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Summary of the Report "Mapping and scientific literature review on the mechatronics skills for Industry 4.0"

Big steps have been taken by project partners towards the creation of Mechatronics 4.0 curriculum requested by the Industry 4.0 in the field of mechatronic in the three participating countries.

The objectives of IO1 are:

Mapping the latest common and specific mechatronics skills needed for industry 4.0 in the countries represented in the partnership in the first part of the implementation period [COM19]. In the first part of this review, it will be done of a general image of Industry 4.0 (definition, evolution, components, state of the art, and advantages industry 4.0). Also, this chapter will also include an approach to Industry 4.0 in the partner countries of this project (RO, SRB, SK). Another subchapter will cover the limitations of the bibliographic research in which the methodology for carrying out this review will be explained as well as a quantitative and qualitative analysis of the information on this field. An important aspect of this review is the identification of the defining competencies of mechatronics in the context of industry 4.0 prior training. The skills in mechatronics are formed by a modern approach to the education process, characterized by the accumulation of competences.

To study the state of the art in industry 4.0, a search was made of the articles that have the most citations on the Web of Science platform:

Table 1: Top ten articles regarding industry 4.0

№	Title	Author(s)	Year	Cit.	DOI
1	Towards smart factory for industry 4.0: a self-organized multi-agent system with big data-based feedback and coordination	Wang, SY. et al.	2016	270	10.1016/j.comnet.2015.12.017

2	Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal	Liao, YX. et al.	2017	186	10.1080/00207543.2017.1308576
3	Software-Defined Industrial Internet of Things in the Context of Industry 4.0	Wan, JF. et al.	2016	182	10.1109/JSEN.2016.2565621
4	Industry 4.0 and the current status as well as future prospects on logistics	Hofmann, E. et al.	2017	177	10.1016/j.compind.2017.04.002
5	Cloud Computing Resource Scheduling and a Survey of Its Evolutionary Approaches	Zhan, ZH. et al.	2015	164	10.1145/2788397
6	Industry 4.0: state of the art and future trends	Xu, LD. et al.	2018	146	10.1080/00207543.2018.1444806
7	A dynamic model and an algorithm for short-term supply chain scheduling in the smart factory industry 4.0	Ivanov, D. et al.	2016	124	10.1080/00207543.2014.999958
8	Blockchain technology in the chemical industry: Machine-to-machine electricity market	Sikorski, JJ. et al.	2017	111	10.1016/j.apenergy.2017.03.039
9	Fog of Everything: Energy-Efficient Networked Computing Architectures, Research Challenges, and a Case Study	Baccarelli, E., et al.	2017	93	10.1109/ACCESS.2017.2702013
10	A Manufacturing Big Data Solution for Active Preventive Maintenance	Wan, JF. et al.	2017	76	10.1109/TII.2017.2670505

Industry 4.0 offers high productivity, which allows the company to produce more and faster with lower material resources. It also allows the elimination of dead times, as well as reducing the downtime of the machines for monitoring and optimizing the machines or the production process [KEI18].

Figure 1 Advantages of Industry 4.0

According to the ranking, Romania has the lowest level of performance in terms of Industry 4.0 in the European Union countries and Turkey. However, Romania invested a lot in automation in the last years and exports of higher added value products have been constantly increasing. In contrast, Slovakia ranked 22nd and Serbia ranked 27th in this top, ranking better than Romania in terms of Industry 4.0. Slovakia, characterized by some as a traditionalist, together with Lithuania, Hungary, Slovenia and the Czech Republic, are among the countries that have understood the trend and are moving towards Industry 4.0, proposing solutions to reach the new industrial stage.

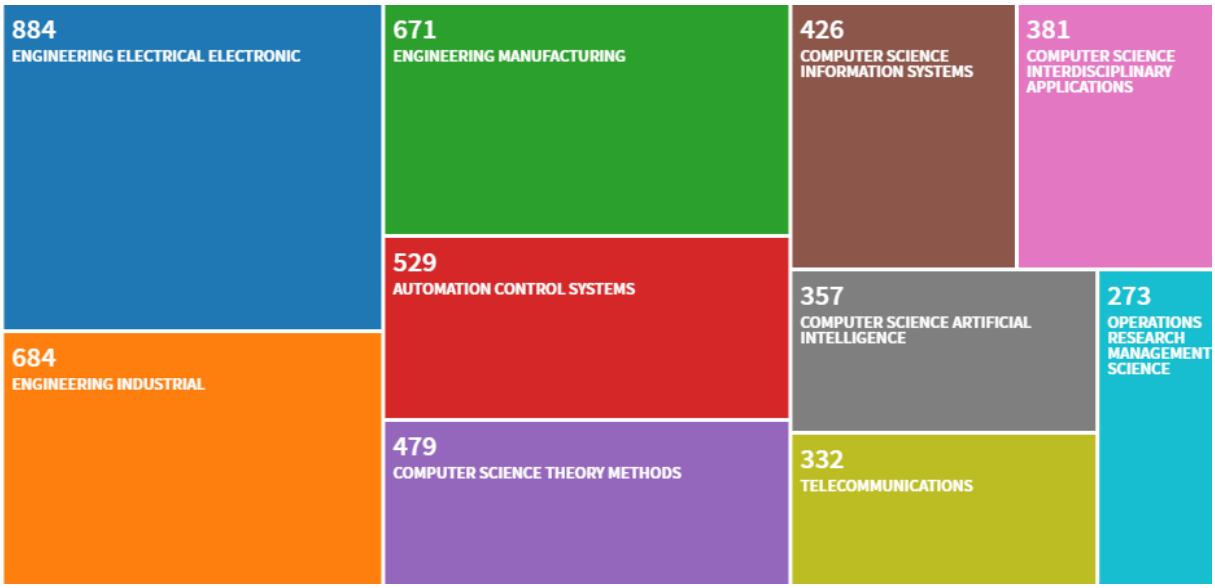

Figure 2 Number of industry-related publications 4.0 per domain, made using the Web of Science database [WWW01]

The change in approach of production and including services is increasingly based on the software component through IoT, sensors, industrial robots and intelligent equipment with numerical control. All these technologies and intelligent equipment produce a large amount of data that must be processed, reaching a very high level of information [CHE18]. The utility of software in industry 4.0 is a very important component, which is why many published articles are in the field of electronic engineering and computer science (fig. 2). Also, many articles have been published in the field of industrial and production engineering, which have a direct impact on industry 4.0.

Mechatronics as a field covers a wide range of skills required for industry 4.0. Of course, improvements and additions to the skills required are needed. In order to identify the skills needed for Industry 4.0 in the partner countries of the MIND project, we have developed a form on the Google Forms platform that we have distributed to companies in the three partner countries (Serbia, Slovakia, Romania).

This form was attended by 55 companies of large, small and medium size; the majority of these companies being producers, and a small part are in the field of development research and distributors.

From the chart below we can say that mechatronics skills are significant and extremely important for the development of their companies (figure 3). Some companies say that mechatronics skills are not too important or not important, because these companies do not work directly with the production or mechatronics field.

These companies are in the field's related services such as consulting, palletizing, industrial construction, finance services, etc.

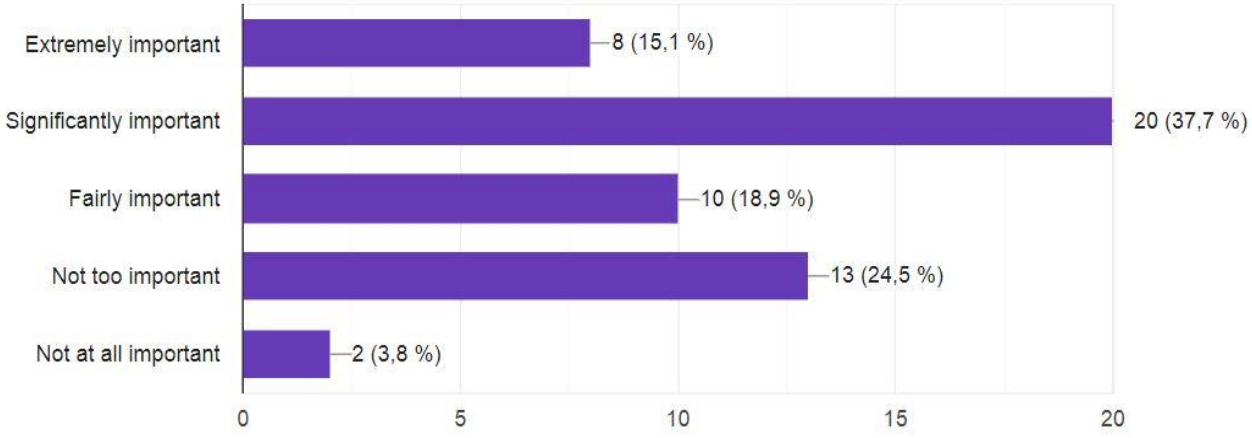

Figure 3 Importance of mechatronics skills.

The question addressed to companies regarding how well trained their employees are in the field of mechatronics, most answered that they are trained in the 1-50% range.

There is also a small part of companies that claim that their employees have a very high degree of mechatronics training (figure 4).

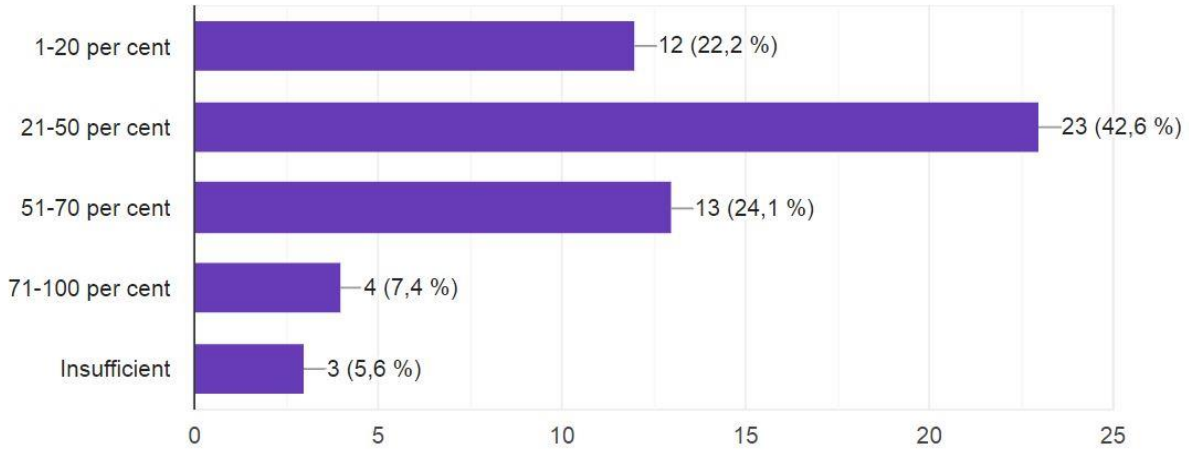

Figure 4 Training of employees in the field of mechatronics.

The most needed specializations required by the current industrial needs are those in manufacturing technology, mechatronics, mechanical engineering and automation, which are needed to be updated according to Industry 4.0 request. Industry 4.0 relies on concepts that are either new or not yet fully developed: cloud computing, fog computing, blockchain, etc. Some of them have spectacularly evolved in the very recent years, but even then, Industry 4.0 its still in its infancy. Technical challenges aside, the transition to this new level will prove to be a test to the current status-quo: sharing vast amounts of information forces the industry actors to change their interaction methods, artificial intelligence decision making will render middle-management job positions obsolete, an eventual leap to a fully automated industrial park will force to rethink social norms and conventions, etc. Since 2011 since the advent of Industry 4.0, this concept has been developed year by year. This is noted by the large number of scientific articles that have been published in this field. It is certain that this field is one of interest due to the advantages it brings over the entire manufacturing process. Some of these advantages were also included in this report. This questionnaire was addressed to the companies from the three partner countries of the MIND project.

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