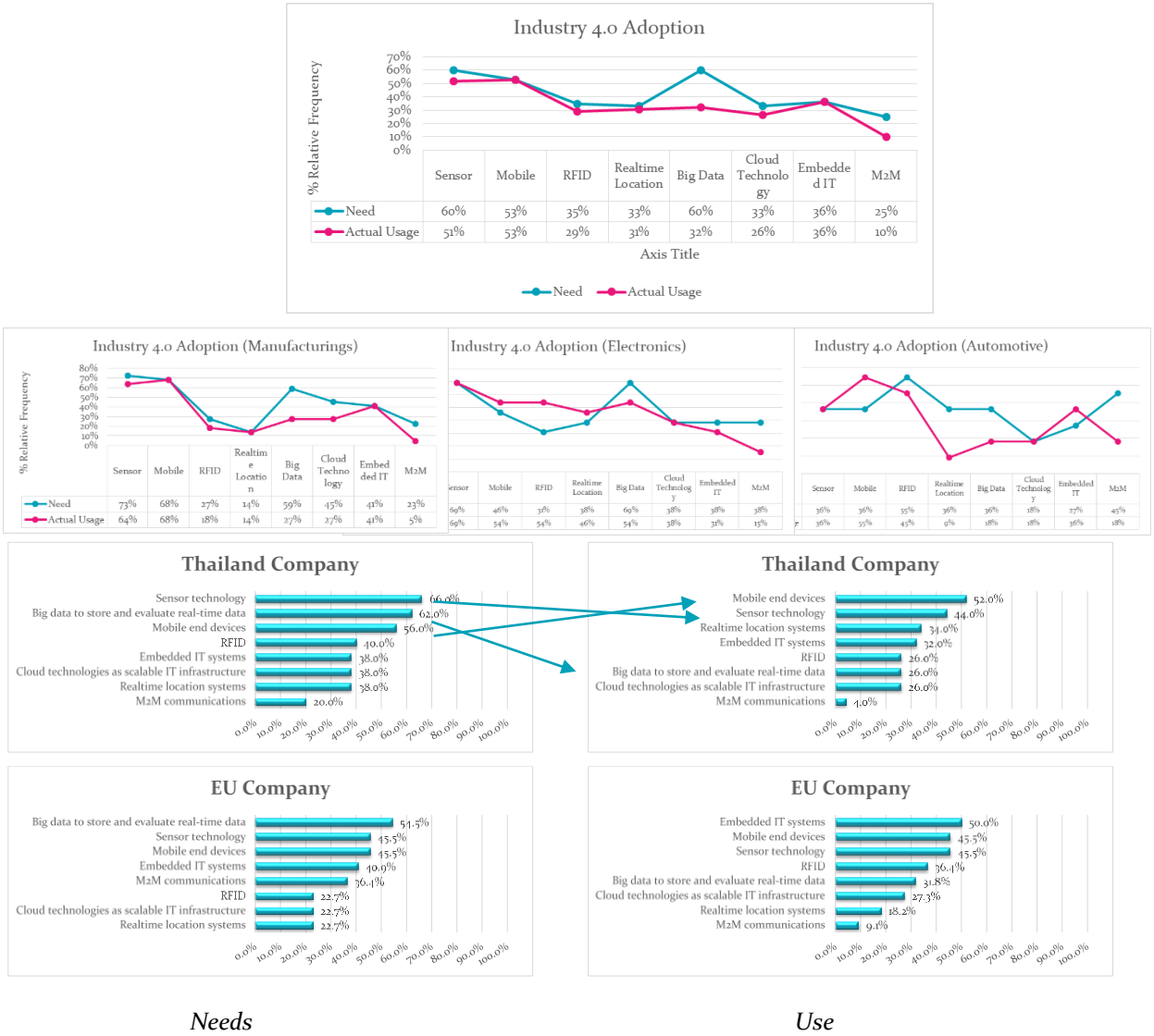


Figure 11 Q1.6 Classification of Industry 4.0 level of Adoption

Figure 12 Level of Contribution and Gap of Industry4.0 (Over all Thai + EU Industry)

- The first three highest needs are sensor technology, Big data to store and evaluate real-time data, and Mobile end devices.
- The first three highest actual usage are Mobile end devices and the sensor technology. The highest gap occurs at the Big data technology.
- This suggests that in order to enhance the business competitiveness of the company, the Big data to store and evaluate real-time data needs to be adopted among all the company.
- The set of technology that needs to be promoted among all types of industry on Industry 4.0 strategy is the Big data to store and evaluate real-time data.

3.1.1.(d) The gap between the perspective on the level of contribution of Industry4.0 that the sampled organization need in order to increase the competitiveness, overall value creation of your products & service shows that almost 70% indicates that (Industry4.0 is relevance to business and we are will need to adopt it in next 1-3 years. However almost 60% of the responses are not currently employing or partly adopted part of Industry4.0.

Regarding the candidate technology, we found that there are various technologies that company need to adopt in order to enhance their business competitiveness. However there are only 3 technologies that are considered needed by more than 50% of the industry consisting of Sensor technology, Big data to store and evaluate real-time data, Mobile end devices whereas the rest of the domains are not significantly emphasized with less than 20%.

This is also relevant to the investigation report of investment analysis from the past 2 years revealing that more than 50% of the industry does not invest in the research and development of industry 4.0 technology. More than 50% has never or small investment of the industry 4.0 technology even in the production area. This is the same situation occurring that the more than 50% of the industry does not invest of the industry 4.0 technology in area of purchasing, sales, logistics, service. This suggested that the strategy planning and adoption need to be emphasized whereas the content of the strategy plan need to be developed covering the whole spectrum of supply chain and data-driven business model.

We have found that the actual level of usage among these 3 domains are quite low especially the big data technology. This indicates the big gap between the needs and the actual usage. More than 50% are requiring the big data whereas only 25% are currently using or adopting this technology.

This is relevant to the existing competence of the company that majority are not currently employ or digitized their average product in your portfolio either by using RFID for identification, sensors, IoT connection, smart products etc. Majority of the company also cannot individualize the products that the customer order and rarely use the digitization and integration of design, planning, engineering, production, services & recycling throughout the product life cycle phases. This will tends to affect the company from collaborating with partners, suppliers and clients for development of products and services.

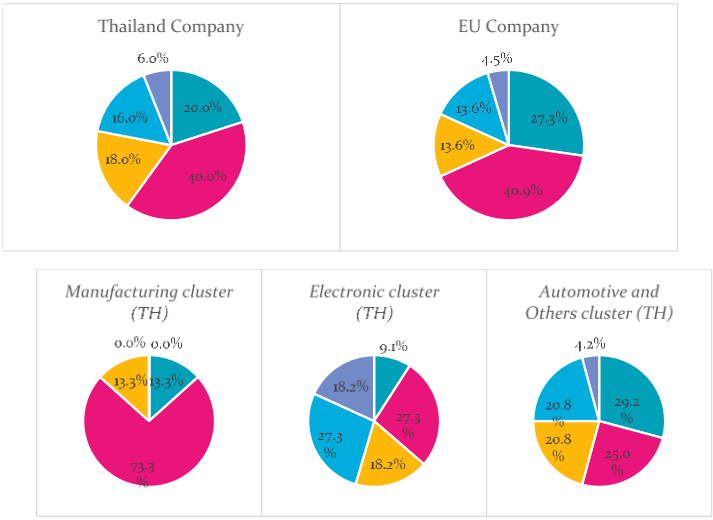


Figure 2 Q1.7 To which degree is the average product in your portfolio digitized (e.g. RFID for identification, sensors, IoT connection, smart products etc.)?

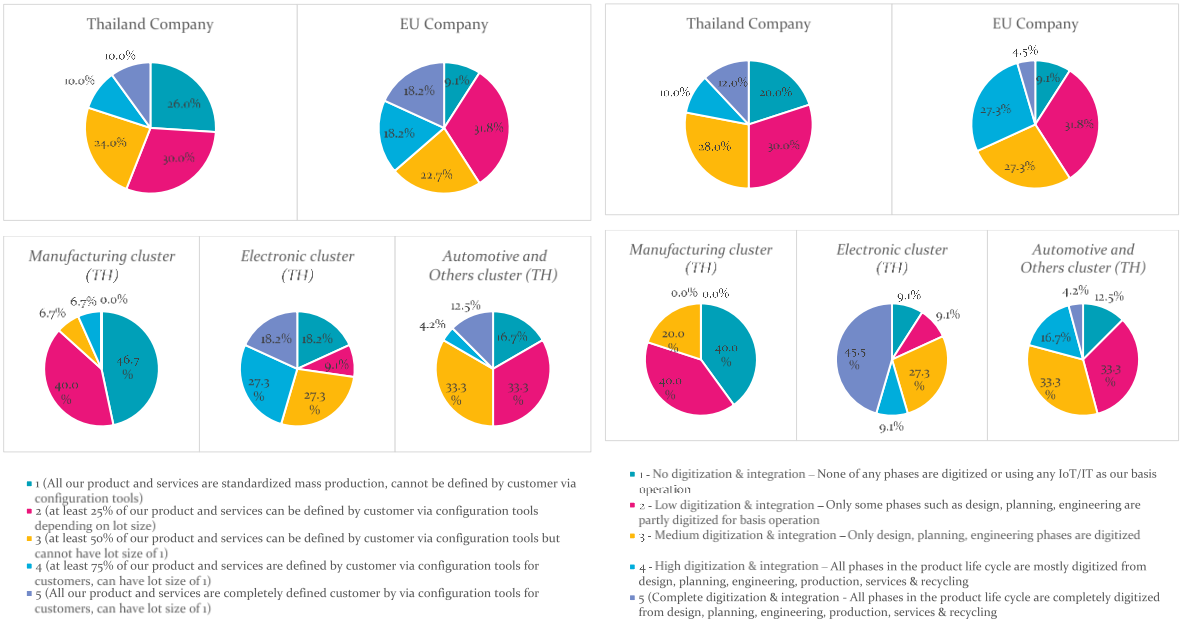


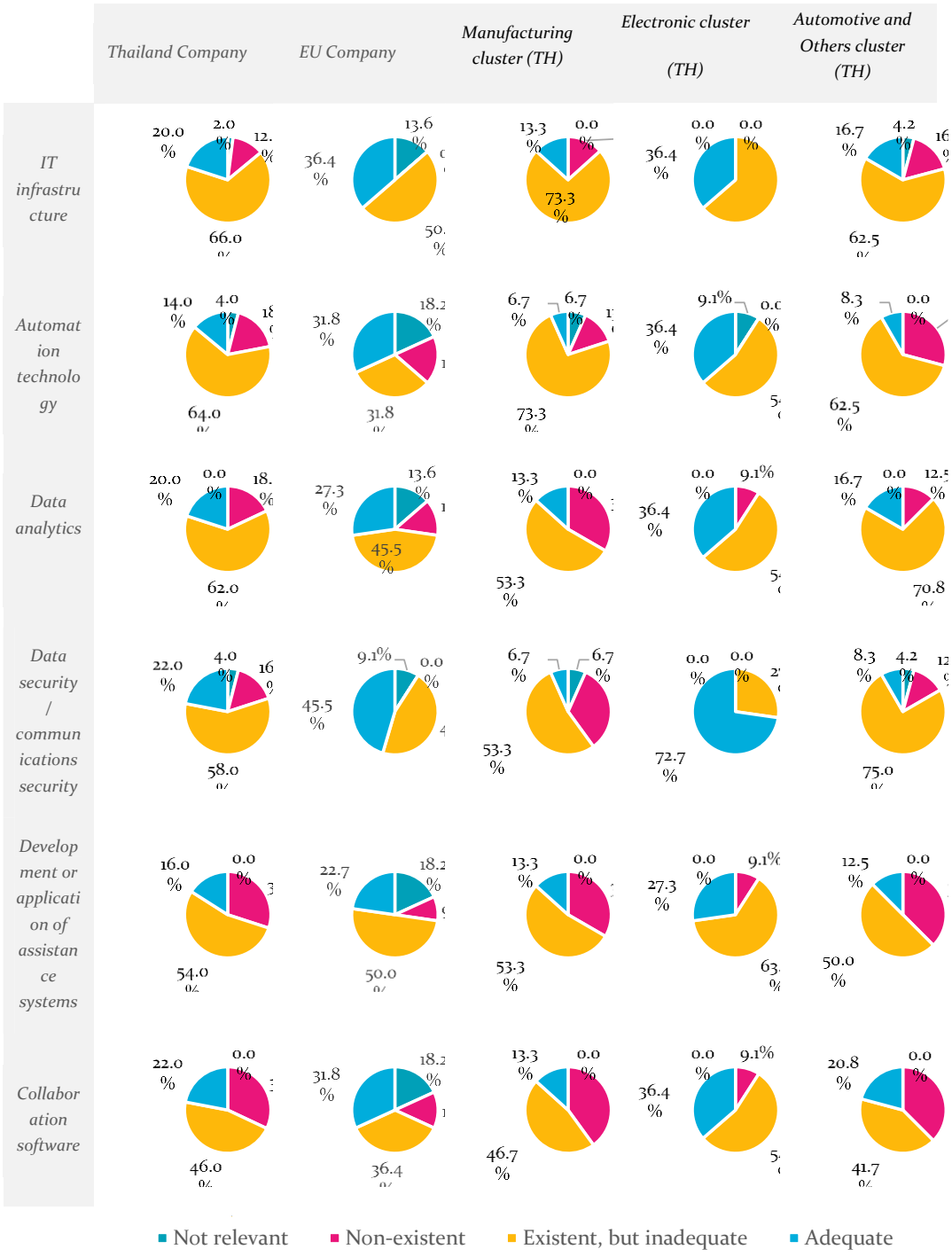
Figure 13 Q1.8,1.9 individualized products, digitized products life cycle phases?

3.1.1.(e) The researcher has also found that this is strongly related to the analysis of the Transversal & Domain related Competences from Employee factor. We hypothesized that Employees help companies realize their digital transformation and are the ones most affected by the changes of the digital workplace. Their direct working environment is altered, requiring them to acquire new skills and qualifications. This makes it more and more critical that companies prepare their employees for these changes through appropriate training and continuing education.

The analysis of employees dimension shows that industry analyze employee skills in various areas and the company's efforts including needs to acquire new skill sets. All industry clusters indicate the same situation where the existing skills of employees exist but not adequate when it comes to the future requirements under Industry 4.0. This helps asserting the needs of student competences in all areas of the

- Collaboration software
- IT infrastructure
- Automation technology
- Data analytics
- Development or application of assistance systems
- Data security / Communications security
- ***Non-technical skills such as systems thinking and process understanding***

Table 2 Q2.1 How do you assess the skills of your employees when it comes to the future requirements under Industry 4.0?



According to the responses from company that more than 90% of Thai industry and majority of the EU industry indicate the same requirement that the company has to make efforts to acquire the skills that are lacking either through special training seminars, knowledge transfer systems, coaching, etc. This also asserts the need of industry 4.0 competence and skill from the graduate. Thus the needs for new M.S.I.E students with industry4.0 skill and competence will definitely align with the current demands on the industry.

Figure 14 Q2.2, 2.4 Areas need to attain Industry4.0 and Efforts to acquire the skills

Based on the analysis of Industry 4.0 Business Strategy, Industry 4.0 is about more than just improving existing products or processes through the use of digital technologies – it actually offers the opportunity to develop entirely new business models. For this reason, its implementation is of great strategic importance. We examine the current openness toward and the cultural interaction with Industry 4.0 using the following four criteria:

- *Implementation status of Industry 4.0 strategy*
- *Operationalization and review of strategy through a system of indicators*
- *Investment activity relating to Industry 4.0 on 3 key technologies*
- *Use of technology and innovation management in 3 keys areas*

We first summarize that there are needs of the Industry 4.0 Business Strategy planning, development, formulation, implementation, the design of indicators that shall be used to develop the monitoring of the business strategy as well. Moreover this Business Strategy shall covers the SCM and DATA-driven business model.
There are needs to acquire top 3 key technologies of sensor technology, Big data to store and evaluate real-time data, and Mobile end devices in which the highest gap occurs at the Big data technology where needs are not fulfilled.
There are top 3 areas of application where industry4.0 technology are needed to be adopted at three key areas of production technology, IT and Centralized integrated management and product management.
The existing lack of these needs are also related to the needs of employee skill and competence. Hence the schematic relationship between the actual industry needs at the Strategy and organization level can be depicted as follow.

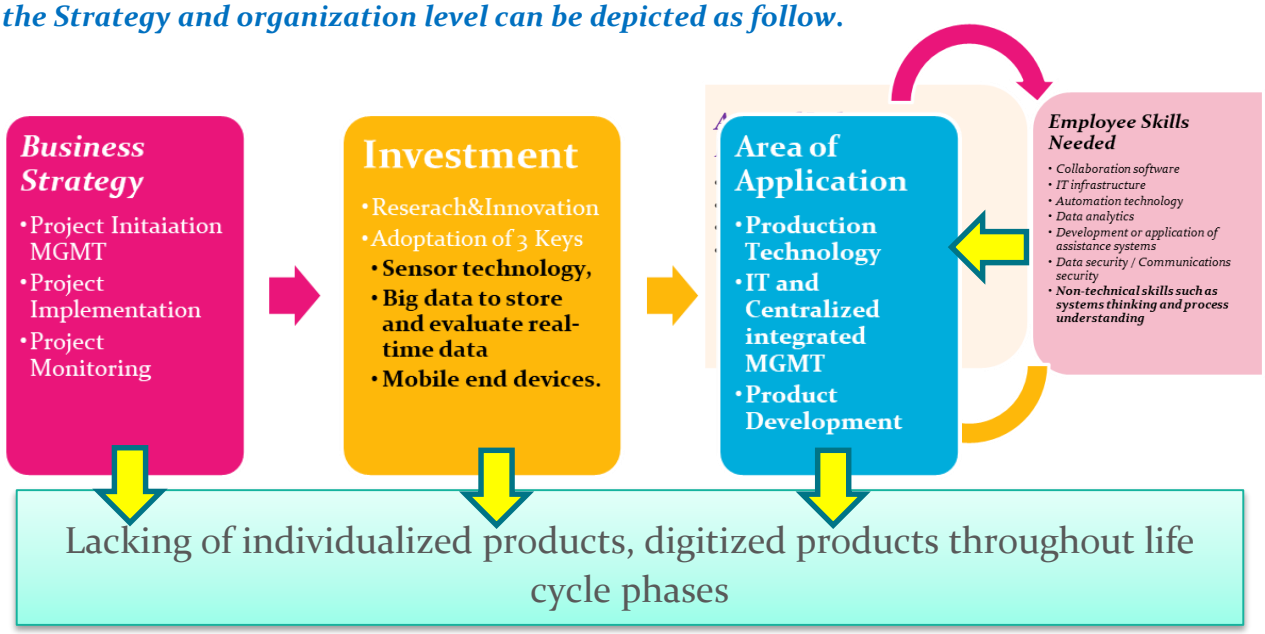


Figure 15 Industry need assessment at Strategy Level

3.1.2 Industry need assessment of at Strategy Level

Next we investigate the gap analysis among the 4 domains as follows

- **1.Smart products & Co-created Design:**
  - To what extent can your products be designed, configured, and created by customer to suit their context, controlled with IT, making it possible for them to communicate and interact with higher-level systems along the value chain?
- **2. Smart factory (Intelligence Manufacturing System):**
  - To what extent does your company have digitally integrated and automated production based on cyber-physical systems?
- **3.Smart operations (Controlling, Adjusting & Monitoring Process Real Time):**
  - To what extent are the processes and products in your company digitally modeled and capable of being controlled through ICT systems and algorithms in a virtual world?
- **4. Data driven services (Integrated Business&Operational Data Management):**
  - To what extent do you offer data-driven services that are possible only through the integration of products, production, and customers?

We will address the answers on the following framework

4. What is the existing level of manufacturing operation with respect to Industry4.0 concepts?
5. What area of Industry4.0 they need to increase the company competitiveness or competences?
6. What are the current existing usage of the 4 main domains?

SMART PRODUCTS - CO-CREATED DESIGN CONCEPTS

The smart co-created design product are a vital value of the company and the customer by allowing the customer to co-construct the service experience to suit their context. This requires value-based collaboration between stakeholders and users, in contrast to standard market research. The Co-design is the process where stakeholders (business or customers) can involve and participate during the design development process to ensure the results meet their needs and are usable.

Smart Product is defined in this research as "*where physical products are equipped with ICT components (sensors, RFID, communications interface, etc.) to collect data on their environment and their own status*". Only when products gather data, know their way through production, and communicate with the higher-level systems can production processes be improved and guided autonomously and in real time. It

also becomes possible to monitor and optimize the status of the individual products. This has potential applications beyond production alone. Using smart products during the usage phase makes new services possible in the first place – through communications between customers and manufacturers, for example.

Finding:

3.1.2 (a) Regarding the actual adoption of the smart product technology, we can summarized that more than 50% of the industry allow the customer to co design, co construct the product or service experience to suit their context. However, more than 60% of the responded company do not offer products equipped with the add-on functionalities based on information and communications technology, i.e., no Product memory or self-supporting equipped, no product memory, no assistance or monitoring system, and no automatic identification equipped.

Table 5 Q1.1,1.2 Does your company allowing the customer to co-design, co-construct the product or service experience to suit their context?

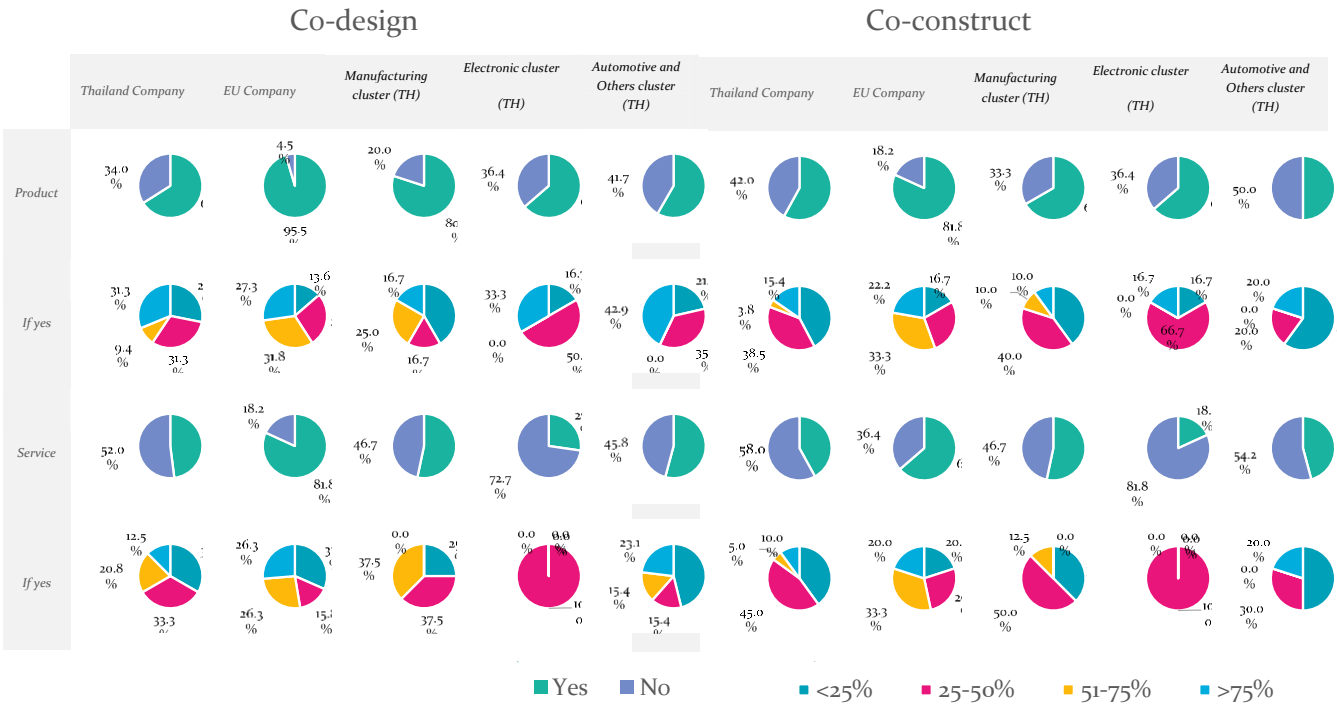
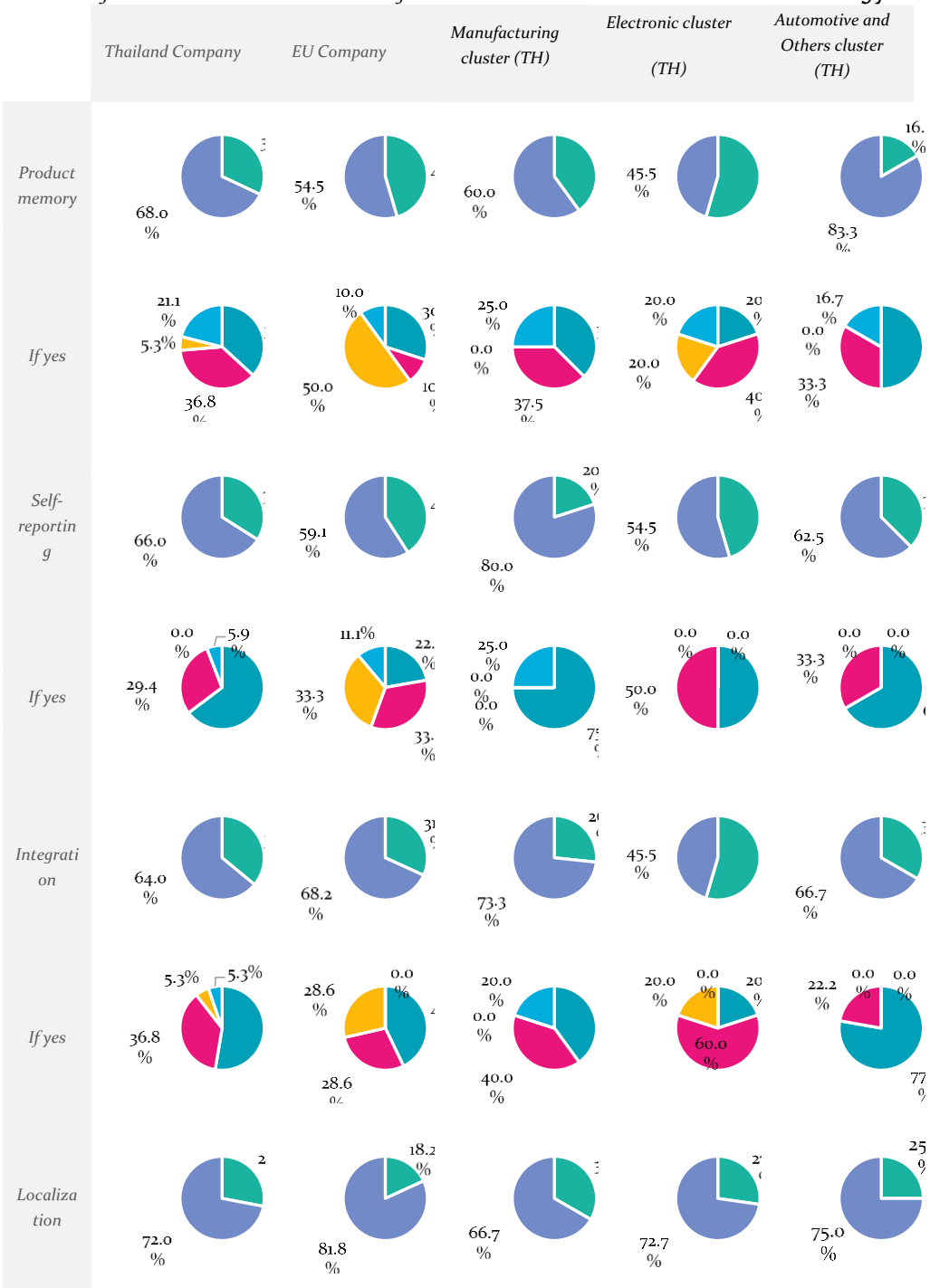


Table 6 Q1.3 Does your company offer products equipped with the following add-on functionalities based on information and communications technology?



Thus this suggested that the domain of smart product has to be ENCOURAGED AND PROMOTED, improved in order to enhance the new business model.

SMART FACTORY: INTELLIGENCE MANUFACTURING SYSTEM

A smart factory is defined in this research as "*a production environment in which the production systems and logistics systems largely organize themselves without human intervention*". The smart factory relies on cyber-physical systems (CPS), which link the physical and virtual worlds by communicating through an IT infrastructure, the Internet of Things.

Industry 4.0 also involves digital modeling through the smart collection, storage, and processing of data. In this way, the smart factory concept ensures that information is delivered and resources are used more efficiently. This requires the real-time, cross-enterprise collaboration between production systems, information systems, and people.

Finding:

3.1.2(b) The results of analysis show that many equipment infrastructure such as Machines/systems can be partly controlled through IT but the M2M: machine-to-machine communications cannot be implemented. Also the equipment are not always adaptable, interoperable; integration and collaboration with other machines/systems possible.

- Less than 15% and 10% of Thai and EU company can have their machine or system controlled by IT.
- Less than 5% can have their equipment communicated or upgradable as M2M: machine-to-machine communications, or interoperability where integration and collaboration with other machines/systems is possible.
- This is the same for the each cluster as well. This suggest the big gap and opportunity for the industry to upgrade and invest in their infrastructure and adopt the industry4.0 technology.

3.1.2(c) Moreover the results of analysis show that the response company can apply the digitization of factories and makes it possible to create a digital model of the factory BUT are not the leading system of the company. Eventhough more than 60% of Thai company indicates that the data are collected during the production,

- Only 3% of the Thai company can have more than 75% of data collected from machine and process during production.

- Only 24% of data collected are used for Quality management and 20% are used for predictive maintenances or optimization of logistics and production processes.
- The usage of data for Creation of transparency across production process and less than 15% use real-time data for Automatic production control.
- This limitation of the data usage does not support the existing Thai company to implement the digital model factory concept. This will also lead to lacking of the smart operation as well.

3.1.2 (d) Most of the data about machinery, processes, and products as well as malfunctions and their causes is collected during production are still collected manually such as Inventory data, Manufacturing throughput times, Equipment capacity utilization, Production residues/waste/WIP, Quality MGMT, Employee utilization, Quality Control data, data about processing, process condition, Production times, Overall equipment effectiveness (OEE).

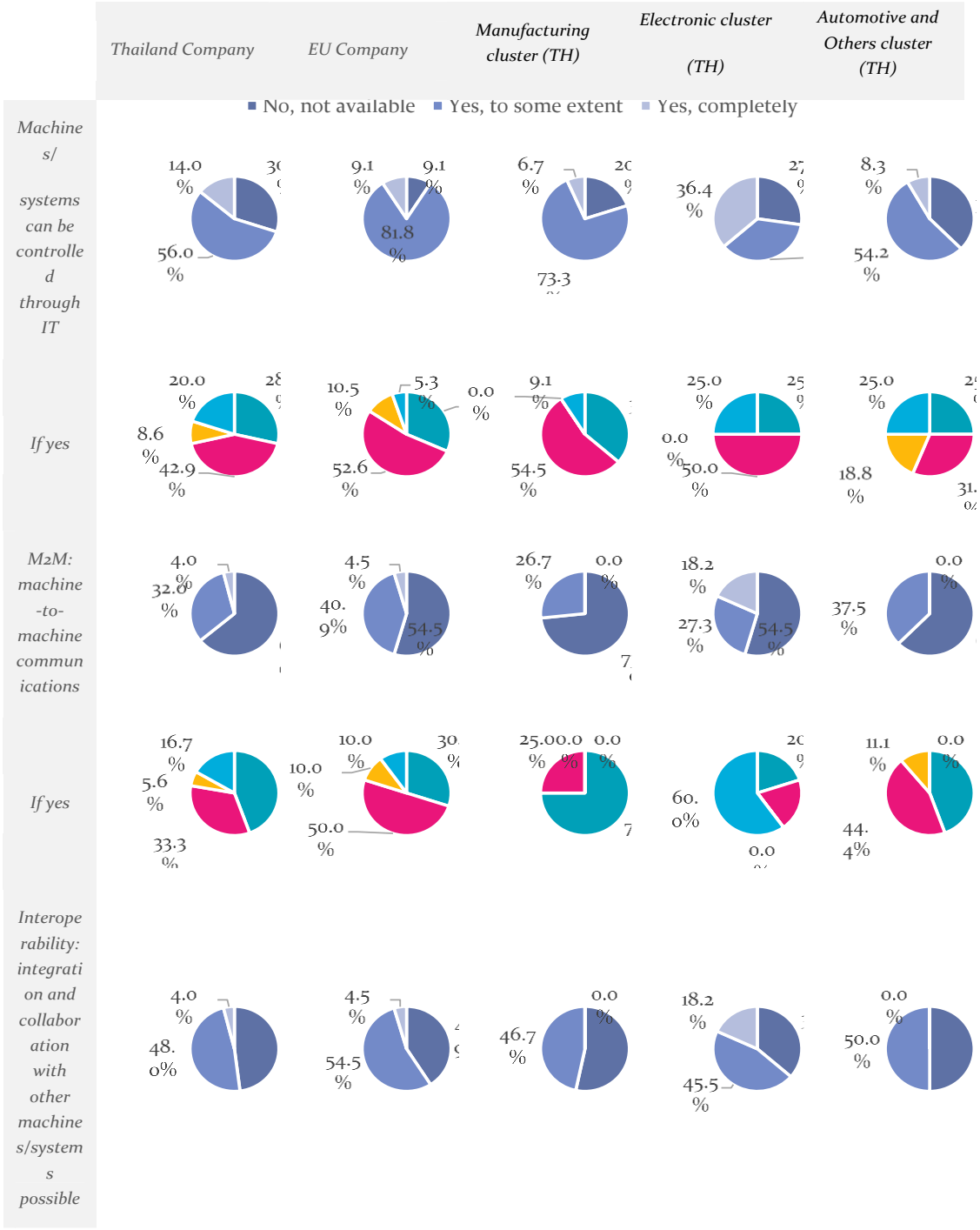
- More than 40% of Thai company are still manually collecting Inventory data, Manufacturing throughput times.
- More than 50% of Thai company are still manually collecting Equipment capacity utilization, Quality Management and Employee utilization. This strong indicates that the data usage for transparency visualization of the system is under utilized.

3.1.2 (e) Most of the company, more than 60% still not be able to have MES: manufacturing execution, PLM: product lifecycle management system to interface with the leading system. However, most of the company have adopted the ERP system as leading system including the PDA – production data acquisition.

The limitation of the data usage does not support the existing Thai as well as EU company to implement the digital model factory concept. This is also corresponds to the lacking of the leading interface system which will also lead to lacking of the smart operation as well.

Thus this suggested that the domain of digital modelling among existing Thai and EU industry is not closely conform to the ideal state of digital factory. This indicate the needs of industry to improve the adoption of digital factory domain in order to enhance the usage of data for real time control of the process.

Table 7 Q2.1 How would you evaluate your equipment infrastructure when it comes to the following functionalities?



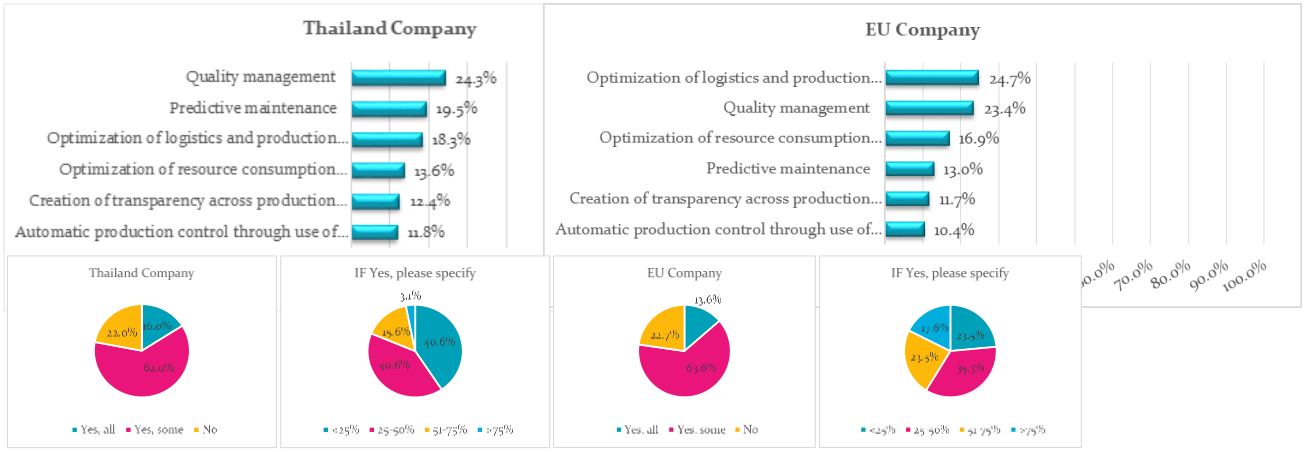


Figure 16 Q2.3, 2.4 Collecting machine and process data during production and Using the data collected for digitization of factory?

SMART OPERATION: CONTROLLING, ADJUSTING & MONITORING PROCESS REAL TIME

The hallmark of Industry 4.0 is the enterprise-wide and cross-enterprise integration of the physical and virtual worlds. The advent of digitization and the plethora of data it has brought to production and logistics have made it possible to introduce what are in some cases entirely new forms and approaches to production planning systems (PPS) and supply chain management (SCM). This technical requirements in production and production planning necessary is to realize the self-controlling workpiece known as smart operations.

Industry 4.0 readiness in the area of smart operations is determined using the following four criteria:

- Information sharing
- IT security
- Cloud usage
- Autonomous processes

This research found that many company does integrate information sharing into your system across departmental, and between enterprise-wide (internal) such as

Production/manufacturing Purchasing Logistics

Finding:

3.1.2 (f) Regarding the Data usage, this suggested that the integrated cross-departmental information are available BUT are not always shared with customer/supplier externally.

- More than 70% of Thai industry does not have complete integration on data usage shared across department as well as across enterprises that can effectively connect the following functions
  - Research and development Production/Manufacturing
  - Purchasing Logistics
  - Sales Finance/Accounting
  - Service IT

3.1.2 (g) Regarding the vision of Industry 4.0 that workpiece can guide itself autonomously through production are not available at many company.

- More than 60% of both Thai and EU company do not have the production processes that can autonomously guide the workpiece throughout the process
- More than 50%, and 60% of the Thai and EU company respectively have production processes that cannot respond autonomously/automatically in real time to changes in production conditions.

3.1.2(h) Regarding the DATA AND COMMUNICATIONS SECURITY, majority of the company organized IT central with mostly solutions in the Security in internal data storage has been implemented.

- However 47% of the company do not use cloud service to support solutions in the Security in internal data storage.
- Similar to the Security of communications for in-house data exchange or data exchange with business partners.

3.1.2 (i) Regarding the degree of the digitization of vertical value chain (from product development to production),

- almost 60% of the Thai company has been classified as No digitization at all - No automated exchange of information along the vertical value chain or Low digitization –some data flow exchange through internal IT within organization.
- At least 45% of the Thai company cannot have real-time view on your production and can dynamically react on changes in demand.

- More than 50% of the Thai company still have isolated planning processes – Neither IT-enabled nor integrated along the value chain or having Low Connected system – Comprising information from actual sale/contract to production planning.
- Many responded company still control Batch production for large lot sizes without insight into production status.
- *Majority has no ability to react flexible on changes in demand* or has Low Virtual Factory – Batch production for large lot sizes with ability to react flexible on changes in demand, *but No Real-time view on productions and no capabilities to dynamically change schedules.*

3.1.2 (j) Regarding the degree that the company has as end-to-end IT enabled planning and steering process from sales forecasting, over production to warehouse planning and logistics,

- at least 52% have isolated planning processes – Neither IT-enabled nor integrated along the value chain (e.g. planning based on past experiences) or Low Connected system – Comprising information from actual sale/contract to production planning.

This finding indicates that the smart operation domain of the industry especially Thai company in all clusters are still lacking of the ability to integrate information within the enterprise-wide and cross-enterprise integration in order to connect and utilize the of the physical and virtual worlds.

This lacking of smart production is mainly due to the lacking of the advent of digitization and the under usage of the data from production to logistic, supply chain and service which have made it impossible to entirely manage the production systems for self-controlling workpiece.

Moreover, with lacking of the digitization and the restricted IT system, this suggested that the competence skill of the employee and the IT system used to support the smart operation need to be improved especially in the context of Data Security and Data Exchange. The Cloud service are needed to be promoted.

DATA DRIVEN SERVICE: INTEGRATED BUSINESS and OPERATIONAL DATA MANAGEMENT

The objective of data-driven services is to align future business models and enhance the benefit to the customer. The after-sales and services business will be based more and more on the evaluation and analysis of collected data and rely on enterprise-wide integration. The physical products themselves must be equipped with physical IT so they can send, receive, or process the information needed for the operational processes. This means they have a physical and digital component, which in turn are the basis for digitized services in the usage phase of the products.

Finding:

3.1.2 (k) This research found that 46% of the Thai company and 50% of the EU company still cannot integrate the process data gathered in production and in the usage phase to enable new services.

- Thus, the share of your revenues come from these new data-driven services are very small and more than 60% of both Thai and EU has at has at most 20% of revenues generated from the new data-driven service. About 20% of Thai company just collected and stored data without using further.

3.1.2 (l) This research found that the company has several use of multiple integrated sales channels to sell products to your customers including One channel - Traditional sales force approach, e.g. local sales force or Integration of digital and non-digital sales. Also Several Channel –various digital and non-digital sales channels, e.g., sales force, web-shop, sales platforms and Multi Channel – Integration of various digital and non-digital sales channels, e.g., sales force, web-shop, sales platforms are also available.

- However, very few has Multi/ Omni-Channel – Integration of various digital and non-digital sales channels, e.g. store, sales force, web-shop, sales platforms.

3.1.2(m) We also found that company has several integrated multiple channels, i.e., website, blogs, forums, social media platforms etc. for customer interactions to communicate news, receive feedback, and manage claims.

- However, 40% still use the One-way communication – Usage of traditional communication channels for information purposes only (e.g. corporate website, newsletters) to response to customer from e.g. corporate website).

- About 40% of Thai company still has Reactive communication – Usage of digital channels to response to customer, e.g. use previous information from customers to product development.
- Only up to 10% of Thai industry have Proactive communication – Usage of digital channels to acquire customer interaction, e.g. some integrating customers into product development. Very few of less than 10% has Interactive communication – Usage of multiple digital channels to foster customer interaction, e.g. integrating customers into product development via social media platforms.
- Only 24% of the Thai company has Digital sales approach - Sales force is supported by digital devices and distribute to all relevant processes and systems using centrally integrated IT.
- Only 4% has High Digital sales approach supported by digital devices and access to all relevant processes and systems to customer and product data using horizontally integrated IT with customers and suppliers
- This low digital saleforce and multiple channels are interconnected with the low usage and need of the mobile devices technology that we found earlier.

In summary, there exists various gaps between the actual implementation and the ideal need of implementation not only on the strategic level but also at the adaptation level. To fully attain the benefit of industry4.0, this report shows that

- *From smart operation perspective, there are eminent deficiency on the current domain of digital modelling that has to be improved in order to enhance the usage of data for real time control of the process. Many equipment infrastructure such as Machines/systems can be partly controlled through IT but the M2M: machine-to-machine communications cannot be implemented. Also the equipment are not always adaptable, interoperable; integration and collaboration with other machines/systems possible.*
- *At least 45% of the company cannot have real-time view on your production and can dynamically react on changes in demand. Many responded company still control Batch production for large lot sizes without insight into production status. No ability to react flexible on changes in demand or has Low Virtual Factory – Batch production for large lot sizes with ability to react flexible on changes in demand, but No Real-time view on productions and no capabilities to dynamically change schedules.*

- *Most of the data about machinery, processes, and products as well as malfunctions and their causes is collected during production are still collected manually such as Inventory data, Manufacturing throughput times, Equipment capacity utilization, Production residues/waste/WIP, Quality MGMT, Employee utilization, Quality Control data, data about processing, process condition, Production times, Overall equipment effectiveness (OEE). Most of the company still not be able to have MES: manufacturing execution, PLM: product lifecycle management system to interface with the leading system. However, most of the company have adopted the ERP system as leading system including the PDA – production data acquisition.*

- *The actual digitization of the company with the IT system, and the competence skill of the employee and the IT system used to support the smart operation are still below the expectation and need of the company. This is needed to be emphasized especially in the context of Data Security and Data Exchange which differed and lower than the current needs of industry in using those to drive competitiveness of the company. Especially the Cloud service is very needed to be promoted.*

- *From technology perspective, there are also clear gap between the needs and the actual usage of the sensor technology, Mobile, RFID, Real time Location, Big Data, Cloud technology, Embedded IT system and the M2M are very prominent and significant. The low digital saleforce found are supported and interconnected with the low usage and need of the mobile devices technology. Hence these technologies are vital to the company competitiveness and needs to be emphasized. The MS IE 4.0 need to embrace those knowledge areas into the curriculum structure*
- *These lead to strong indication that the industry are currently lacking of the Data usage enhancement that integrate all data from production, to sales across-departmental that are available for sharing with customer/supplier externally in order to enhance information flow along the value chain. There are still lacking of the adoption of digital modelling domain that has to be improved in order to enhance the usage of data for real time control of the process.*

- *The company has to improve and adopt several use of multiple integrated sales channels to increase sale competitiveness with Multi/ Omni-Channel – Integration of various digital and non-digital sales channels, e.g. store, sales force, web-shop, sales platforms with proactive communication – Usage of digital channels to response to customer, e.g. use previous information from customers to product development*

- *The domain of smart product has to be ENCOURAGED AND PROMOTED, improved in order to enhance the new business model.*

In general, we have found the interconnection between the lacking of actual competence in those 4 domains that can affect each other. The lacking of the key competence technologies of sensor, big data and centralized IT has led the industry to be lacking of the smart product domains. This again leads to lacking of smart factor, smart operation and smart business. Hence the area of adoption and application of industry4.0 in 3 key areas of production technology, centralized IT and product development will strongly enhance the competitiveness of the industry especially for Thailand where the M.S.I.E curriculum is being developed. The following provides the summary and relationship between 3 key technologies of industry4.0 needed for Thai, 3 key areas of their adoption, and finally the competence of industry at operation level. Without the business mindset, the company cannot drive all initiatives to implements those 3 key technologies of industry4.0 on the 3 key areas of their adoption.

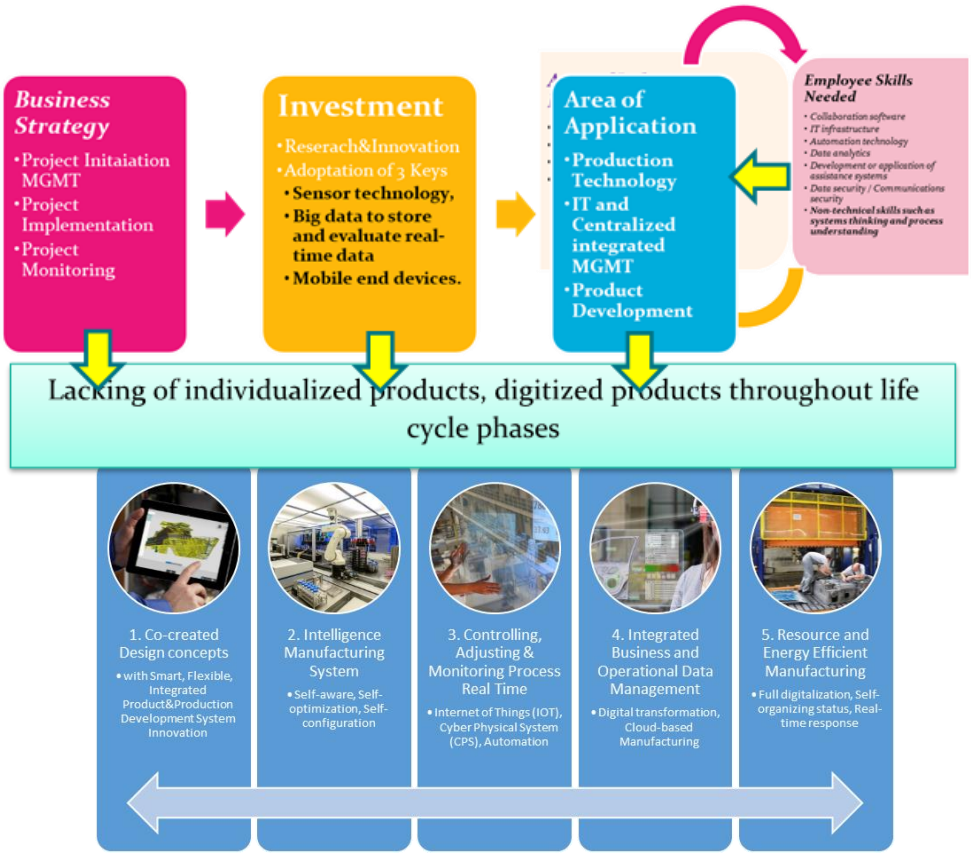


Figure 17 Relationship model of key drivers and enabler of Industry Needs Assessment

3.2 The results of 1st Module on Industry Needs

3.2.1 Student need assessment of Competence: Part 1: Industry 4.0 Adoption Literacy

This section describes the analysis of student need assessment with respect the competence of Industry 4.0 in terms of the Adoption Literacy. We investigate the competence of students at both business perspectives and how to adopt the strategic planning literacy to initiating the industry 4.0 project.

Following the questionnaire development framework of industry need assessment, the TL developed the questionnaire framework of students in correspondent with questioning item of industry. This section help asserting the assessment whether the student competences are matched with industry needs at strategy level

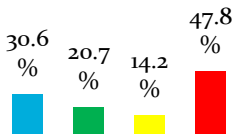
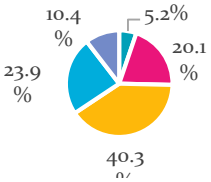
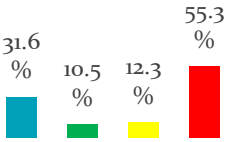
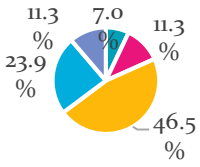
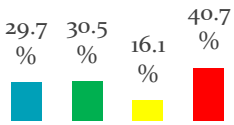
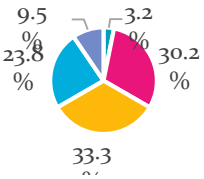
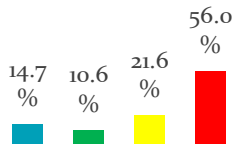
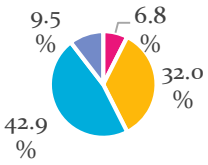
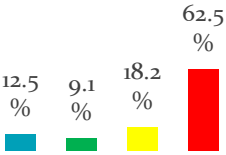
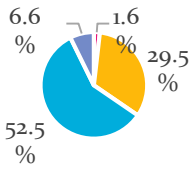
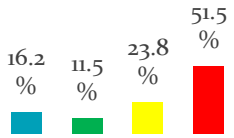
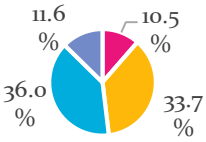
- 1. Business strategy, Business Models

Finding:

3.2.1(a) Regarding the ability in defining/implementing Industry 4.0 strategy, the surveys from students showed the overall student's ability in defining/implementing Industry 4.0 strategy do not have knowledge, competences in defining/implementing Industry 4.0 strategy.

- Although, almost 50% of both Thai and EU students do not have knowledge, competences to define/implement Industry 4.0 strategy, this group of student feels strongly aware that they need to acquire/learn it since in the past and within the next 1 year (>70% from the total).
- This information presented that students have high possibility to further their study for obtaining the knowledge for Industry 4.0 implementation in soon time.
- This finding does not depends on the background and level of study indicating that the existing curriculum of M.S.I.E. in Thailand and EU may not produce students with industry 4.0 competence especially from the adoption literacy perspective.

Table 8 Q1. How would you describe your ability to define/implement Industry 4.0 strategy?

	Overall	Master 1st-year cluster	Master 2nd-year and Others cluster
TH	 If don't have knowledge 	 If don't have knowledge 	 If don't have knowledge 
E U	 If don't have knowledge 	 If don't have knowledge 	 If don't have knowledge 

Note:

- (a) I have ability to apply my knowledge to formulate Industry 4.0 strategy
- (b) I have ability to design a system, component, or process to meet Industry 4.0 strategy
- (d) I have ability to setup, function and communicate on Multi-Disciplinary Teams
- I don't have knowledge, competences to define/implement Industry 4.0 strategy
  - 1 (But I don't think I need to learn it in next 3 years)
  - 2 (somewhat need to learn it in next 2 years)
  - 3 (need to learn it in next 1 years)
  - 4 (very need to learn since past 1 years)
  - 5 (strongly need to acquire this since past 2 years)

3.2.1 (b) Regarding the surveys from students showed that actual competences of IE students about modern business and organization management for sustainability with respect to Industry4.0, majority of students do not have competence on and students who do not have knowledge in modern business and organization management for sustainability with respect to Industry4.0 presented their opinions to acquire this ability.

- There are 44.9% of students from the survey has knowledge in modern business and organization management for sustainability with respect to Industry4.0 and 57.3% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (58.7% from the total) and the next two year (28.5% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2 Student need assessment of Competence: Part 2: Industry 4.0 Readiness Competence

This section help asserting the assessment whether the student competences are matched with industry needs at operational level

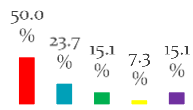
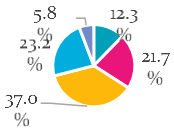
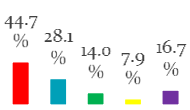
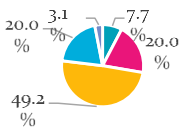
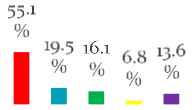
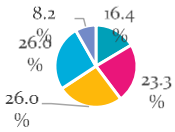
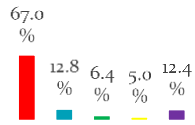
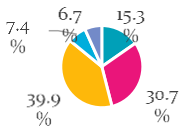
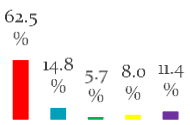
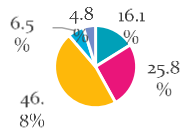
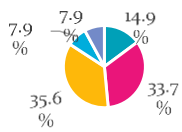
- 2. Transversal & Domain related Competences: Student as Employee

Finding:

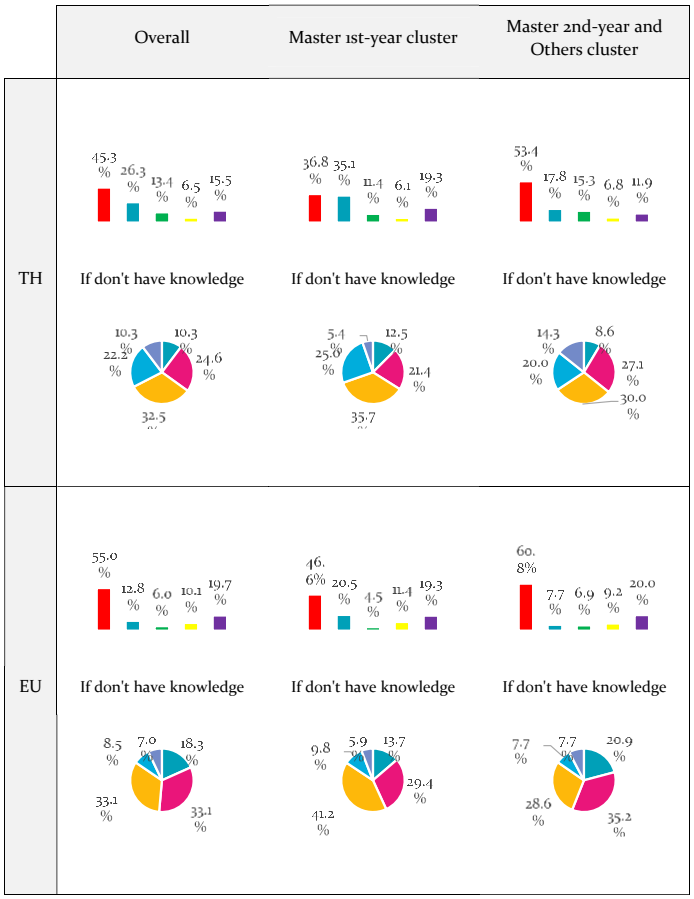
3.2.2(a) Regarding the actual competences of IE students about IT Knowledge and technology with respect to Industry4.0, the surveys from students showed that actual competences of IE students about IT Knowledge and technology with respect to Industry4.0 are still lacking knowledge and competence in defining and implementing the following 3 key technologies needed by industry.

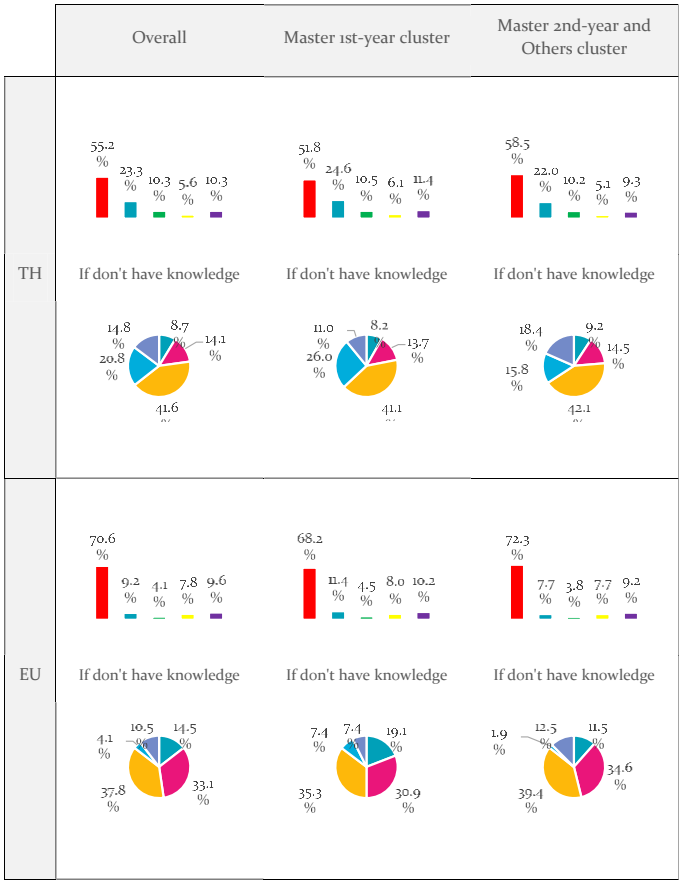
about IT Knowledge

- [ ] **1) Mobile Device**
- [ ] **2) Sensor technology**
- [ ] **3) Realtime Location System**
- [ ] **4) Big data Technology**
- [ ] 5) Cloud technologies
- [ ] 6) RFID
- [ ] 7) Embedded IT systems
- [ ] 8) M2M Communication

	Overall	Master 1st-year cluster	Master 2nd-year and Others cluster
TH	 If don't have knowledge 	 If don't have knowledge 	 If don't have knowledge 
EU	 If don't have knowledge 	 If don't have knowledge 	 If don't have knowledge 

Sensor





Mobile end device

Big Data

- I don't have knowledge, competences to define/implement Big data technology
- (a) I have ability to apply my knowledge to formulate Big data technology
- (c) I have ability to design a system, component, or process the Big data technology
- (d) I have ability to setup, lead the Multi-Disciplinary Teams regarding Big data technology
- (e) I have ability to identify, formulate, and solve Big data technology problems
  - 1 (But I don't think I need to learn it in next 3 years)
  - 2 (somewhat need to learn it in next 2 years)
  - 3 (need to learn it in next 1 years)
  - 4 (very need to learn since past 1 years)
  - 5 (strongly need to acquire this since past 2 years)

Figure 18 Assessment of IT competence of Students

3.2.2(b) Regarding the surveys from students showed that actual competences of IE students about computer programming and coding with respect to Industry4.0, majority of students do not have knowledge in computer programming and coding with respect to Industry4.0 and presented their opinions to acquire this ability.

- About half of students from the survey (48% from the total) has ability in computer programming and coding.
- Although 52% of students do not have knowledge, competences in computer programming and coding with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within the next 2 year (88.1% from the total).
- This information presented that students have high possibility to further their study for obtaining the knowledge for computer programming and coding in the near future.

3.2.2 (c) Regarding the surveys from students on the actual competences of IE students about data and information processing and analytics with respect to Industry4.0, majority of students do not have competence on information processing and analytics and students who do not have knowledge in data and information processing and analytics with respect to Industry4.0 presented their opinions to acquire this ability.

- About half of students from the survey (48% from the total) has ability in data and information processing and analytics.
- Although 54.4% of students do not have knowledge, competences in data and information processing and analytics with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (61.5% from the total) and the next two year (28.3% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2 (d) Regarding the surveys from students showed that actual competences of IE students about data analytic/statistical knowledge with respect to Industry4.0, majority of students do not have competence on data analytic/statistical knowledge and students who do not have knowledge in data analytic/statistical knowledge with respect to Industry4.0 presented their opinions to acquire this ability.

- About half of students from the survey (53.3 % from the total) has ability in data analytic/statistical knowledge.
- Although 48.7% of students do not have knowledge, competences in data analytic/statistical knowledge with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (65.3% from the total) and the next two year (25.3% from the total).

- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2 (e) Regarding the surveys from students showed that actual competences of IE students about IT security data protection with respect to Industry4.0, majority of students do not have competence on IT security data protection and students who do not have knowledge in IT security data protection with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 33.9% of students from the survey has knowledge in IT security data protection and 67.1% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (59.4% from the total) and the next two year (26.0% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(f) Regarding the surveys from students showed that actual competences of IE students about ability to interact with modern interfaces (human-machine/human-robot) with respect to Industry4.0, majority of students do not have competence on modern interfaces (human-machine/human-robot) and students who do not have knowledge in ability to interact with modern interfaces (human-machine/human-robot) with respect to Industry4.0 presented their opinions to acquire this ability.

- There are 40.2% of students from the survey has ability to interact with modern interfaces (human-machine/human-robot) and 59.8% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (58.1% from the total) and the next two year (27.1% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(g) Regarding The surveys from students showed that actual competences of IE students about smart work and ergonomics with respect to Industry4.0, majority of students do not have competence on smart work and ergonomics and students who do not have knowledge in smart work and ergonomics with respect to Industry4.0 presented their opinions to acquire this ability.

- About half of students from the survey (49.8 % from the total) has ability in smart work and ergonomics.
- Although 52.7% of students do not have knowledge, competences in smart work and ergonomics with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (60.2% from the total) and the next two year (27.1% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(h) Regarding the surveys from students showed that actual competences of IE students about smart product with respect to Industry4.0, majority of students do not have competence on smart product and students who do not have knowledge in smart product with respect to Industry4.0 presented their opinions to acquire this ability.

- About half of students from the survey (54.3 % from the total) has ability in smart product.
- Although 47.6% of students do not have knowledge, competences in smart product with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (65.4% from the total) and the next two year (25.1% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(i) Regarding the surveys from students showed that actual competences of IE students about co-created design with respect to Industry4.0, majority of students do not have competence on co-create design and students who do not have knowledge in co-created design with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 39.7% of students from the survey has knowledge in co-created design and 62.7% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (57.7% from the total) and the next two year (25.8% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(j) Regarding the surveys from students showed that actual competences of IE students about smart digital factory with respect to Industry4.0, majority of students do not have competence on smart digital factory and students who do not have knowledge in smart digital factory with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 41.6% of students from the survey has knowledge in smart digital factory and 60.4% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (63.6% from the total) and the next two year (24.4% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(k) Regarding the surveys from students showed that actual competences of IE students about smart operations-controlling, adjusting and monitoring process real time with respect to Industry4.0, majority of students do not have competence on smart operation and students who do not have knowledge in smart operations-controlling, adjusting and monitoring process real time with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 45.6% of students from the survey has knowledge in smart operations-controlling, adjusting and monitoring process real time with respect to Industry4.0 and 56.9% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (60.5% from the total) and the next two year (26.0% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2 (l) Regarding the surveys from students showed that actual competences of IE students about data driven services-integrated business and operational data management with respect to Industry4.0, majority of students do not have competence on services-integrated business and operational data management and students who do not have knowledge in data driven services-integrated business and operational data management with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 34.9% of students from the survey has knowledge in data driven services-integrated business and operational data management with respect to Industry4.0 and 66.0% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (59.2% from the total) and the next two year (26.9% from the total).

- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(m) Regarding the surveys from students showed that actual competences of IE students about centralized integrative production operation management with respect to Industry4.0, majority of students do not have competence on centralized integrative production operation management and students who do not have knowledge in centralized integrative production operation management with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 36.5% of students from the survey has knowledge in centralized integrative production operation management with respect to Industry4.0 and 65.1% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (60.6% from the total) and the next two year (26.3% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(n) Regarding the surveys from students showed that actual competences of IE students about digitization life cycle production management with respect to Industry4.0, majority of students do not have competence on digitization life cycle production management and students who do not have knowledge in digitization life cycle production management with respect to Industry4.0 presented their opinions to acquire this ability.

- There are only 38.5% of students from the survey has knowledge in digitization life cycle production management with respect to Industry4.0 and 64.4% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (56.9% from the total) and the next two year (26.5% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2 (o) Regarding the surveys from students showed that actual competences of IE students about modern quality management with respect to Industry4.0, majority of students do not have competence on modern quality management and students who do not have knowledge in modern quality management with respect to Industry4.0 presented their opinions to acquire this ability.

- About half of students from the survey (46 % from the total) has knowledge in modern quality management.

- Although 55.8% of students do not have knowledge, competences in knowledge in modern quality management with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (59.9% from the total) and the next two year (30.8% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2 (p) Regarding the surveys from students showed that actual competences of IE students about modern supply chain and logistics management with respect to Industry4.0, majority of students do not have competence on modern supply chain and logistics management and students who do not have knowledge in modern supply chain and logistics management with respect to Industry4.0 presented their opinions to acquire this ability.

- About half of students from the survey (49.9 % from the total) has knowledge in modern supply chain and logistics management.
- Although 55.8% of students do not have knowledge, competences in knowledge in modern supply chain and logistics management with respect to Industry4.0, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (66.0% from the total) and the next two year (26.2% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

3.2.2(q) Regarding the surveys from students showed that actual competences of IE students about modern preventive/predictive maintenance management with respect to Industry4.0, majority of students do not have competence on modern preventive/predictive maintenance management and students who do not have knowledge in modern preventive/predictive maintenance management with respect to Industry4.0 presented their opinions to acquire this ability.

- There are 45.1% of students from the survey has knowledge in modern preventive/predictive maintenance management with respect to Industry4.0 and 57.1% of students has no knowledge in this area.
- However, this group of student feels strongly aware that they need to acquire/learn it in the past and within one year (60.0% from the total) and the next two year (28.0% from the total).
- This information presented that students have high possibility to further their study for obtaining this knowledge in the near future.

The following summarize the industry 4.0 student needs on Transversal & Domain related Competences: Student as Employee

Adoption	Readiness Competence
• defining/implementing Industry 4.0 strategy • modern business and organization management for sustainability	• IT Knowledge • computer programming and coding • information processing and analytics • data analytic/statistical knowledge • on IT security data protection • modern interfaces (human-machine/human-robot) • smart work and ergonomics • smart product • co-create design • smart digital factory • smart operation • services-integrated business • centralized integrative production • digitization life cycle production • modern quality management • modern supply chain and logistics • modern preventive/predictive maintenance

Figure 19 List of Student Needs with respect to Industry Needs

3.2.3 Student need assessment of Competence: Part 3: Character quality of 21st century skill

This section help asserting the assessment whether the student competences are matched with industry needs with respect to the t operational level

- 2. Transversal & Domain related Competences: Student as Employee

Finding:

3.2.3(a) Regarding the actual competences of IE students about character quality that IE students need to understand to increase their competences and competitiveness, the surveys from students showed that the topics that they need to understand to increase their competences and competitiveness are ranked as follows.

1) Communication skills with respect to Industry4.0
2) Team working abilities with respect to Industry4.0
3) Social skills with respect to Industry4.0
4) Self and time management with respect to Industry4.0
5) Adaptability and ability to change in new technologies with respect to Industry4.0
6) Legal affairs and sustainability with respect to Industry4.0

Figure 20 Rank of Character Quality for Student Needs

Adoption	**Readiness Competence**	Character Quality
• defining/implementing Industry 4.0 strategy • modern business and organization management for sustainability	• IT Knowledge • computer programming and coding • information processing and analytics • data analytic/statistical knowledge • on IT security data protection • modern interfaces (human-machine/human-robot) • smart work and ergonomics • smart product • co-create design • smart digital factory • smart operation • services-integrated business • centralized integrative production • digitization life cycle production • modern quality management • modern supply chain and logistics • modern preventive/predictive maintenance	• Communication skills with respect to Industry4.0 • Team working abilities with respect to Industry4.0 • Social skills with respect to Industry4.0 • Self and time management with respect to Industry4.0 • Adaptability and ability to change in new technologies with respect to Industry4.0 • Legal affairs and sustainability with respect to Industry4.0

Figure 21 List of overall Student Needs

3.3 The results of 3rd Module on Gap analysis

This section summarize the existing situation and the gaps between the current needs of industry and student. Based on the developed analysis Triangular framework model, the answers of the 6 main questions can be summarized as follows

3.3.1 Q1 What are the conclusion of the Actual competence/need of Industry regarding Industry 4.0?

- Based on the analysis of Industry 4.0 Business Strategy, Industry 4.0 is more than just improving existing products or processes through the use of digital technologies – it actually offers the opportunity to develop entirely new business models. For this reason, its implementation is of great strategic importance. We proposed the 1st set of ideal need for industry toward the business sustainability

    1. Needs of Industry 4.0 strategy management with review strategy through a system of indicators
    2. Needs of 3 key technologies of Sensor, Big data and Mobiles devices.
    3. Needs of investment activity and technology and innovation management in 3 keys areas of production technology, centralized IT-integrated management, and product development.
    4. Needs of competence in those 4 domains that can affect each other. The lacking of the key competence technologies of sensor, big data and centralized IT has led the industry to be lacking of the smart product domains. This again leads to lacking of smart factor, smart operation and smart business.
    5. From the analysis of the Transversal & Domain related Competences, there are strong needs on digital transformation. This also related to the needs on the employee skill that help companies changing to digital workplace.
    6. The analysis of employees dimension shows that industry analyze employee skills in various areas and the company's efforts including needs to acquire new skill sets. All industry clusters indicate the same situation where the existing skills of employees exist but not adequate when it comes to the future requirements under Industry 4.0. This helps asserting the needs of student competences in all areas of the following

        - Collaboration software
        - IT infrastructure
        - Automation technology

- Data analytics
- Development or application of assistance systems
- Data security / Communications security
- Non-technical skills such as systems thinking and process understanding

3.3.2 Q2 What are the conclusion of the ideal need of Industry regarding Industry 4.0

1. The actual digitization of the company with the IT system, and the competence skill of the employee and the IT system used to support the smart operation are still below the expectation and becomes ideal need of the company. This is needed to be emphasized especially in the context of Data Security and Data Exchange which differed and lower than the current needs of industry in using those to drive competitiveness of the company. Especially the Cloud service is very needed to be promoted.

2. From technology perspective, there are also clear gap between the needs and the actual usage of the sensor technology, Mobile, RFID, Real time Location, Big Data, Cloud technology, Embedded IT system and the M2M are very prominent and significant. The low digital saleforce found are supported and interconnected with the low usage and need of the mobile devices technology. Hence these key technologies are vital to the company competitiveness and becomes the ideal needs for the industry.

3. The lacking of technological competence leads to strong indication that the industry are currently lacking of the Data usage enhancement that integrate all data from production, to sales across-departmental that are available for sharing with customer/supplier externally in order to enhance information flow along the value chain. There are still lacking of the adoption of digital modelling domain that has to be improved in order to enhance the usage of data for real time control of the process. Hence the vertical/horizontal integration becomes ideal needs for the industry.

4. The company has to improve and adopt several use of multiple integrated sales channels to increase sale competitiveness with Multi/ Omni-Channel – Integration of various digital and non-digital sales channels, e.g. store, sales force, web-shop, sales platforms with proactive communication – Usage of digital channels to response to customer, e.g. use previous information from customers to product development

5. Since employee skill is ultimately important, altered, requiring them to acquire new skills and qualifications. The need son employee skill with respect to the industry 4.0 on those Collaboration software, IT infrastructure, Automation technology, Data analytics, Development or application of assistance systems, Data security becomes the ideal needs for industry.

6. Finally there are mandatory needs of the Industry 4.0 on the Business Strategy planning, development, formulation, implementation, the design of indicators that shall be used to develop the monitoring of the business strategy as well. Moreover this Business Strategy shall covers the SCM and DATA-driven business model. This will assure that the acquisition of those top 3 key technologies of sensor technology, Big data to store and evaluate real-time data, and Mobile end devices in which the highest gap occurs at the Big data technology where needs will be fulfilled. This will also ensure that the application of the industry40 technology on the top 3 areas of production technology, IT and Centralized integrated management and product management will also be succeeded.

3.3.3 Q3 What are the conclusion of the Actual competence/need of students regarding Industry 4.0

- Students at all graduate level currently studying the M.S.I.E are lacking of the shills and competence in all 3 levels of
    1) Business strategy, Business Models
    2) Transversal & Domain related Competences: Student as Employee
    3) Character Quality
- The students are incompetence in 4 domains of industry4.0. We can conclude succinctly that Student need understanding and implementation of the concept of
    1. Smart products & Co-created Design:
    2. Smart factory (Intelligence Manufacturing System):
    3. Smart operations (Controlling, Adjusting & Monitoring Process Real Time):
    4. Data driven services (Integrated Business&Operational Data Management):
- In order to adopt, and manage the industry 4.0 project, the students needs to acquire knowledge and competence on how to define/implement Industry 4.0 strategy. Also student need to understand and integrate the concept of modern business and organization management for sustainability into the project.
- In order to work with company, the students need to acquire knowledge on the top 3 keys technologies of sensor, Big data and mobile devices. Also students need to be

able to apply the knowledge in the top 3 application areas of production technology, Centralized It-integrated management, and product development.

- The details of learning items that students needs in order to apply those key 3 technologies in key 3 areas are consisting of
    1. IT Knowledge
    2. computer programming and coding
    3. information processing and analytics
    4. data analytic/statistical knowledge
    5. on IT security data protection
    6. modern interfaces (human-machine/human-robot)
    7. smart work and ergonomics
    8. smart product
    9. co-create design
    10. smart digital factory
    11. smart operation
    12. services-integrated business
    13. centralized integrative production
    14. digitization life cycle production
    15. modern quality management
    16. modern supply chain and logistics
    17. modern preventive/predictive maintenance
- Moreover, the student need to acquire the 21st century skill of Character Quality consisting of
    1. Communication skills with respect to Industry4.0
    2. Team working abilities with respect to Industry4.0
    3. Social skills with respect to Industry4.0
    4. Self and time management with respect to Industry4.0
    5. Adaptability and ability to change in new technologies with respect to Industry4.0
    6. Legal affairs and sustainability with respect to Industry4.0

Q12 What are the conclusion on the gap between the Actual need of industry vs Ideal of Industry 4.0

- At the strategy level, the finding are summarized as follows., the Gap Analysis was preliminary done by comparing the actual usage of the industry 4.0 with the needs of the company. The analysis was first carried by each domain of technology and the cross tabulation was applied. The gap analysis between the needs and the actual usage of the sensor technology, Mobile, RFID, Realtime Location, Big Data, Cloud technology, Embedded IT system and the M2M.

- There exist the differences between the needs and the actual usage of the industry 4.0 technology. The first three highest needs are sensor technology, Big data to store and evaluate real-time data, and Mobile end devices. The first three highest actual usage are Mobile end devices and the sensor technology. The highest gap occurs at the Big data technology. This suggests that in order to enhance the business competitiveness of the company, the Big data to store and evaluate real-time data needs to be adopted among all the company.

- There are needs to acquire top 3 key technologies of sensor technology, Big data to store and evaluate real-time data, and Mobile end devices in which the highest gap occurs at the Big data technology where needs are not fulfilled.

- There are top 3 areas of application where industry4.0 technology are needed to be adopted at three key areas of production technology, IT and Centralized integrated management and product management. The existing lack of these needs are also related to the needs of employee skill and competence. Hence the schematic relationship between the actual industry needs at the Strategy and organization level can be depicted as follow.

Q13/23 What are the conclusion on the gap between the Actual/Ideal industry vs current IE student competence?

- Based on the surveys collected from students, we concluded that the actual competences of IE students about Industry 4.0 literacy and competency, majority of students do not have competence on all domain related to the implementation or adoption of Industry 4.0. However students who do not have knowledge with respect to Industry4.0 presented their opinions to acquire this ability

Table 1 : Scoring of each skill when comparing level of need and student competency

Skill	Level of Company's Need	Student Competency	Level of Important
1) IT Infrastructure	Very strong to strong level as 65.3%. (2nd = 6 points)	Students who do not have ability were about 52% to 74%. (1st= 7 points)	Total Point = 13 **High**
2) Automation Technology	Very strong to strong level as 63.9%. (3rd= 5 points)	Students who do not have ability were about 43% to 46%. (6th= 2 points)	Total Point = 7 **Medium**
3) Data analytics	Very strong to strong level as 69.4%. (1st= 7 points)	Students who do not have ability were about 48% to 54%. (5th= 3 points)	Total Point = 10 **High**
4) Data security / communications security	Very strong to strong level as 58.4%. (5th= 3 points)	Students who do not have ability were about 67.1%. (6th= 2 points)	Total Point = 5 **Low**
5) Development or application of assistance systems	Very strong to strong level as 56.9%. (6th= 2 points)	Students who do not have ability were about 56%. (4th= 4 points)	Total Point = 6 **Low**
6) Collaboration software	Very strong to strong level as 61.1%. (4th= 4 points)	Students who do not have ability were about 56% to 66%. (3rd= 5 points)	Total Point = 9 **Medium**
7) Non-technical skills such as systems thinking and process understanding	Strong level as 58.3% (7th= 1 points)	- Current competencies of students who do not have ability in this area were above 50%. (5th) - Approximately 70% of students students feel aware and need to learn in soon time (5th= 3 points)	Total Point = 4 **Low**

- The results from Table 9 can be used to classify the important level of technological competence in 2 classes as follows.
- Level High: Big data Technology and Embedded IT systems (High need but low level of competency).
- Level Medium: Mobile Device, Sensor technology, Realtime Location System, Cloud technologies , RFID, and M2M Communication (Medium need and medium level of competency).

Final Model Framework of Relationship Analysis of Industry and Student