WP 1 - Gap Analysis

Outcome 1.5 - Gaps between the needs and graduates' competences

Project Acronym:	MSIE 4.0
Project full title:	Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry
Project No.:	586137-EPP-I-2017-I-TH-EPPKA2-CBHE-JP
Funding Scheme:	Erasmus + KA2 - Capacity Building in the field of Higher Education
Coordinator:	AIT
Work Package:	WP1 – Gap Analysis
WP Leaders:	Rui M. Lima (UMinho) and Wichai Chattinnawat (CMU)
Task Title:	Task 1.4 Identifying gaps
Task Leader:	Rui M. Lima (UMinho)
Last version date:	24/01/2019
Status:	Draft
Dissemination Level:	Institution - Local - National - International

REVISION SHEET

Version	Date	Author (Partner/Person)	The revision reason
1	23/10/2018	UMinho / Rui M. Lima	First version - draft version of WP1 Task1.4 - Outcome 1.5. Template structure for the report sent for WP1 leader feedback.
2	28/11/2018	UMinho / Rui M. Lima	Second version – draft version of WP1 Task1.4 - Outcome 1.5. Development of the contextual background.
3	16/01/2019	UMinho / Rui M. Lima	Third version – final version of WP1 Task1.4 - Outcome 1.5. This version integrates a gap analysis supported by the curriculum analysis developed in Task 1.2 and the results of the questionnaire applied and cross-analysed by the project team in Task 1.3.
4	24/01/2019	UMinho / Rui M. Lima	Final version according to PEC evaluation

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1 Executive Summary

The preparation for designing phase of the MSIE4.0 program includes the 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 needs of industry to attain Industry 4.0, the identification of the needs of students perceive for their own development. After setting the needs, it is possible to identify the gaps between the real needs of the industry, the student needs and the actual offered curricula, which will inform the identification of competitive factors and recommendations for the new curriculum development. The current report is dedicated to the gap analysis between the industry and students' needs and graduates' competences and a comparison between industry needs of Thai and European selected companies.

The results of the comparison between industry needs of Thai and European selected companies show that, in general, Thai companies have a higher need of development of technologies and systems to support Industry 4.0 than the European surveyed companies do. These results give support to the need of development of an educational program such as the MSIE4.0 that will allow the development of Industrial Engineers to make a contribution for bridging this gap.

The competences gap analysis is informed, on one side, by the industry and students' needs developed in previous report based on questionnaires answered by 72 companies and 450 students. By the other side, the analysis of 26 master programs in Industrial Engineering allowed to create a perspective on the current status of competences' development. The analysis of competences needed by industry to attain Industry 4.0 was also enhanced by the view of the project's team based on the questionnaire data and the analysis of the curriculum. Thus, the gap analysis was based on a triangular analysis data source between industry needs, students' needs and curricula current situation.

The data collected from the industry and students questionnaires allowed to identify three main needed technologies as being Big Data, Sensors and Mobile systems, and three main domains of application as being production, product development and IT. Furthermore, those aspects were cross analysed by the project's team and developed into applications Industrial Engineers should be able to deal with in their managerial roles. These evolved to the identification of the competences level, based on Bloom's taxonomy, that graduates should be able to develop. For the gap analysis, the project's team added an analysis of the current situation related to the development of this level of competences. The weight of the level of competences and the comparison between the current level of development and the needed level, allowed to identify the following areas of application as having the main gaps in required competences: Data Analytics, Quality Management, Flexible Production Planning and Scheduling for Changing Demands and Customization, Trend analysis, Data Distribution, Logistic and supply chain management, Forecasting, Inventory Management, Maintenance Management and Real Time Process Control.

The professional role of Engineers need not only technical competences, but also transversal competences, has stressed internationally by Higher Education systems. Additionally, both companies and students identified the development of transversal competences as being highly important. Nevertheless, the analysis of curricula showed barely existent references to the development of transversal competences in current master programs. Thus, there is a huge gap regarding the explicit intentional development of transversal competences.

In summary, this report show the main gaps between the current level of development of technical and transversal competences and the industry and students' needs, which will contribute for the MSIE4.0 curricula design.

2 Introduction

WP1 aims to provide a 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. Within this context, task 1.4 aims to analyse gaps between the actual competence of MSc graduates in Industrial Engineering and the real needs of industry for Thailand 4.0 and Industry 4.0 and in EU countries referring to Europe 2020 goals. The outcome of the task are presented in the form of a report.

2.1 Context Background

With the development of the Internet, increasingly smaller and more powerful sensors and increasingly sophisticated software and hardware systems create an adequate environment for machine learning and collaboration through giant networks of "things". The integration of these systems in industrial environments has been causing a change in the industry. The impact on competitiveness, society and the economy is such that it will transform the world as we know it. Computer-based digital technologies, software and networks are not new, but they are becoming more sophisticated and integrated and therefore capable of transforming society and the global economy. Brynjolfsson and McAfee (2014) state that the world is at a turning point in which the effect of these digital technologies will manifest itself with "full force" through automation and "unprecedented things".

The fourth industrial revolution is a term that can be attributed to the idea of Industry 4.0, first used at the Hannover Fair in 2011 and subsequently presented as one of ten future projects identified by the German government as part of its action plan of the 2020 strategy (BMBF, 2014). More recently, the term became associated with the work of Schwab (2017), the German economist and founder of the World Economic Forum (WEF), in his book "The Fourth Industrial Revolution".

The Fourth Industrial Revolution puts us on the verge of a technological revolution that will fundamentally alter the way we live, work and relate to one another (Schwab, 2017; WEF, 2016). In its scale, scope and complexity, the transformation will be different from what humanity has experienced before. We still do not know how this will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving all stakeholders in global policy, from the public and private sectors to academia and civil society.

The Industry 4.0 concept demands interdisciplinary approaches, closing the cooperation between key areas and different technologies. Most of the pillars of technological advances are currently installed, but isolated, i.e. non-integrated, and it is in Industry 4.0 that these technologies will transform production through interoperability. Isolated, optimized cells bind to form fully integrated, automated and optimized production flows, providing greater efficiency and a shift in traditional relationships between distributors, producers and customers, and between machines and humans. The main nine pillars of technological advancement create a common ground for the Industry 4.0 (Rüßmann et al., 2015): Big Data and analytics; Autonomous Robot; Simulation; Horizontal and Vertical System Integration; The Industrial Internet of Things; Cybersecurity; The cloud; Additive Manufacturing and Augmented Reality.

Big Data and analytics - Allows to optimize production quality, save energy and improve equipment efficiency. In I4.0, the collection and exhaustive evaluation of data from many different sources (equipment and production systems, customer management systems ...) becomes a standard to support real-time decision making. The concept acts as a large database and appears in the industrial world due to the increase in the amount of data to be analysed from different sources, such as equipment and systems.

Autonomous Robot - The concept provides greater utility for automation, making it flexible and collaborative in that it interacts with other robots and works hand in hand with humans, safely, learning from them.

Simulation - In the engineering phase, 3-D simulations of products, materials and production processes are already used, but in the future, simulations will be used more intensively in industrial operations. These simulations will leverage real-time data to mirror the physical world into a virtual model, which may include machines, products, and humans.

Horizontal and Vertical System Integration - Most information technology systems are not fully integrated. Companies, distributors and customers are often not connected as well as different departments of the company, like engineering, production or service. However, with Industry 4.0, companies, departments, functions and capabilities, will be much more cohesive through universal data integration networks, which may enable value chains to be truly integrated and interoperable.

The Industrial Internet of Things - With the industrial internet of things, more devices and equipment will be integrated and connected through technological standards. This will allow the devices to communicate and interact with each other.

Cybersecurity - The general industry still depends on unmanaged or closed production and management systems. However, with increased connectivity and use of standard communication protocols involved in Industry 4.0, the need to protect critical systems and industrial production lines from cyber threats will increase dramatically.

The cloud - Some cloud-based software and analytics applications are already being used, but with Industry 4.0, a greater number of production-related tasks requires more data exchange between sites and enterprises. At the same time, the performance of cloud technologies will improve, reaching reaction times of a few milliseconds. As a result, the data and functionality of the machines will increasingly use of cloud computing, allowing more data-driven production systems services.

Additive Manufacturing - Currently 3D printing is mainly used for prototyping and production of individual components. With Industry 4.0, this technology will be widely used to produce small batches of custom products. We will have decentralized, high performance additive production systems, reducing transport and storage distances.

Augmented Reality - Augmented Reality systems based on supporting a variety of services, such as parts selection in a warehouse and maintenance operations through mobile devices. This technology at the service of production management is still at an early stage, but in the future companies will give augmented reality a greater importance, to provide workers with real-time information in order to improve decision-making.

Industry 4.0 facilitates the vision and implementation of "smart factories" with their modular structures, cyber-physical systems (CPS) that monitor and control physical processes, and the creation of a virtual copy of the physical world that facilitates decentralized decisions. In a perspective, with the internet of things, cyber-physical systems communicate and cooperate with each other and with humans in real-time, and through cloud computing. In this way, it contributes to internal and intra-organizational services being made available and used by participants along the value chain (Hermann, Pentek, & Otto, 2016; Kagermann, Wahlster, & Helbig, 2013). In this context, several changes are expected in the industrial world, in order to give meaning to the concepts of "smart manufacturing" and "smart industry", with production processes based on the integration of physical production with digital technologies, collecting and analyzing data on operations and supply chain, and contributing in real time to improvements in production, procurement and supply chain management (Schwab, 2016). Moreover, with the incorporation of this type of technology, the products have become complex and integrated, thus becoming systems that combine hardware, sensors, data storage, microprocessors, software and connectivity. This so-called Smart Connected Products (SCP) has unleashed a new era in intercompany competition, through functional enhancements, device miniaturization and wireless connectivity. They open up a range of new functionality opportunities, of greater reliability, greater utility and capacity, crossing the barriers of the previous concept of a product, which increasingly merges with the service (Porter & Heppelmann, 2015).

Training and continuous professional development are key factors in achieving the objectives of Industry 4.0, as they will significantly transform the work profiles and competences of workers. Therefore, partnerships between companies / factories and higher education institutions will be even more important in the future. It will be important to open up access to science and engineering studies and place greater emphasis on crosscutting competences' development and assessment. Increasingly powerful digital technologies have evolved very rapidly and are affecting the demand for human labour, invading areas that used to be just people's domain, such as complex communication and advanced pattern recognition (Brynjolfsson & McAfee, 2012). In this way, it is necessary to analyse the emerging challenges that Industry 4.0 sets-up and how these challenges influence the professions, industrial relations and the necessary competences, in planetary conditions that no human being has ever experienced (Schwab, 2016). This project aims to make a contribution to bridging this gap of new competences needed by professional practice and the way the academic world can evolve and help its graduates in the field of Industrial Engineering. Higher education institutions need to provide both in-depth subject knowledge, and an ability to make interdisciplinary connections, creating the opportunity to develop both cognitive and non-cognitive focused competences (WEF, 2017).

2.2 Gap Analysis Background

Gap analysis is based on the comparison between the current state of competences development in industrial engineering (IE) programs, the current perception that IE students have about their own competences and the needs industries are facing to develop themselves towards Industry 4.0. This comparison required a triangular approach to data collection, with three main sources of information:

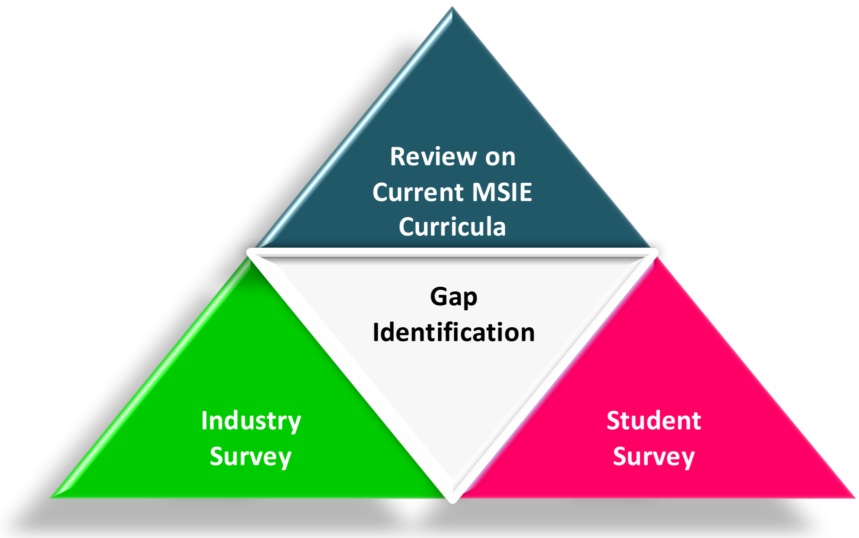


Figure 1. Triangular model of data sources for gap analysis

The main activities of task 1.4 are the following:

- Comparing the needs of industries in Thailand and European partners' countries
- Identifying gaps between the needs of industry and the competence of MSIE graduates

The comparison between the needs of industries in Thailand and European partners' countries is based on industry survey results related to Industry 4.0. The questionnaire sent to 72 companies allowed identifying the needs perceived by companies in regard to the development towards Industry 4.0. Moreover, it allowed to identify some of the main technological and domains of application needs. The combination of these results, allowed to create an image of the needs of companies, with the desired and/or required competences for the development toward Industry 4.0. The questionnaire answered by 450 industrial engineering master students allowed to identify the competences they perceive as needed for the role of

Industrial Engineering professionals in the implementation of Industry 4.0. Additionally, the analysis of existing curricular approaches created a perspective on the current way the Industrial Engineering competences are being developed (curriculum induced) in master programs. Figure 2 illustrates how the gap between the needs of industry and the competence of MSIE graduates was identified.

Figure 2. Model of analysis of the gap between industry and students' needs

This model of analysis draws on the results of tasks 1.2 and 1.3. Task 1.2 started with an analysis of Industrial Engineering programs, which showed that most of the curricular approaches of master programs, at both Thai and European universities, are based on a high diversity of course areas during the first year, followed by the development of a thesis in the second year. Although the diversity of courses is high, it was clear that it is not yet aligned with what could be expected from main knowledge areas related to Industry 4.0. Additionally, the relation between this structure and current recommendations found in literature and professional organizations show that there is a need to develop flexible curricular solutions aligning curricular elements for the development of both technical and transversal competences.

Main results of Task 1.2 - Outcome 1.3, about pedagogical approaches, showed that there is a lack of Active Learning environments and approaches such that the Industry 4.0 competences can be developed in an effective way. Moreover, these Active Learning environments may be developed using multidisciplinary Problem and Project-Based Learning in interaction with industrial accompanies, which will contribute for curricula that are more flexible and aligned with the industry needs.

Main results of Task 1.3 – Outcome 1.4 showed that the core needs identified by industries towards Industry 4.0 are three main technologies, Big Data, Sensors and Mobile devices, which will be used for applications in the domains of production, product development and IT systems. These results were confirmed by the students' survey, which showed that they perceive the need to develop those technologies and domains of application. Additionally, the team of the project, developed a cross analysis of the previous data and created a perspective of the main competences industrial engineers have to use in their managerial roles, to achieve the expected outcomes from the utilization of the above referred main technologies in the core domains of application. This result was created in successive iterations and refinements of a matrix of relation between three main technologies, three main domains of application, outcomes, applications, managerial roles and level of competences. This matrix was presented at the end of the previous report.

In the context of the current report, the project's team of experts developed a perspective on the current existing level of development of the competences that were considered needed for Industrial Engineers to be able to give support to companies attaining Industry 4.0. Thus, a new field of analysis (current level of competence) was added to the previous referred matrix. The current level of the competence was proposed by the team's experts, deeply influenced by the information they gathered for the analysis of curricula from previous tasks. Finally, the comparison between current level of development of competences and the needed competences, allowed to identify a gap in student competences.

Data from industries and students' survey about transversal competences, compared with the analysis of curricula, and with teaching and learning methods, allowed to identify a gap in the development of transversal competences.

The following sections summarize the existing situation and the gaps between the current needs of industry and students, based on the following main dimensions: comparing the needs of industries in Thailand and European partners' countries; identifying gaps between the needs of industry and the competence of MSIE graduates.

3 Comparing the needs of industries in Thailand and European partners' countries

The responses to the questionnaire, presented in the report for Task 1.3, showed that the main technological needs of both selected Thai and European companies are Big Data, Sensors and Mobile devices (Figure 3 – repeated from the previous report). These results show that there is a high consensus between Thai and European companies. Nevertheless, is possible to identify consistently a higher percentage of Thai companies indicating the need of technologies in comparison with selected European companies. The opposite result can be identified just in the case of M2M and Embedded IT.

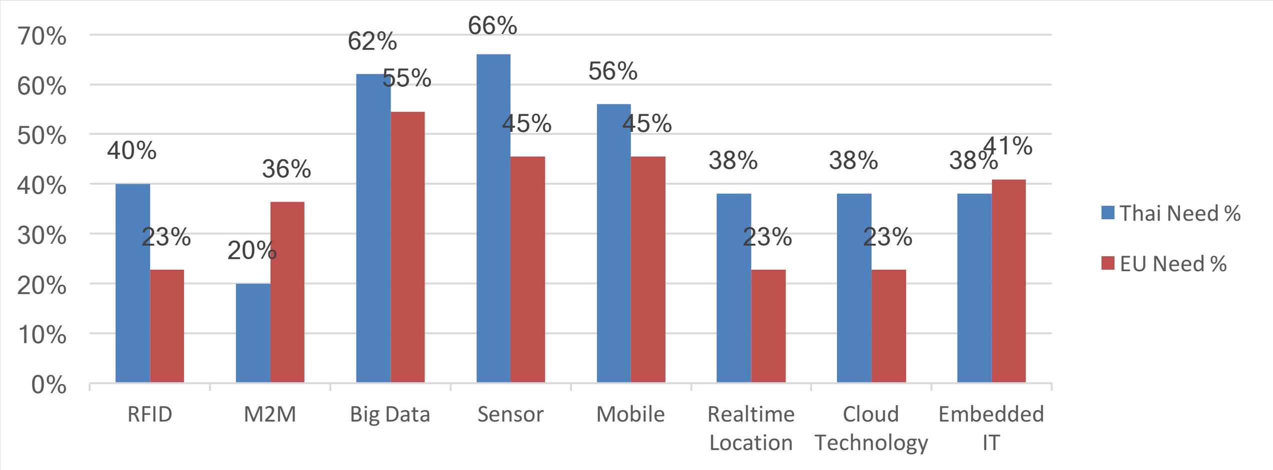
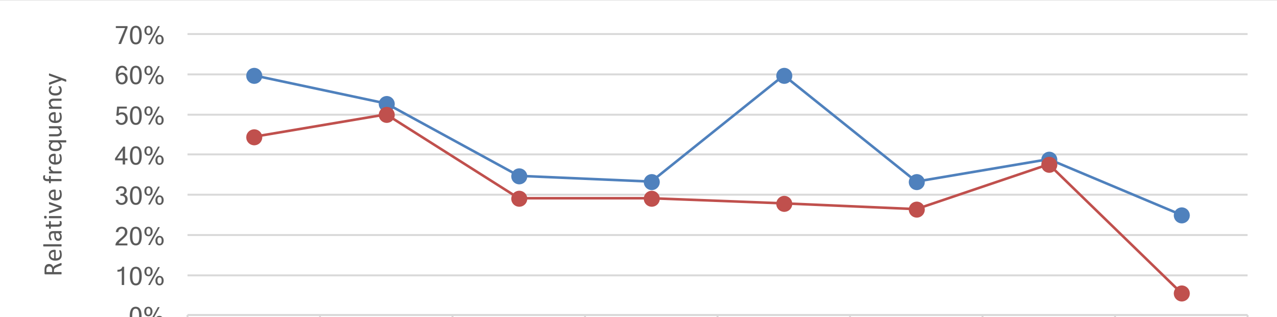


Figure 3. Level of adoption of technology, aggregated by region - level of need.

The analysis of the highest gap between the current level of implementation and the current needs (Figure 4 – repeated from the previous report) shows that the highest gaps can be identified in Big Data, followed by Sensor technologies. This result gives an indication that there may be currently a higher level of need for competences related to these two technologies.



	Sensor	Mobile	RFID	Realtime Location	Big Data	Cloud Technology	Embedded IT	M2M
Need	60%	53%	35%	33%	60%	33%	39%	25%
Usage	44%	50%	29%	29%	28%	26%	38%	6%

Figure 4. Level of adoption of technology – comparison between current level and level of need.

The analysis of the product design, configuration, and creation influenced by customers, i.e. the analysis of the way companies enable a customer to co-design and co-construct their products, services, and integrated products and services shows some differences between Thai and European surveyed companies. Figure 5 (repeated from the previous report) shows that the higher share of companies enabling co-design and co-

construct could be observed in EU based companies. Physical products are the most common ground for such practices, but services and integrated products and services are following this scheme as well.

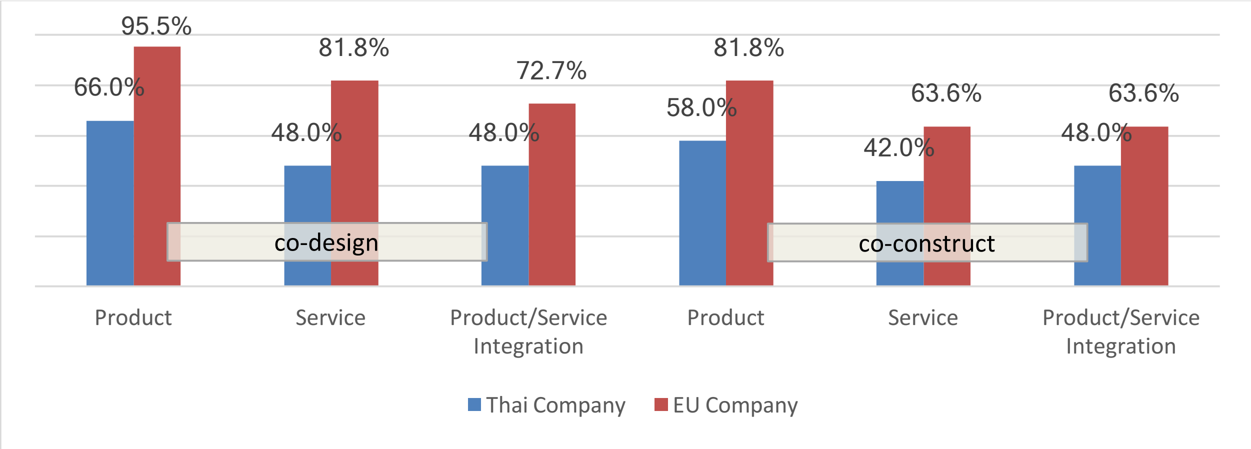


Figure 5. Enabling co-design and co-construct, analysed by Thai and EU companies

Another gap identified between Thai and European surveyed companies is related to the use of computer-aided systems to manage certain areas of its operations. Figure 6 shows a visible gap between the percentage of Thai and European companies using these systems. This difference points out to a higher need of Thai companies to implement these type of management systems: MES – manufacturing execution system, ERP – enterprise resource planning, PLM – product lifecycle management, PDM – product data management, PPS – production planning system, MDC – machine data collection, CAD – computer-aided design and SCM – supply chain management. PPS and SCM are the only two systems in which the European surveyed companies do not have a higher level of utilization.

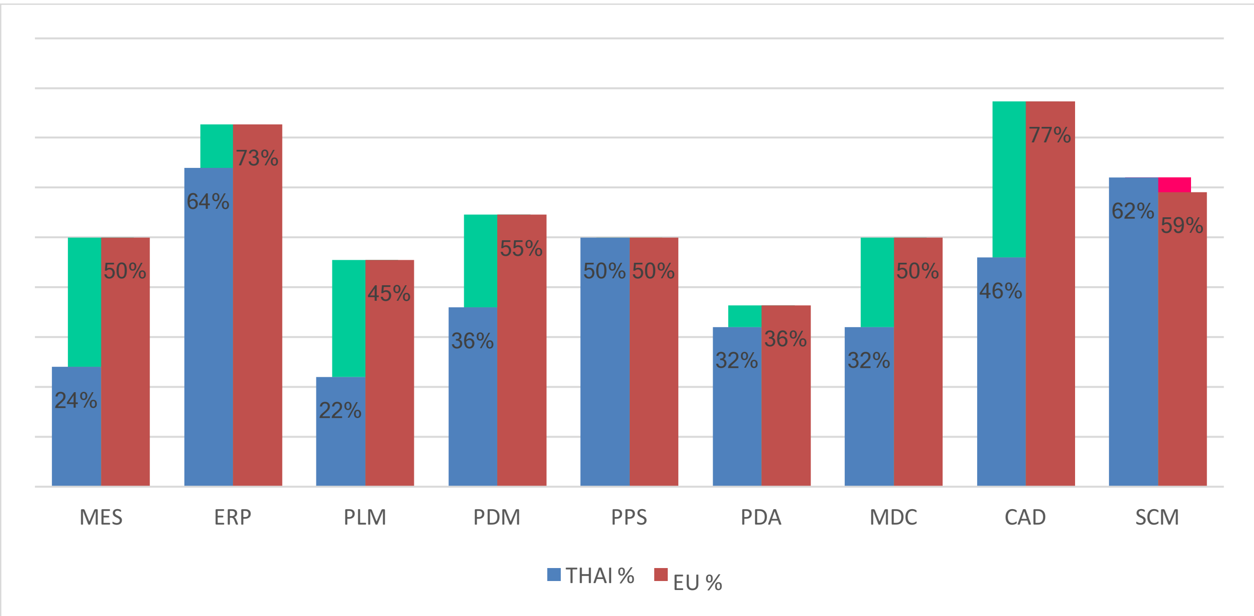


Figure 6. Adoption of computer aided systems gap

The results presented in this section show that, in general, Thai companies have a higher need of development of technologies and systems to support Industry 4.0 than the European surveyed companies do. These results give support to the need of development of an educational program such as the MSIE4.0 that will allow the development of Industrial Engineers to make a contribution for bridging this gap.

4 Identifying gaps between the needs of industry and the competence of MSIE graduates

Next subsections will present the main identified gaps between the needs of industry and the competence of MSIE graduates.

4.1 Technical competences gap

As previously referred, the results of Task 1.3 showed that the main needs identified by industries towards Industry 4.0 are the three technologies, Big Data, Sensors and Mobile devices, which will be used for applications in the domains of production, product development and IT systems. The project team identified the need to create a more specific perspective of the expected role and competences of industrial engineers in relation with these technologies and domains of application. Thus, through an iterative process, the team developed a list of needs for Industry 4.0, categorised by types of outcomes and applications that was presented in section 6 of the previous task report.

Additionally, during the development of Task 1.3, the project team of experts developed an analysis of the relative importance of the Industrial Engineer roles. In this process, the experts expressed their opinion considering the relative importance of Industrial Engineers roles and the expected result for the master program graduates. The result was presented in the previous report. Experts considered the most important technologies, from the highest to the lowest, to be Big Data (weight 3), Sensors (weight 2) and Mobile devices (weight 1). Additionally, experts considered the most important domains of application, from the highest to the lowest, to be production (weight 3), product development (weight 2) and IT-based integrated systems (weight 1). Considering the relative importance, it was also possible to create a ranking of outcomes that is helpful to build a perspective of the expected profile of the master program graduates. Thus, outcomes related to Big Data and Production have a combined weight of 9 (3 x 3). The overall results of the relative importance of types of outcomes of main technologies applied to main domains of application are represented in Table 1.

Table 1. Relative importance of types of outcomes of main technologies applied to main domains of application

Main Technologies	Domains of application	Outcomes	Weight
Big data	Production technology	Better Solution for Various Industry Practical Problems	9
Big data	Product development	Utilization of Data for Better Responsiveness	6
Sensors	Production technology	Real Time Data for operations management	6
Sensors	Product development	Rapid development of (smart) products	4
Big data	IT-based Integrated System	Data Management	3
Mobile Devices	Production technology	Accessibility to Information	3
Sensors	IT-based Integrated System	Tracking Systems	2
Mobile Devices	Product development	Customer Engagement	2
Mobile Devices	IT-based Integrated System	Data transfer	1

The team of experts iteratively developed a list of applications that industrial engineers should be able to develop and deal with, in different levels of competences' complexity within different management roles. This list and cross analysis allowed to embody a vision on the relative importance of the necessary competences. The complete view on this perspective was presented in the previous report.

Moreover, in order to develop a perspective of the potential existing gap, the team developed a common view (average) of the current level of development of competences in each of the previously referred applications (see above). The competences were classified according to Blooms taxonomy and weighted with a value of 1 to 5, ranging from *understanding* to *creating* respectively, as illustrated by Table 2. The low level remembering was not considered in the classification.

Table 2. Blooms taxonomy and weight used for classification of competences

Description	Create	Evaluate	Analyse	Apply	Understand	Not exist
Weight	5	4	3	2	1	0

If an expert identified the current program of its institution as not having the specific expected learning outcome, then a value of zero would be attributed to the weight. The summary of the assessment is available in Table 3.

Table 3. Results of Industry Needs Cross Analysis and Corresponding Competences Gaps

Applications	**Role of MSIE Graduates**	**Target Competence Level**	**AVG. Current Skill Level**	***AVG. Gap Level***
Quality Management	Improvement	5	0.29	4.71
Flexible Production Planning and Scheduling for Demand Changes and Customization	Improvement	5	0.43	4.57
Maintenance Management	Improvement	5	0.43	4.57
Data Distribution	Improvement	5	0.57	4.43
Logistic and supply chain management	Improvement	5	0.57	4.43
Inventory Management	Improvement	5	0.71	4.28
Trend analysis	Improvement	5	0.86	4.14
Forecasting	Improvement	5	1.00	4
Real Time Process Control	Control	4	0.71	3.28
Data Analytics	Improvement	4	0.86	3.14
Remote Monitoring and Control Functions of Product for Service	Monitoring	3	0	3
Condition Based Maintenance	Improvement	3	0.14	2.86
Operational Safety	Monitoring	3	0.17	2.83
Automatic Guided Control System	Monitoring	3	0.29	2.71
Customer Need Analysis	Control	3	0.57	2.43
QFD and FMEA	Control	3	0.57	2.43
Resources Allocation	Control	3	0.57	2.43
Location Tracking in Logistic Management	Monitoring	3	0.71	2.28
Warehouse Operations Management	Monitoring	3	1	2
Interactive Communication	Monitoring	2	0	2
Data Envelopment Analysis	Monitoring	2	0	2
Data Transfer	Monitoring	2	0	2
Smart Product with Sensor Embedded	Control	2	0.14	1.86
Reverse Engineering	Monitoring	2	0.14	1.86
Product Life Cycle Assessment	Control	2	0.29	1.71
Business Process Modeling	Control	2	0.29	1.71
Data Retrieval and Filtering	Observing	2	0.29	1.71
Data Mining	Observing	2	0.29	1.71
Virtual Laboratory and Simulation	Monitoring	2	0.57	1.43
Remote Monitoring	Monitoring	2	0.57	1.43
Co-created Design	Control	2	0.57	1.43
Shop Floor Control	Control	2	0.71	1.28

Figure 7 presents the result of the gap comparison between the expected competence of MSIE 4.0 graduates and current competence, ordered from the most to the least important. As an example, the competences related to the applications that will improve solutions for various industry practical problems, using Big data in the domain of production technology are considered the most important with a combined weight of 9. These are positioned in the left part of the graph. One can identify the highest gaps in this left part, because this are the competences with expected highest levels of complexity (according to bloom's taxonomy). The assessment also indicates that the current curricula cannot build sufficient competences for graduates to support sustainable smart industry.

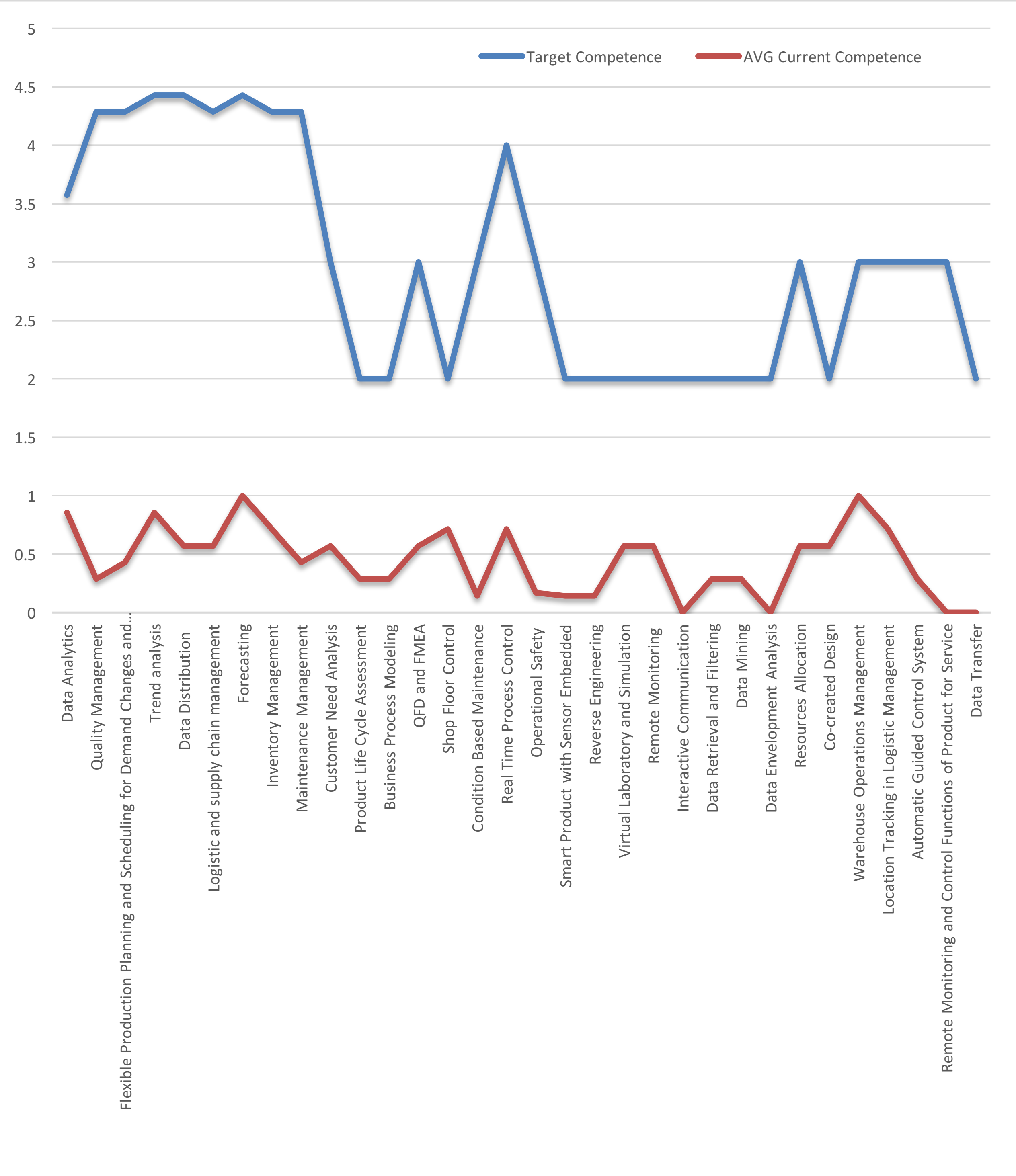


Figure 7. Gap comparison between the expected and current level of competence of MSIE graduates

4.2 Transversal competences gap

One of the most explicit results of the questionnaire applied in the context of task 1.3 is that students say they need to develop transversal competences. Specifically, as referred in the previous report, the analysis of the responses of the students that perceive the importance of development of these types of competences in the near future, or feel they should have developed them in the near past, allowed to identify the high level of importance students assign to transversal competences. These results range from 90.7% to 95.1%. Despite the fact that all results are extremely high, above 90%, it is possible to create the following ranking of the relative importance of the transversal competences:

1) Adaptability and ability to change 95.1%
2) Teamwork 94.0%
3) Communication skills 93.3%
4) Social skills 93.3%
5) Self and time management 92.4%
6) Legal affairs and sustainability 90.7%

In short, it is possible to conclude that more than 90% of the students consider transversal competences as highly important in their development.

Another way of analysing the need for transversal competences came from surveyed companies, as presented in the previous report. Transversal competences presented the highest percentage of companies identifying it needed (*non-existent* plus *existent but inadequate*, 76.4%). Adding to the fact that it is the type of competence selected by the lowest percentage of companies as being adequate (15.3%), give a strong indication that it is a highly important type of competence to be developed by Industrial Engineers.

The analysis of learning outcomes presented in the report "GD-T1.2_O1.2" present a residual percentage of references to learning outcomes (LO) in the formal curriculum. The only LOs related to transversal competences identified in the analysed curricula are: Communication competences (4%), Teamwork competences (1%), Ability to solve problems (1%), Leadership competences (1%), Professional ethic (1%) and Foreign languages (2%).

Thus, adding to the fact that the analysis of learning outcomes presented in the report "GD-T1.2_O1.2", does not present almost references to transversal competences, the main conclusion is that a transversal competences gap must be overcome.

5 Discussion and Recommendations

This project aims developing a master program for Thai graduates being able to make a successful contribution in companies aiming to evolve to Industry 4.0. In order to create a better understanding of the needs of companies, a comparison between Thai and European surveyed companies was developed. In this comparison, a gap was identified in which, in general, Thai companies have to develop their competences regarding co-design and co-construct, as one of the Industry 4.0 dimensions. Another gap identified between Thai and European surveyed companies is related to the use of computer-aided systems to manage certain areas of its operations, showing a visible gap between the percentage of Thai and European companies using these systems. This difference points out to a higher need of Thai companies to implement these type of management systems: MES – manufacturing execution system, ERP – enterprise resource planning, PLM – product lifecycle management, PDM – product data management, PPS – production planning system, MDC – machine data collection, CAD – computer-aided design and SCM – supply chain management.

Finally, the analysis between the needs and current level of implementation of technologies related to Industry 4.0, confirmed that Big Data and Sensor technologies are not only the two most needed technologies according the surveyed companies, but also the two with the highest gaps between levels of current implementation and needs. This analysis allowed to create a perspective on the technical competences needed by Industrial Engineers towards Industry 4.0.

Technical competences are the core competences of an Industrial Engineering (IE) professional activity, and it is what makes a person identifiable as being able to execute activities from that specific profession. Thus, it is normal that during the implementation of courses, a strong emphasis is given to the definition of these type of competences. In the initial phases of development of the MSIE4.0 project the team developed the analysis of several IE master programs for creating a view on the way competences are proposed to be developed. The result of this analysis, compared with current trends and with the existing knowledge on most effective ways of development of competences in Engineering Education, allowed the need to apply Active Learning and Industrial PBL approaches. These approaches contribute to reduce a gap that was globally identified and is being tackled in the last decades, in which a stronger emphasis is being put on the need to develop professionals able to perform with higher efficiency and efficacy right from the beginning of their professional activity.

In order to create a better understanding of the need of competences, in addition to the industry questionnaire, a students' questionnaire was developed and applied. The results of the analysis of this questionnaire were developed in the previous report. These results were combined with the results of industry needs and a view of needs collected from academic experts enrolled in MSIE4.0 project. This combination of results evolved to the identification of a list of main applications related to the Industrial Engineering role in the Industry 4.0 context. Crossing this list with the current state of learning curricula allowed to develop a view on the existing gap in technical competences of IE graduates when related to Industry 4.0. The identification of the highest gap is related to the main needed technologies and domains of application for Industry 4.0, according to the surveyed companies: Big Data and Sensors cross-related with Production and Product development.

The professional role of Engineers need not only technical competences, but also transversal competences, has stressed internationally by Higher Education systems, which lead to the importance of defining the expected transversal competences that graduates should be developing in their degrees. The analysis of curricula showed barely existent references to the development of transversal competences in current master programs. Additionally, both companies and students identified the development of transversal competences as being highly important. Thus, there is a huge gap regarding the explicit intentional development of transversal competences. Considering the identified need for transversal competences toward Industry 4.0, the MSIE4.0 curriculum should give the due importance to the development of transversal competences, which are required by the Industry 4.0 professional activities. The development of competences need the implementation of specific educational strategies to be effective, and this should be considered in the curriculum development.

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