ANALYSIS OF KNOWLEDGE GAP IN STUDY PROGRAMS: A STRATEGY FOR SUCCESSFUL IMPLEMENTATION OF INDUSTRY 4.0

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Abstract: *The adoption and implementation of the Industry 4.0 concept, which essentially refers to the digitization of production and service systems, is heavily dependent on the knowledge and skills of the employees. For this reason, it is important for companies that their staff is trained to operate according to the principles of Industry 4.0. Adapting and improving the current study programs to match the market's evolving needs is one strategy to satisfy the demand for an adequate workforce. This paper will present the findings of the research indicating the expected demand and perceived gap for particular knowledge from the perspective of Industry 4.0 on the Master's academic study programs in the field of Industrial Engineering and Engineering Management from the perspective of professors, students, and former students of these study programs, as well as the points of view of employees in manufacturing and service companies on these issues. More specifically, the trends will be presented as a comparative analysis of the results obtained in the Southeast European (SE) countries compared to those gathered in several European Union (EU) countries. The study's findings indicate that there is a high degree of agreement between two analyzed groups. Furthermore, the research results show evidence about existence of the knowledge gap for specialized expertise relevant to the implementation of the Industry 4.0 concept. These findings show that Industry 4.0 is acknowledged as a concept that requires adaptation of the knowledge and skills of the employees, and that study programs need to be designed and developed with this understanding in mind.*

Key words: *industrial engineering, engineering management, Industry 4.0, study program, knowledge gap, industrial systems*

1. INTRODUCTION

In order to effectively address the problems provided by the adoption of digital technologies and the idea of Industry 4.0 in the business environment, companies require a new strategic approach to human resource management. A growing number of professionals with advanced degrees and specialized knowledge and abilities are required as the processes become increasingly complex (Erol et al., 2016). Having as many skilled workers as feasible is one of the most important requirements for achieving the greatest possible transition to new trends in production and service systems (Benešová & Tupa, 2017). The new market conditions have sparked the academic community's interest and involvement in developing solutions, including improvements to current study programs to create a new generation of employees who, in turn, could easily respond to various market needs caused on by the introduction of Industry 4.0 (Richert et al., 2016).

Given that skills in both engineering and social capabilities are needed for Industry 4.0, this topic is crucial for the discipline of industrial engineering and management, which integrates both (Shet & Pereira, 2021). In this light, it is essential to investigate the competencies that employees will require in the context of Industry 4.0, as well as how these competencies are currently represented in trainings organized by companies and study programs at institutions of higher education that offer programs in industrial engineering and management (Ivanov et al., 2021).

This paper will present the results of research indicating the anticipated demand and perceived knowledge gap for a specific area of expertise from the perspective of Industry 4.0 on master's academic study programs in the field of Industrial Engineering and Engineering Management from the perspectives of professors, students, and former students of these study programs, as well as the points of view of

employees in manufacturing and service companies on these issues. More precisely, the patterns will be shown through a comparison of data from various European Union (EU) countries with those from Southeast European (SE) countries.
The remainder of the paper is structured as follows. The process for acquiring data, the design of the instruments utilized, and a few straightforward sample descriptions are covered in the next section. Additionally, the methods used for the research purposes are briefly explained. The results and discussion section, which makes up the bulk and most crucial portion of the article, follows. The main results, the study's shortcomings, and suggestions for future research directions are all included in the concluding part of the paper.

2. METHODS AND DATA

Data was acquired for this research's purposes using a quantitative survey. More precisely, the questionnaires were created and delivered to stakeholder groups (i.e., companies, professors, alumni, and students). The questionnaires were coded in MS Forms to enable distribution and completion as simple as feasible. This made it possible to automatically gather responses and keep track of them daily to make necessary corrections and accumulate a considerable number of responses. The stakeholders received a questionnaire invitation that included a summary of the research's objectives and a link to the related questionnaire.
Each competency-related question in the questionnaire requested the respondent to evaluate the frequency of adoption (i.e., offer) and the frequency of predicted adoption (i.e., demand) (Anisic et al., 2022). The respondent might choose from one of five options for both the offer and the demand: not offered/required, low, medium, high, and don't know. The gap between offer and demand is then assessed using the responses. Each potential response was given a numerical value, as indicated in Table 1, to facilitate quantitative analysis.

Table 1: Numerical values adopted for each answer in the analysis of questionnaires' results

Answer	Values
"not offered/required"	0
"low"	1
"medium"	2
"high"	3
"don't know"	null

This paper's analysis is entirely supported by statistics. For the purposes of this research, we specifically employed comparative analysis and descriptive statistics. This involves grouping the data that each stakeholder provided as well as comparing the results obtained in the Southeast European (SE) countries compared to those gathered in several European Union (EU) countries. The comparison is performed for each of the stakeholder groups using the competencies that are evaluated as most important considering the demand and the gap between offer and demand.

3. RESULTS AND DISCUSSION

This section will present a comparison of the results of research conducted in EU countries with the results of research conducted in SE countries.
The comparison was performed for each of the categories of respondents (i.e., companies, academies, alumni, and students), trying to find similarities and differences in demand and gap trends for the most influential characteristics. The selected most influential samples were compared in terms of overlap between two groups of samples from different countries.

3.1 Comparison of responses and attitudes from the perspective of companies

Looking at the most important specialties from the group "Knowledge, skills and competencies" from the point of view of companies, we can conclude that there is a high degree of matching with identical three out of five most important specialties. EU companies notice that the lack of knowledge dominates in the

field of Innovation and Communication skills, while SE companies consider that the lack of knowledge is in the field of Teamwork and Investment and Finance (see Table 2).

Table 2: Comparison of companies' responses from EU and SE countries in the group Knowledge, skills and competencies

Companies' perspective EU		Companies' perspective SE	
Knowledge, skills and competencies		Knowledge, skills and competencies	
Demand	Gap	Demand	Gap
Problem Solving and Decision Making	**Problem Solving and Decision Making**	**Team Working**	**Problem Solving and Decision Making**
Team Working	**Entrepreneurial Mindset and Skills**	**Problem Solving and Decision Making**	Team Working
Communication Skills	Innovation and Change Management	Quality Management	**Strategic Management**
Project Management	Communication Skills	Safety of Work	Investment and Finance
Innovation and Change Management	**Strategic Management**	**Communication Skills**	**Entrepreneurial Mindset and Skills**

Looking at the most important specialties from group "Operational tools" we can conclude that there is a certain match considering the demand, but some differences between the demand and offer of courses for certain operational tools. EU companies are dominated by the need to analyze large amounts of data, as well as the need for Machine learning, artificial intelligence and Big data analysis, while this is not the case in SE companies, where Management software tools and Cyber security competencies are the most lacking (see Table 3).

Table 3: Comparison of companies' responses from EU and SE countries in the group Operational tools

Companies' perspective EU		Companies' perspective SE	
Operational tools		Operational tools	
Demand	Gap	Demand	Gap
Management Software Tools	**Computer-based Statistic Competencies**	**Computer-based Statistic Competencies**	Management Software Tools
Computer-based Statistic Competencies	Big Data Analysis	**Management Software Tools**	**Computer-based Statistic Competencies**
Big Data Analysis	Machine Learning/AI Competencies	Cyber Security Competencies	Cyber Security Competencies

Regarding the methodology of knowledge transfer, there are no significant shortcomings, with a minor gap in the EU countries for the Web-based synchronous transfer method, while in the companies from SE countries there is a slight need for Web-based asynchronous transfer method.

3.2 Comparison of responses and attitudes from the perspective of academics

The next category of respondents is academics, who have interesting overlapping between EU and SE countries. Comparing the answers from belonging to the group "Knowledge, skills and competencies", we can notice a high degree of agreement from the point of view of demand with four identical skills, while this match considering the gap is slightly less with only two identical skills. The highest gap between offer and demand in EU companies goes in the direction of Communications, Leadership and Entrepreneurial thinking, while in the case of academics from the selected SE countries the difference is oriented towards Safety of work, Industrial Marketing and Operations Management. Generally, it can be concluded that the answers differ in nuances and that there are no essential differences (see Table 4).

Table 4: Comparison of academics' responses from EU and SE countries in the group Knowledge, skills and competencies

Academics' perspective EU		Academics' perspective SE	
Knowledge, skills and competencies		Knowledge, skills and competencies	
Demand	Gap	Demand	Gap
Project Management	Communication Skills	**Project Management**	**Problem Solving and Decision Making**
Operations Management	Leadership Issues	Quality Management	**Team Working**
Team Working	Entrepreneurial Mindset and Skills	**Operations Management**	Safety of Work
Problem Solving and Decision Making	**Team Working**	**Logistics**	Industrial Marketing
Logistics	**Problem Solving and Decision Making**	**Problem Solving and Decision Making**	Operations Management

Analyzing the differences in answers related to the use of "Operational tools" it should be noted that the differences are high, both for demand and gap. The impression is that in the EU countries more operational tools are needed to process large amount of data that already exist in companies, while in the SE countries the focus is on the field of sensor installation and connection of machines and equipment to start collecting data (see Table 5).

Table 5: Comparison of companies' responses from EU and SE countries in the group Operational tools

Academics' perspective EU		Academics' perspective SE	
Operational tools		Operational tools	
Demand	Gap	Demand	Gap
Big Data Analysis	Big Data Analysis	Machine Learning/AI Competencies	**Cyber Security Competencies**
Computer-based Statistic Competencies	**Cyber Security Competencies**	IoT Monitoring Competencies	Sensor-based Monitoring Competencies
Management Software Tools	Machine Learning/AI Competencies	Sensor-based Monitoring Competencies	Augmented/VR Competencies

In the last group of comparisons regarding "Knowledge Transfer Methodology", the technics used are almost identical, which leads us to the conclusion that academics from the EU and the SE countries use the same methods to transfer knowledge (see Table 6).

Table 6: Comparison of companies' responses from EU and SE countries in the group Knowledge Transfer Methodology

Academics' perspective EU		Academics' perspective SE	
Knowledge Transfer Methodology		Knowledge Transfer Methodology	
Demand	Gap	Demand	Gap
Seminars	**Field Trips**	Field Trips	**Field Trips**
Workshops	**Workshops**	**Traditional F2F Lectures**	**Workshops**
Traditional F2F Lectures	**Asynchronous web-based learning**	**Workshops**	**Asynchronous web-based learning**

3.3 Comparison of responses and attitudes from the perspective of alumni

Considering alumni' perspective related to "Knowledge, skills and competencies", the similarity of answers between the two observed groups is obvious (see Table 7).

Table 7: Comparison of alumni's responses from EU and SE countries in the group Knowledge, skills and competencies

Alumni's perspective EU		*Alumni's* perspective SE	
Knowledge, skills and competencies		Knowledge, skills and competencies	
Demand	Gap	Demand	Gap
Problem Solving and Decision Making	**Leadership Issues**	**Problem Solving and Decision Making**	**Problem Solving and Decision Making**
Team Working	**Communication Skills**	**Communication Skills**	**Entrepreneurial Mindset and Skills**
Communication Skills	**Entrepreneurial Mindset and Skills**	**Team Working**	**Leadership Issues**
Project Management	**Problem Solving and Decision Making**	Entrepreneurial Mindset and Skills	**Communication Skills**
Leadership Issues	Project Management	**Project Management**	Team Working

Analyzing the differences in answers related to the use of "Operational tools" it should be noted that Alumni from EU countries highlight the importance of Management Software Tools and Computer-based Statistic Competencies, while in the SE countries the focus is on the field of Augmented/VR, 3D Printing, and Cybersecurity competencies. Big Data and Machine Learning/AI Competencies are important for both observed groups (see Table 8).

Table 8: Comparison of alumni's responses from EU and SE countries in the group Operational tools

Alumni's perspective EU		Alumni's perspective SE	
Operational tools		Operational tools	
Demand	Gap	Demand	Gap
Big Data Analysis	**Big Data Analysis**	Augmented/VR Competencies	**Big Data Analysis**
Management Software Tools	**Machine Learning/AI Competencies**	3D Printing Competencies	Cyber Security Competencies
Computer-based Statistic Competencies	Management Software Tools	**Big Data Analysis**	**Machine Learning/AI Competencies**

As far as knowledge transfer methodologies are concerned, the impression is that there are requirements for Field trips in all categories, but that there is a lack of appropriate offer for them. There is also a gap between offer and demand for Synchronous web-based learning that is noticed from both observed groups (see Table 9).

Table 9: Comparison of alumni's responses from EU and SE countries in the group Knowledge Transfer Methodology

Alumni's perspective EU		Alumni's perspective SE	
Knowledge Transfer Methodology		Knowledge Transfer Methodology	
Demand	Gap	Demand	Gap
Workshops	**Field Trips**	Asynchronous web-based learning	**Field Trips**
Seminars	Asynchronous web-based learning	**Field Trips**	Workshops
Field Trips	**Synchronous web-based learning**	Traditional F2F Lectures	**Synchronous web-based learning**

3.4 Comparison of responses and attitudes from the perspective of students

In the last category of students, we also have a similar picture of mutual comparisons, as in the case of the previous three groups. In the group "Knowledge, skills and competencies" there is a high level of matching between the two groups of respondents. It is not easy to establish a clear pattern-

consequential relationship, and it can be considered that the answers mostly match without pronounced differences (see Table 10).

Table 10: Comparison of students' responses from EU and SE countries in the group Knowledge, skills and competencies

Students' **perspective EU**		***Students'*** **perspective SE**	
Knowledge, skills and competencies		Knowledge, skills and competencies	
Demand	Gap	Demand	Gap
Problem Solving and Decision Making	Leadership Issues	**Team Working**	Safety of Work
Team Working	**Communication Skills**	**Communication Skills**	**Problem Solving and Decision Making**
Project Management	**Entrepreneurial Mindset and Skills**	**Problem Solving and Decision Making**	**Communication Skills**
Communication Skills	**Problem Solving and Decision Making**	Quality Management	Innovation and Change Management
Operations Management	Strategic Management	Logistics	**Entrepreneurial Mindset and Skills**

In the observed group "Operational tools" there are obvious differences in the given answers, which complies with previous categories of respondents. In the case of demand, there are two matches, while in the case of the gap, the answers are completely different. In this case, similar to the previous respondent categories, the demand for analysis and processing of large amounts of data dominates for a group of EU respondents, while among respondents from the SE countries, the demand for AR/VR competencies, artificial intelligence and cyber security are the most important (see Table 11).

Table 11: Comparison of students' responses from EU and SE countries in the group Operational tools

Students' perspective EU		**Students' perspective SE**	
Operational tools		Operational tools	
Demand	Gap	Demand	Gap
Big Data Analysis	Big Data Analysis	**Management Software Tools**	Augmented/VR Competencies
Computer-based Statistic Competencies	Management Software Tools	**Big Data Analysis**	Cyber Security Competencies
Management Software Tools	Computer-based Statistic Competencies	Augmented/VR Competencies	Machine Learning/AI Competencies

When it comes to knowledge transfer methodologies, we have an almost complete match comparing observed groups. In this group of respondents, there is a pronounced need for a field trip method of knowledge transfer (see Table 12).

Table 12: Comparison of students' responses from EU and SE countries in the group Knowledge Transfer Methodology

Students' perspective EU		**Students' perspective SEC**	
Knowledge Transfer Methodology		Knowledge Transfer Methodology	
Demand	Gap	Demand	Gap
Workshops	**Workshops**	**Workshops**	**Field Trips**
Field Trips	**Field Trips**	**Seminars**	**Workshops**
Seminars	**Asynchronous web-based learning**	Traditional F2F Lectures	**Asynchronous web-based learning**

3.5 Comparison summary

The differences in the answers between the respondents from the EU and the Balkan countries can be summarized as follows:

- In the category of “Knowledge, skills and competencies” we have a high degree of agreement in the answers with minimal differences
- A group of respondents from the SE countries has a need for Safety of Work, which has never been the case with EU respondents
- In the category “Operation tools” there were the most differences in the given answers. Among the respondents from the EU, the following dominated: Big Data Analysis and Computer-Based Statistic Competencies, while respondents from the SE countries had requests in the area Augmented/VR Competencies, Cyber Security Competences, and Machine Learning/AI Competences
- In the category of “Knowledge Transfer Methodology” there were no significant differences. Characteristically, there is a need for both groups of respondents for Field Trips.

4. CONCLUSIONS

The research presented in this paper shows the findings that indicate the expected demand and perceived gap for particular knowledge from the perspective of Industry 4.0 on the Master's academic study programs in the field of Industrial Engineering and Engineering Management from the perspective of companies, professors, alumni, and students on these issues. More specifically, the trends are presented as a comparative analysis of the results obtained in SE countries compared to those gathered in several EU countries.

The results indicate that the two groups that were analyzed have a lot of similarities with each other. Furthermore, the necessity for improvements of study programs is recognized in both regions in which the research is conducted. This is especially important for SE countries that should follow the path of more advanced partners from EU counties. The fact that the answers from both groups of respondents are similar is a good starting point for further improvements.

This study is limited to the use of simple statistical tools such as descriptive statistics with the main idea to check the status in different countries considering their development level. Further research could include some advanced statistical tools to perform in depth analysis of the data to get more detailed information on the samples, as well as their relationships. Furthermore, the findings presented in this paper could serve as a basis for the development of new and improved study programs in the field of Industrial Engineering and Engineering Management that can match the market's evolving needs for knowledge of their employees.

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