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# THE COMPETENCES REQUIRED BY THE NEW TECHNOLOGIES IN INDUSTRY 4.0 AND THE DEVELOPMENT OF EMPLOYEES' SKILLS

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***Abstract:*** *The concept of Industry 4.0 is highlighting that high-speed mobile internet, artificial intelligence, big data analytics and cloud technology are very likely to develop in all sectors of industry technologies between 2020 and 2022. The companies are already looking into machine learning, augmented reality, and additive manufacturing for considerable business investments. All this will increase the need of highly qualified trainees and therefore, the universities will need to align with the needs of industry. The paper will present an overview of Additive Manufacturing training, the needs of highly skilled competences according to Industry 4.0 and will also underline the role of ergonomics specialists in Industry 4.0.*
***Key words:*** *Industry 4.0, Additive Manufacturing, Ergonomics, Training, Skills, Qualifications.*

## 1. INTRODUCTION

Europe strategy is to deliver smart, sustainable, and inclusive growth, to find ways to create new jobs and a sense of direction to our societies. The dynamic of the qualification is very high and for that the approach is different between Industry needs and University. Qualification is also very high in the technical field [1] and with a well-thought-out new courses focused on the needs of the Industry, the gap between Industry and University Qualifications can be filled with different courses in the field of Additive Manufacturing, Robotics, Ergonomics etc. The strong collaboration and partnership between the University and Industry generates new opportunities for implementing laboratory tested technology on the market.

Today is even more important to understand the key role of university in supporting Industry 4.0. In addition to that, the role of government is important as well, to support the industrial environment to acquired and implement the new technologies, associated to Industry 4.0.

With the new technologies the Small Medium Enterprises (SMEs) are already facing the Industry 4.0, where the new level of automatization and process digitalization provide data in real time. Cloud computing is using the data to generate process improvements and the complex network system communication changes the actual conventional supply chain concept, all these are generating a change in manufacturing and operation executed by human operators. The challenge is to support all industry sectors to adopt the new technology, to be able to make the transition to a higher connectivity and decentralized processes, commonly known as “Industry 4.0” [2]. In Figure 1 can be observed the constraints and the enablers from SME in Industry 4.0.

The fourth technological revolution will bring new approaches over the complete production chain, will generate new synergies between humans and machine and require new competencies to be developed. The new qualifications and new courses related Industry 4.0 need flexible and freely accessible e-learning materials and a complete toolbox of training products covering: Production, Machine Learning, 3D Printing, Big Data, Robotics, and Programmable Logic Controllers. Cloud Computing, Internet of Things, Smart

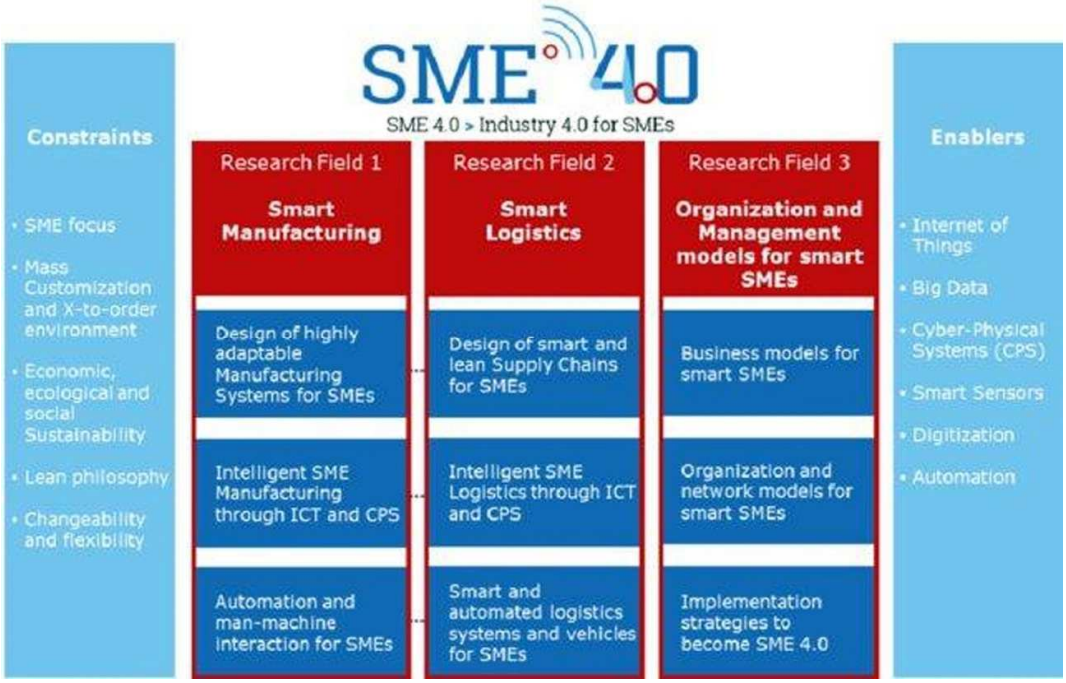


**Fig. 1.** Research fields and topics in the project SME 4.0 [2]

## 2. IMPACT OF THE INDUSTRY 4.0 IN THE FUTURE OF WORK AND THE NEED OF UPSKILLING

The 4th Industrial Revolution is mainly driven by few advanced technologies: Internet of Things (IoT), Big Data (BD), Cloud Computing (CC), Artificial Intelligence (AI). All together, these technologies generate a different set of skills and competencies, required for future jobs. Out of all these new technologies, the AI is expected to create the most significant impact on employment rate, especially on high developed countries.

"UK, German and US by 2022, 50% of companies believe that automation will decrease their number of full-time staff and by 2030; robots will replace 800 million workers across the world" [3].

Qualified staff will need to have relevant skills in the Figure 2 can observed the top 10 skills relevant to Industry 4.0 that should be fulfilled in the future. It can be observed that skills like Emotional Intelligence or Cognitive Flexibility will be appreciated in the future jobs.

The new way of manufacturing, based on the new technology, discard some working positions while at the same time generates help in creating new ones. Given that, the industry needs to be prepared to adopt the new technology, but at the same time to develop the human workforce to accept the movement from conventional way to a high-level automatization manufacturing. Therefore, the key for success of any company is the strategy to buy-in agile workforce, capable to continuously increase the competencies [4].

Regarding the new technologies, trends in business models and the changing division of labor between workers and machines transforming current job profiles, many employers think that, by 2022, the skills required to perform most jobs will change significantly. While these new highly skill demands are likely to develop differently globally across different industries and regions. The employers expect average skills stability - the proportion of core skills required to perform a job that will remain the same - to be about 58%, meaning an average shift of 42% in required workforce skills over the 2018–2022 period, also in table 1 it can be observed the summary of the new skills demand on 2018 and 2022 [5].


**Fig. 2.** The top 10 skills relevant to Industry 4.0 (according "Word Economic Forum") between 2015 – 2020

Given the wave of new technologies and trends disrupting business models and the changing division of labor between workers and machines transforming current job profiles, the vast majority of employers surveyed for this report expect that, by 2022, the skills required to perform most jobs will have shifted significantly. While these skill shifts are likely to play out differently across different industries and regions, globally, our respondents expect average skills stability - the proportion of core skills required to perform a job that will remain the same - to be about 58%, meaning an average shift of 42% in required workforce skills over the 2018–2022 period, also in table 1 it can be observed the summary of the new skills demand on 2018 and 2022.

*Table 1*

**Comparing skills demand, 2018 vs. 2022**

| Period | Skills demand |
|---|---|
| Today, 2018 | • Analytical thinking and innovation<br>• Complex problem-solving<br>• Critical thinking and analysis<br>• Active learning and learning strategies<br>• Creativity, originality and initiative<br>• Attention to detail, trustworthiness<br>• Emotional intelligence<br>• Reasoning, problem-solving and ideation<br>• Leadership and social influence<br>• Coordination and time management |
| Trending, 2022 | • Analytical thinking and innovation<br>• Active learning and learning strategies<br>• Creativity, originality and initiative<br>• Technology design and programming<br>• Critical thinking and analysis<br>• Complex problem-solving<br>• Leadership and social influence<br>• Emotional intelligence<br>• Systems analysis and evaluation |
| Declining 2022 | • Manual dexterity, endurance and precision<br>• Memory, verbal, auditory and spatial abilities<br>• Management of financial, material resources<br>• Technology installation and maintenance<br>• Management of personnel<br>• Quality control and safety awareness<br>• Coordination and time management<br>• Visual, auditory and speech abilities |

## 3. NEW QUALIFICATION RELATED INDUSTRY 4.0

"*... people's qualifications are one of the critical aspects that need renewal ...*" (EWF). As we know the field of Additive Manufacturing is one of the pillars of Industry 4.0 and in the last period the first International Qualification System for Additive Manufacturing personnel was built by the European Federation for Welding, Joining and Cutting, widely known as European Welding Federation – EWF.

| | |
|---|---|
| | • Technology use, monitoring and control |

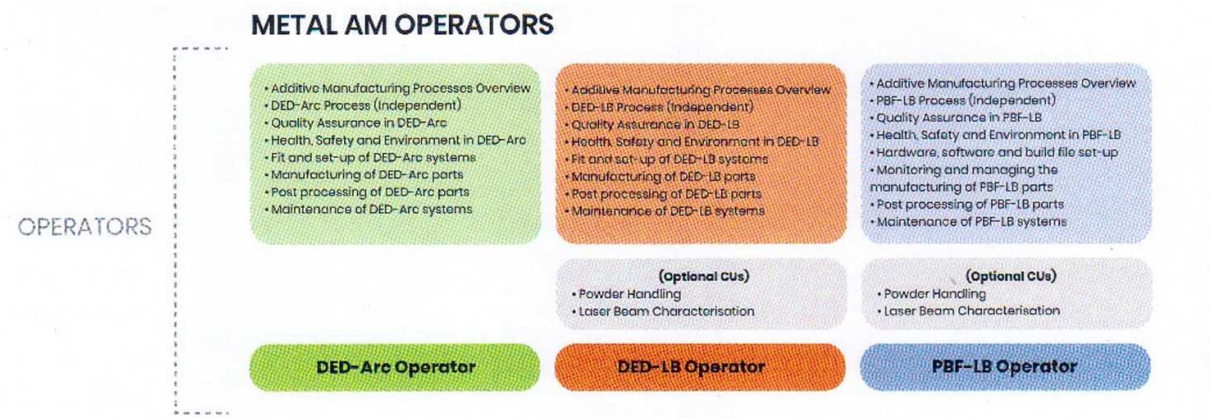


**Fig. 3.** EWF AM Qualification System for Operators [6].

EWF currently offers six Qualifications in Metal AM: three at the Operator level and three at Engineering level, as it can be seen in Figure 3 and Figure 4.

The first countries offering these qualifications are Italy, Germany, France, UK, Portugal, and Spain, and the first course for Laser Powder Bed Fusion (LPBF) operator took place in Italy in May 2019. The 2019 EWF AM Qualification System includes 4 processes related to Professional Profiles in either Operator or Engineer levels.

Besides the EWF (European Federation for Welding, Joining and Cutting) is the Additive Manufacturing Association, this association is an international industrial platform for 3D printing. The platform is open to all participants in the value supply chain.

The importance of manufacturing cannot be overstated as a key pillar of European relevance on global markets. Manufactured goods represent 83% of EU exports, presenting a trade surplus of 233 billion euro in 2017 [7] and contributing immensely to the overall trade balance of the European Union (23 billion euro in the same period), compensating for the great imports of necessary primary goods such as energy [5], [8].

In Romania, the field of Additive Manufacturing (AM) is at the beginning encouragement of both, Industry and University, to collaborate on this topic could create new opportunities and win-win situation.

Additive Manufacturing (AM) is a comprehensive name for all the technologies that build 3D objects by adding layer-upon-layer, regardless of the type of material. It includes many technologies subsets like 3D Printing, Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), layered manufacturing and additive fabrication. AM application is limitless, but its development has been brewing for a few decades before becoming critical for all industries. For this reason, in the future will be needed to update the curricula of the MSc course or the curricula of the short trainings in field of AM to the needs of the Industry [9], [10].

In correlation with the new trend and the Additive Manufacturing field the new qualifications need to be aligned with the Z Generation. The Z Generation is a very digital generation, a generation familiar with the news in the field of Additive Manufacturing (3D printing, rapid prototyping etc.).

The attention of Z Generation is estimated between 8 and 10 seconds, this being the reason they think that technology should provide everything rapidly in all the fields (courses, industry, economics, etc.). The Z Generation has no time and patience for slow movements and things such as unavailable internet, no phone signals, no friendly devices.

The Z Generation follows the Millennial Generation as well the Alpha Generation. Members of Generation Z are accustomed to use digital technology from a young age and are comfortable with the Internet and social media.

Almost all the members of Generation Z are the members of Generation X.

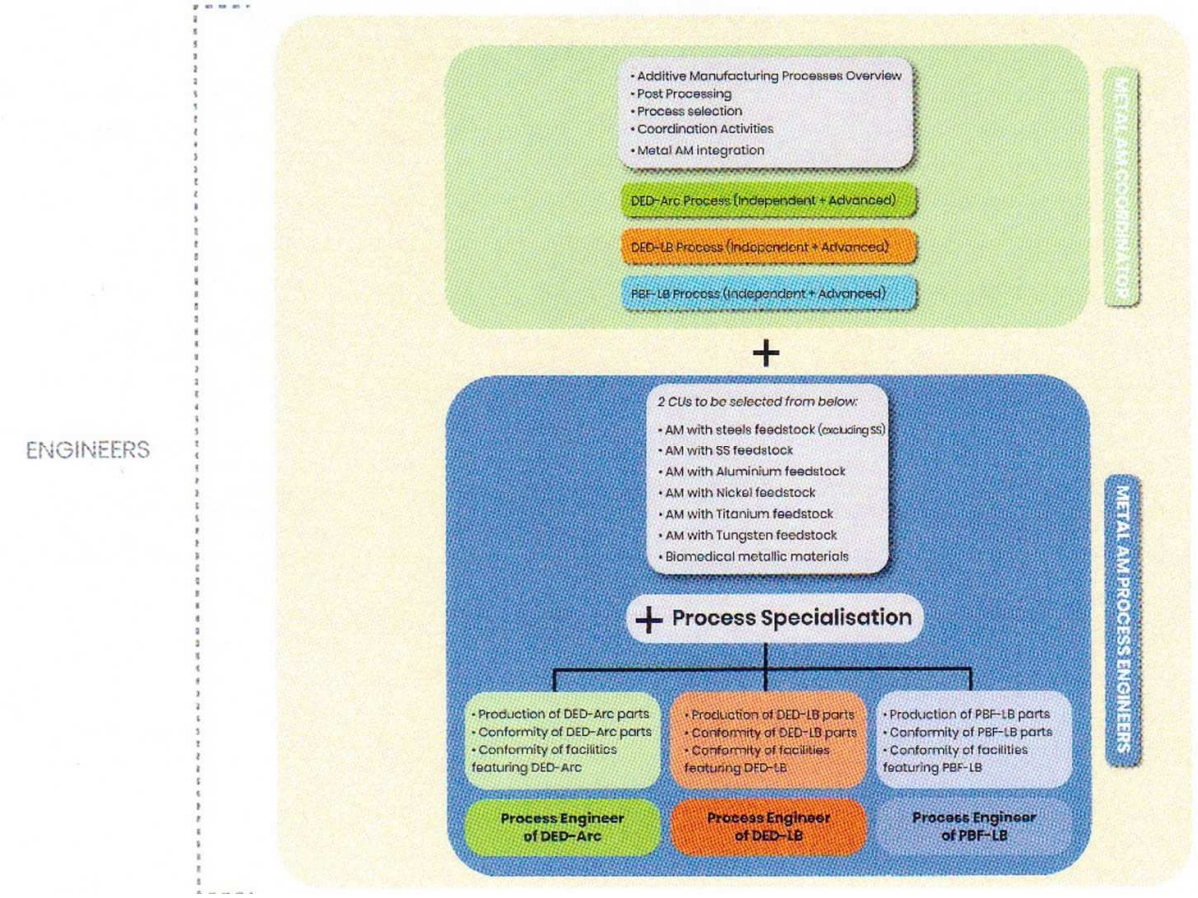


**Fig. 4**. EWF AM Qualification System for Engineers [6]

Skills of Z Generation are:

- Is faster, more curious, more able to negotiate;
- Gets used to technology from an early age;
- Has more civic sense;
- Learn to trust their abilities;
- Thinks he does not have to learn much;
- Look for mistakes, will try again;
- Quickly gets bored of a project; is superficial;
- Accepts challenges if they look cool;
- Has a high appetite for world change.

The new trainings/courses in the field of pillars of Industry 4.0 will need to be aligned with the Z generation thinking and skills.

Regarding the ergonomics concept the new qualifications related Industry 4.0 will need to follow the next recommendations:

- Reduce injuries and disorders;
- Ensure worker Safety;
- Ensure worker Health;
- Reduce Absenteeism;
- Ensure worker Productivity.

In the mindset of Industry 4.0, the role of ergonomics specialists become more and more important to optimize work performance and worker health and safety. The ergonomics concepts study and try to explain the interaction between humans and other elements of a system and this concept applies theory, principles, data, and methods to optimize design to obtain a high-performance system [11].

The ergonomics specialist became more and more important due to the increased number of technical evolutions and the increased number of interactions between humans and machine in special in automotive field. Work environment is studied by the ergonomics specialists and thought their work the ergonomics specialists observe the human movement and actions during their tasks. Through their competences the ergonomics specialists analyses the impact

of the environment workplace on the musculoskeletal function and how can this improve the safety and the efficiency of the workplace. Ergonomics is a system of analyzing and optimizing workstations, tools and equipment in a way that increases user productivity, safety, and comfort in industry and in trainings. Related training the workstations of the trainees need to fulfil the ergonomics concepts, in the Figure 5 is the correct description of workstations that fulfil the ergonomics concepts.

## 4. PROGRAMS TO SUPPORT THE NEW QUALIFICATIONS REQUIRED BY INDUSTRY 4.0 IN ROMANIA

Companies need to adapt fast in order to take advantage of this new world for this reasons some universities already chance their curricula and adapt their courses or the universities had involved in consortium of some European Projects to try to create new qualifications. Below are two examples of European Projects covering some of the pillars of Industry 4.0.

The project INDUCE 4.0 [13] is an Erasmus Plus Project in direction of VET training, this project is a research partnership between manufacturing SMEs, universities, commerce chambers and NGO. The project tries to provide, in the manufacturing field, flexible work trainings compatible with the changes of Industry 4.0.

In addition, the project INDUCE 4.0 tries to provide a joining between the needs of the industry and VET provider related to the Knowlagent of the concepts of Industry 4.0.

The second example is DIGIMAN [14] – Erasmus Project, the Project want to develop an MSc course based on digital manufacturing (DM) technologies. The main objective of the project is to elaborate a master program study related to DM to meet the needs and challenges of Industry 4.0 and therefore, to improve the performance of the companies.

## 5. CONCLUSIONS

Additive Manufacturing (AM) is one of the pillars of Industry 4.0 and in the last years this field has had a very big development. A lot of new technologies are been developed in the field of AM and future industry will need trained staff in this field.


**Fig. 5.** Workstations - fulfilled the ergonomics concepts [12]

The expectation is that AM will be established at industrial scale for a lot of products and processes. As aspects, Additive Manufacturing (AM) has economic advantages (less workmanship, short period of execution, etc.) but has also limits regarding quality standards, available materials, hourly working time etc. In the future additive manufactured products should be superior from a quality perspective in comparation with manufactured products.

Regarding the state-of-the-art in this field, some researchers came with the idea to combine additive manufacturing with usual technologies, to develop hybrid products and maybe in the future will be more developed this idea.

From the beginning of the AM the ergonomic concepts are considered and there were some applications for repetitive processes (e. g., a printed ergonomic mouse). The development of the field of Additive Manufacturing (AM) will lead to a higher demand for an ergonomics specialist, therefore the curriculum of all master courses from the field of Industrial Engineering will, should need to contain more hours dedicated to the ergonomics concept.

Future work will be developed similar as [15; 16] promoting values such as interaction and working in collaborative international teams and trying to have international certification of the skills in AM field.

## 6. REFERENCES


[1] Popa, D., *Interviu Varujan Pambuccian despre educație și meseriile viitorului.* Retrivent from: http://economie.hotnews.ro/stiri-finante_banci-20329581-interviu-varujan-pambuccian-imi-permit-dau-sfat-parintilor-nu-incurajati-copiii-spre-scolile-balet-bune-maniere-acestea-produc-someri-precizia-unui-ceas-elvetian-dialog-despre-educatia-din-prezent-mes.htm (Access on 20-03-2020)

[2] Peruzzini, M., Pellicciari, M., & Bil, C. (Eds.), *Transdisciplinary Engineering Methods for Social Innovation of Industry 4.0*, Proceedings of the 25th ISPE Inc. International Conference on Transdisciplinary Engineering, IOS Press, Vol. 7, 2018.

[3] Moldovan, L., *State-of-the-art Analysis on the Knowledge and Skills Gaps on the Topic of Industry 4.0 and the Requirements for Work-based Learning*, The 12th International Conference Interdisciplinarity in Engineering, Procedia Manufacturing 32, 294-301, 2019

[4] Deteşan, O., *Workspace determination for the RTTRR modular small-sized serial robot*, Acta Tehnica Napocensis, Series: Applied Mathematics and Mechanics, 60(I), 75-78, 2018.

[5] Eurostat, *Your key to European statistics.* Retrieved from: http://ec.europa.eu/eurostat/statisticsexplained (Access on 12-03-2020)

[6] Whitepaper – *Crafting qualification for the challenges of additive manufacturing*, EWF. Retrieved from: https://www.ewf.be/news/white-paper-2019.aspx (Access on 20-03-2020)

[7] TED, *Ideas worth spreading*. Retrieved from: https://www.ted.com/talks/olivier_scalabre_the_next_manufacturing_revolution_is_here/transcript (Access on 18-03-2020)

[8] Word Trade Organization, *Ch. 4 Goods and services – what is being traded?* World Trade Statistical Review 2018. Retrieved from: https://www.wto.org/english/res_e/statis_e/wts2018_e/wts2018chapter04_e.pdf (Access on 18-03-2020)

[9] Covaciu, F., Iordan, A., *Designing and building a serial robotic arm with four degrees of freedom*, Applied Mathematics and Mechanics, 62(II), 317-322, 2019.

[10] Popescu, D., Popişter, F., Eles, A., Comes, R., *Improving the quality of plastic parts obtained by 3d printing*, Acta Tehnica Napocensis, Series: Applied Mathematics and Mechanics, vol. 58, Issue I, ISSN 1221-5872, pp. 25-30, 2015, Cluj- Napoca, România

[11] Lorenza, O., *Industry 4.0, and process ergonomics: Exoskeletons application in Automoti*ve, Master Dissertation at Master of Science in Automotive Engineering, 2018

[12] Focuson Intervention, *Ergonomic evaluation.* Retrieved from: https://www.focusonintervention.com/ergo.htm (Access on 20-03-2020)

[13] Induce 4.0, *Project Induce 4.0*. Retrieved from: http://induce-project.eu/ (Access on 12-04-2020)

[14] MTT-BME. Retrieved from: *Digiman*. Retrieved from: http://varta.mtt.bme.hu/en/resarch/Digiman (Access on 20-03-2020)

[15] Riel, A., Draghici, A., Draghici, G., Grajewski, D., & Messnarz, R., *Process and product innovation needs integrated engineering collaboration skills*. Journal of Software: Evolution and Process, 24(5), 551-560, 2012.

[16] Draghici, A., Mocan, M., & Draghici, G., On-line training and certification solution for business process managers. In International Conference on ENTERprise Information Systems (pp. 380-389). Springer, Berlin, Heidelberg, 2010.

## Competențele cerute de noile tehnologii din Industria 4.0 și dezvoltarea abilităților angajaților

**Rezumat:** Conceptul de Industrie 4.0 evidențiază faptul că internetul de mare viteză, inteligența artificială, analiza de date mari și tehnologia cloud sunt foarte susceptibile să se dezvolte în toate sectoarele industriei în perioada 2020-2022. De asemenea, companiile se orientează spre învățare automată, realitate augmentată și fabricație aditivă, pentru investiții considerabile în afaceri.Toate acestea vor crește nevoia de cursanți cu înaltă calificare și, prin urmare, universitățile vor trebui să se alinieze nevoilor industriei. Lucrarea va prezenta o imagine de ansamblu asupra instruirii in domeniul fabricației aditive, și o imagine de ansamblu asupra nevoile de perfecționare conform Industriei 4.0, de asemenea, lucrarea va sublinia rolul specialiștilor în ergonomie în Industria 4.0.

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