

A VIEW ON HUMAN CAPITAL IN INDUSTRY 4.0

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The article's subject is the definition of areas where space is created for targeted workforce management and its successful implementation within the Industry 4.0 concept. In most cases, if we talk about the performance of Industry 4.0 elements, the investments of enterprises are primarily directed to the area of production, information and communication technologies, research and development, not to the formation of specific competencies of Work 4.0 and support for the implementation of human capital in practice. It is generally assumed that introducing Industry 4.0 will mean a lower need for labour for the enterprise, which will be replaced by a higher degree of automation and robotization. It is essential to recognize that human participation will still be required in work systems that are more automated and digitized, but that humans need to be sufficiently prepared for the changed way of doing work. The digitalization of the economy is not only creating new jobs and occupations but is also creating the need for new skills for employment. Employees will need to be willing and able to continue to learn and acquire new skills. It is essential to work with the workforce in the enterprise and gradually equip them with the missing skills and abilities. Several analytical methods were used to obtain the analytical background to identify areas of investment for companies in Industry 4.0 and to identify threats and risks associated with implementing Industry 4.0. An important component was the perspective of the affected employees and their perception of disadvantages within Industry 4.0. The analysis findings are used to understand better the workforce status in the enterprise and the gaps where space is created for workforce development in the changing needs of industrial enterprises in the Industry 4.0 environment.

KEYWORDS

employee, Industry 4.0, Work 4.0, work change, work competencies

1 INTRODUCTION

Increasing digitisation and automation are having a significant impact on work and employment today. On the one hand, some professions and economic sectors will be negatively affected; some jobs will disappear entirely and be replaced by technology. On the other hand, however, new work areas will directly result from automation. It is essential to think about this transformation of jobs now, look for solutions and prepare well [Jobs for Work 2022].

The concept of Industry 4.0 is familiar to many. It describes the transformation of industry, primarily through digitisation as well as globalisation and the accompanying technological changes. The concept of Industry 4.0 poses significant challenges for the formation of human capital and is reflected in the idea of Work 4.0, which is subject to the same evolution. Indeed, change in the world of work is always a debate about generations. The generations concerned are, in turn, shaped by their environment, and so it is not surprising that the current

generations in the labour market present stark contrasts [Krenicky 2022]. Moreover, these contrasts are accompanied by very different needs [HR Services 2022].

The Work 4.0 concept aims to draw attention to and raise awareness of the changing world of work, including the impact of digitalisation on the labour market and the threats and opportunities arising from this new phenomenon [Jobs for Work 2022]. The area of the work environment in the context of the formation and realisation of human capital in the labour market is one of the main dimensions in which quantifiable indicators of the construction of a specific information society appear in numerous works. Innovative changes associated with the development of the digital society, identified in the concept of Industry 4.0, create a framework for the adaptation and use of new patterns of work activity and, in a mutually conditional relationship with the broader social environment, also a framework for the formation and realisation of abilities, skills and competencies as dynamic components of human capital, as the basis of the concept of Work 4.0 [Porubcinova 2021].

So far, several studies have been carried out in which experts estimate the percentage of jobs that are expected to disappear due to digitisation. On the contrary, the second group of experts with a more positive approach claims that modern technologies will not take away people's jobs; only the nature and form of employment will change [Masarova 2021].

The development of Industry 4.0, the digital economy, and the associated changes will significantly impact the labour market. This will create new jobs on the one hand, but with the inherent consequence of putting existing jobs at risk. This does not necessarily mean their disappearance; instead, in a broader sense, it is also about their transformation into as yet unnamed positions [Tumidalska 2019].

Expected changes in the structure of jobs with a reduction in entry-level positions and a decline in demand for traditional classes are also foreseen, along with increased jobs requiring specific skills, e.g., creative and technical skills, e-leadership, and innovative engineering [Masarova 2019]. According to [Tupa 2020], it is mainly low- and middle-skilled jobs that will be threatened by automation, resulting in their gradual disappearance and the subsequent release of more labour. On the other hand, new jobs related to the operation and maintenance of production machines or robots will be created [Modrak 2017].

Changes in technology have increased the demand for highly skilled workers while at the same time reducing the need for workers with lower education and skill levels [Smeringaiova 2021]. This has created a labour market with solid requirements in high-skilled and low-skilled areas. The problem is that middle-skilled labour is no longer in high demand. This is due to the development of new technologies that are causing a decline in low-skilled physical and hazardous work, and emerging job roles will place ever higher demands on human intellect [Grencikova 2020].

The threats we face are mainly related to less skilled people who have low digital skills but also to people over 50 years of age [Krajnakova 2020]. A digitally literate person understands programming and can use digital technologies for personal development [Serafin 2019]. In empirical research to identify the skills needed by manufacturing workers and managers in intelligent manufacturing, it was found that critical thinking is the most needed skill [Khosravi 2022]. Subsequently, the most necessary and used skills are communication, teamwork, creativity, the ability to look for different solutions and options, digital skills, and so on. Employees must realise the need to master these skills to continue to do their jobs while respecting the current conditions and trends in businesses. Every

employee should be attentive to lifelong learning and see it as a source of acquiring new relevant information [Karbach 2019]. It completely changes the view of the value of people skills. There is a need for employees with a high degree of apprenticeship, i.e., who are willing and able to continue learning and acquiring new skills. Developing skills and acquiring knowledge through education is increasingly important because these skills and creative thinking are not replaceable by artificial intelligence [Dyadyura 2021]. There is an imbalance between supply and demand due to a shortage of skilled labour. Skilled workers are essential for individual businesses to keep pace with the ongoing digitalisation [Zalezakova 2018].

Industry4 magazine states that soft skills such as management, communication, leadership, and adaptive skills will also be necessary for addition to IT workers or developers. They also defined the future jobs that will be created as a result of digitalisation, e.g., digital manufacturing engineer, digital ethicist, virtual reality systems specialist, virtual simulation specialist, manufacturing cyber security strategist and others [Industry4 2021].

Researchers at the US-based Institute for the Future have long been involved in predicting future trends on a global scale. Together with the University of Phoenix, they released a study naming eight critical skills needed to be a successful worker in the next decade. According to them, the qualities necessary for success in the coming years are as follows [Karierainfo 2022]:

- **The ability to breathe life into data** - to select only the relevant data. Knowing what the numbers from data warehouses and spreadsheets mean in real life will continue to be the skill that differentiates humans from super-powerful computers.
- **Social intelligence** - empathy, the ability to "connect" to others, listen to them, understand how they feel and be able to adapt our communication to them, is another essential trait where humans win over machines. It's no longer just about perceiving your closest co-workers but also understanding colleagues from different cultures - whether meeting them in the workplace or through virtual teams remotely. Social intelligence is also related to the ability to function internationally.
- **Out-of-the-box and adaptable thinking** - positions that require abstract thinking (scientific work, management) or manual tasks (health care, cooking) will increase in importance. Only such jobs are not easily replaced by machines or cheaper workers in distant countries. This is only true if people can come up with new solutions and apply them in an ever-changing environment.
- **Computational thinking** - knowledge of MS Office-type tools will cease to be sufficient in the big boom in "big data", i.e. the processing of a massive quantum of information. The emphasis on working with data will cause businesses to expect employees to have even basic knowledge of programming or statistics. A related skill will be selecting only the essential data from the massive amount of data rolling in and learning to ignore some information consciously. We will never work with perfect information - not because there is a shortage of it, but rather because there will be an abundance of data available. It's not just about selecting the correct data but also learning to use tools to help filter the information automatically.
- **Literacy in using new media** - photos and videos often replace texts on the internet. Visuals are enriched by online interaction in the form of social networking. Content creation is increasingly becoming the domain of

individuals. It will become increasingly crucial for content consumers to select relevant information from a wealth of knowledge and independently create interactive content on the internet. Whether it be working with graphic editors, video and photo editing, gamification or the use of games in the business, or superior knowledge of social networks.

- **Perspective in different disciplines** - is needed more than being good in one sentence. It will be necessary to deepen continuous knowledge of the field one enjoys while taking an active interest in developments in other disciplines. This approach requires not just relying on formal education and maintaining a lifelong curiosity and willingness to learn new things.
- **Adaptability** - prepare for the work environment to change significantly over time [Dima 2010]. With the virtualization of work and the current knowledge of what environments stimulate the human brain to perform better, there will also be a change in the office. Architects will design offices that absorb the work-life blending trend and are reconfigurable so that employees feel comfortable at work and perform at their best at any time of the day.
- **Virtual collaboration** - working remotely is becoming more and more common. Communicating with colleagues from the other side of the world or country will be vital to achieving positive results. Team leaders need to learn how to motivate, praise and even reprimand people they may never meet in person.

2 METHODOLOGY

The methodology is focused on describing the research problem and defining the research objective. The aim of the research was to identify the areas where space is created for targeted workforce management and its successful implementation within the Industry 4.0 concept. We specified the research problem by defining the research questions. The paper is based on materials collected using an online questionnaire in a survey of industrial enterprises in Slovakia for the needs of the VEGA project "Identification of priorities for sustainable human resource management about disadvantaged employees in the context of Industry 4.0". Empirical data on the topic were collected using a scientific questionnaire containing 37 closed questions. The first part was aimed at finding out the identification and demographic characteristics of the respondents. The selected questions were mainly aimed at finding out the status and level of implementation of Industry 4.0 elements; the impact of Industry 4.0 implementation on the area of employee management, identifying the necessary skills of employees in the changed nature of work activities, revealing the areas in which organizations have invested for the implementation of Industry 4.0, as well as the risks arising in connection with the implementation of the Industry 4.0 concept. The research sample consisted of employees of enterprises of all sizes in Slovakia. The sample consisted of 556 respondents. Of this number, 80 (14%) respondents work in the public and state administration sector, 138 (25%) in the service sector and 338 (61%) in industrial production. In the preparation of the paper, the primary thought processes such as analysis, synthesis, abstraction, concretization, deduction, analogy, comparison etc., were used. The interpretation of data was made through descriptive and quantitative statistical methods. The collected data were processed through Microsoft Excel and IBM SPSS 22.0. The anonymity of the respondents was preserved in the processing of the results.

An essential source for the evaluation of outputs was also the results of research by domestic and foreign authors in the field.

3 RESULTS

In estimating the impact of Industry 4.0 on the workforce, it is necessary to understand which areas of employee management will be affected by the implementation of Industry 4.0 in practice and in what way. In the survey, we focused on defining the areas of employee management that are facilitated by the use of digital technologies, online applications, etc. The assignment of importance was through a Likert scale where 0 meant don't know, one the best and five the worst. As shown in the results presented in Table 1, the adoption of technology had the most positive impact in the areas of appraisal and job control, employee compensation, employee orientation and adaptation, training and development, and the results also show that digital technology facilitates employee communication and awareness.

Table 1. Areas of employee management facilitated by the use of technology

| Staff management area | Arithmetic mean of \bar{x} | Scatter |
|--|------------------------------|---------|
| Recruitment and selection of employees | 1.953 | 2.063 |
| Employee orientation and adaptation | 2.189 | 1.811 |
| Staff training and development | 2.050 | 1.526 |
| Health protection and hygiene measures | 1.977 | 1.954 |
| Assigning and changing work tasks | 2.018 | 1.492 |
| Changing the place of work | 1.942 | 2.043 |
| Employee communication and information | 2.020 | 1.710 |
| Presence in the workplace | 1.894 | 2.034 |
| Evaluation and control of work tasks | 2.128 | 1.590 |
| Staff remuneration | 2.151 | 2.427 |
| Dismissals (redundancies) | 1.978 | 2.982 |

The introduction of new technologies into practice was most often perceived by respondents as facilitating work or as a necessity, as demonstrated in Figure 1. Respondents are aware of scientific and technological advances and the associated inevitable changes in the way work is carried out and the need to respond flexibly to the situation.

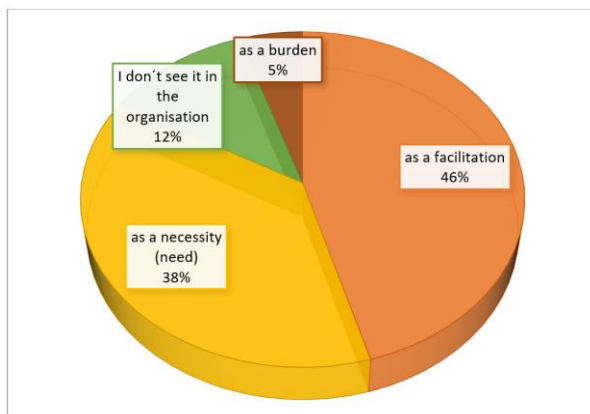


Figure 1. The importance of adopting new technologies from the perspective of respondents

When examining why employees perceive threats if forced to change their current job (Figure 2), the most significant threats

are lack of foreign language skills, narrow specialization of employees with work experience in only 1 area, and age.

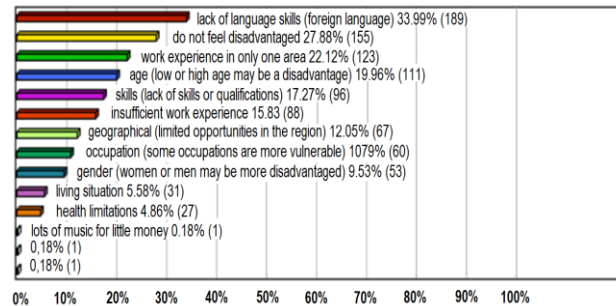


Figure 2. Reasons why employees are at a disadvantage when changing jobs

Lack of skills or qualifications of the employee was the reason for 17.27% of the respondents, and 27.88% of the employees do not feel any disadvantage. This suggests that apart from the standard reasons for weakness, employees do not see a possible weakness in the context of Industry 4.0, which may result in low interest in complementing the specific skills and capabilities that the implementation of Industry 4.0 will require.

When asked how they see the impact of their current job in the future, over 38% of respondents identified their current workplace as a space that allows them to develop, but it is also worth mentioning the relatively large group of employees for whom the current workload already places an increased psychological strain, as Figure 3 demonstrates.

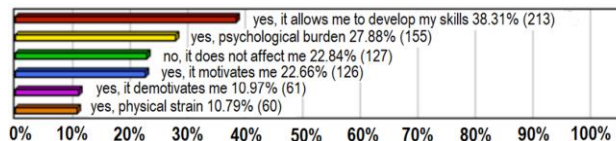


Figure 3. Impact of current work experience on future work ability

So far, investments in connection with the implementation of Industry 4.0 have been mainly in the areas of production, information technology or research and development, or the respondents needed to be made aware of the areas in which the company had invested in connection with Industry 4.0. Investing in employee development is currently not a priority when implementing Industry 4.0 elements (Figure 4.)

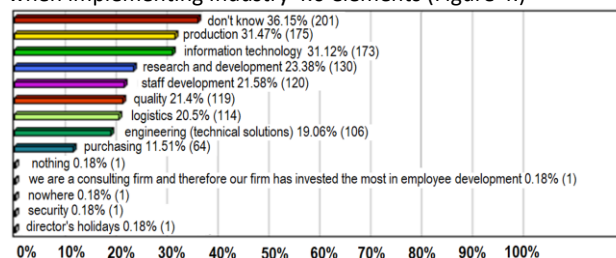


Figure 4. Areas of investment for organisations in the context of Industry 4.0

The survey defined the skills or capabilities of employees that are important for digitalisation and automation. Again, a Likert scale was used to determine their order of importance under the same conditions. The results show that the essential skills for implementing Industry 4.0 will be digital, technical, and communication skills, as presented in Table 2.

Table 2. The importance of skills in the face of digitalisation and automation, according to respondents

| Ability (skill) | Arithmetic mean of \bar{x} | Scatter |
|---|------------------------------|---------|
| Technical (professional) skills | 3.329 | 2.581 |
| Communication skills | 3.043 | 2.002 |
| Organisation of time at work, work tasks | 2.971 | 1.945 |
| Manage and make decisions | 2.995 | 2.117 |
| Learn | 3.290 | 2.472 |
| Work under pressure | 2.948 | 2.028 |
| Digital skills | 3.421 | 2.557 |
| Languages (foreign languages) | 3.146 | 2.196 |
| Social (ability to get along with other people) | 2.759 | 1.866 |
| Initiative (entrepreneurship, commitment) | 2.910 | 1.823 |
| Flexibility, adaptation | 3.144 | 2.170 |
| Creativity and innovation | 3.108 | 2.147 |

Associated with the investments made are the expectations businesses see in implementing Industry 4.0 elements. Most expected benefits relate to improving production quality, reducing costs [Man 2011], eliminating waste, and optimising processes (Figure 5). Investing in the workforce, improving working conditions or ensuring job sustainability are not currently given due attention when implementing Industry 4.0 elements.

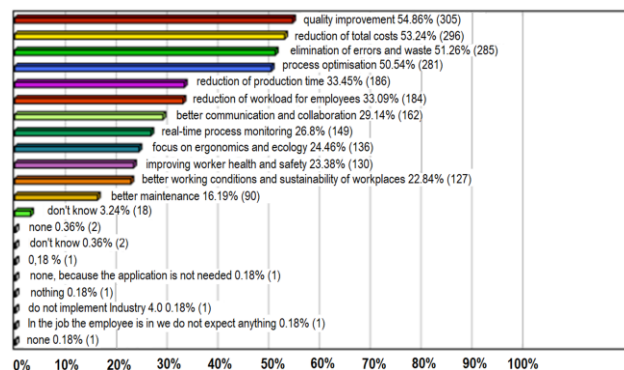


Figure 5. Benefits of applying Industry 4.0 elements in enterprises

Paradoxically, however, when asked to define the potential risks associated with the implementation of Industry 4.0, as many as 37.23% of the respondents cited the lack of experience of the workforce, which will not be sufficiently able to respond to changes in the implementation of the Industry 4.0 concept, as the most significant risk (Figure 6). Even the factor of an unprepared workforce is identified as a more severe risk than risks related to information technology security, hacker attacks and terrorism. Thus, organisations are aware of the need to equip the workforce with the necessary skills but have not yet invested increased resources in this area.

As the outputs of the Vega project show, both employees and companies are aware of the importance of implementing Industry 4.0 elements into company practice. At the same time, it is possible to observe a trend of supporting mainly technical and informational components of implementation. Targeted training and retraining of the workforce for the conditions changed by the impact of the performance of Industry 4.0 is not given due attention.

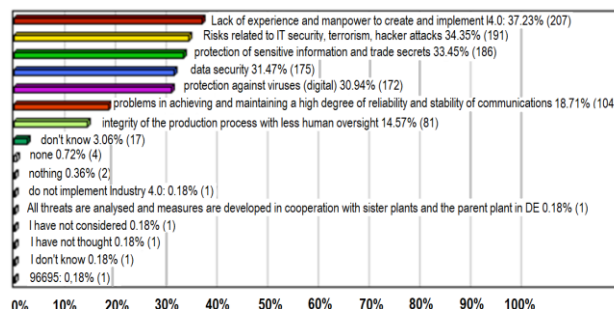


Figure 6. Defining the risks associated with implementing Industry 4.0 for the enterprise

4 DISCUSSION

Industry 4.0 will become the engine of economic growth in the country. The aim will be to harness the technological potential and increase private and public investment in new technologies. It will therefore be necessary for the state to help businesses prepare for such a transformation. This preparation will be possible in particular if the state provides businesses with the knowledge and the possibility to access technologies, incentives, and initiatives to address specific problems, for example, through digital innovation centres. The innovative approaches and benefits of Industry 4.0 can significantly help the Slovak economy to operate sustainably, environmentally friendly and efficiently [MIRRI 2019].

With the continued deployment of automated technologies, most industrial and agricultural sectors will experience a growing shift in skills. When working with new technologies, employees will need to be able to take on complex, less automated tasks such as troubleshooting, coming up with new solutions and approaches, and thinking critically. Similarly, cognitive skills, social skills, communication skills, organisational skills, technological skills and creativity are categories that will continue to increase in importance and will be sought after in the labour market [MIRRI 2019].

According to McKinsey, more and more fields demand highly skilled professionals as digitisation leaps ahead by several years. The demand for skills is precisely in the digital domain. At the forefront are data skills such as big data analytics and the transformation above to Industry 4.0 [HR Services 2022].

Changes in the labour market due to digitalisation have made the process of change more intensive and permanent, requiring changes in the education system and other areas of society, especially in the organisation of work at both micro and macro levels. New forms of education will require various new components of the education system, such as non-formal education or online courses, self-learning, etc., adapted primarily to unique mobile platforms (e.g. e-learning will become m learning), etc. [Masarova 2021]

The faster technology changes, the quicker the profile of employee requirements changes. Still, the industry must find a way to keep up with developments. On the contrary, regular training in Work 4.0 and continuous education are needed to keep employees up-to-date. It's about more than training managers first and then others. Instead, companies need to work closely with employees to create individually tailored development offers and test them regularly. Also, more and more companies are allowing internal knowledge sharing, i.e. employees teaching employees. However, the same approach also applies to employees. They need to find a way to afford to stay with old ways of thinking and develop their skills. This includes skills such as working independently, digital thinking, playful use of PCs and knowledge of foreign languages. These

will be commonplace in the future. With advancing technological developments such as artificial intelligence (AI) machines, the human worker will take on different tasks. While machines will take over schematic logical thought processes in the future, humans will increasingly be responsible for the 'creative' part [HR Services 2022].

Work 4.0 will become significantly more complex for employees in digitalization and internationalization. The same applies to the requirements that employers will have to meet in the future to be perceived on the labour market as an attractive option for future skilled workers [HR Services 2022].

Today, it is crucial that organisations understand the importance of their digitalisation and tailor appropriate corporate skills training for employees so that they can acquire the right skills and capabilities needed for the digital society and economy. There is also a need to create an education system that supports the emergence and development of digital skills while still at school, thus preparing graduates for employment in the digital age.

Slovakia needs a comprehensive systemic change in the education system. Progress in the digital economy can only be achieved by improving the quality of education and developing the skills of students, employees and consumers who can respond to new challenges in the labour market and accept the technological innovations that will emerge ever more rapidly. Education at all levels of schooling must focus on the overall development of a person's personality, the result of a culture of relationships, the ability to learn, abstract problems and acquire knowledge in a targeted way, and navigate the vast data of the digital world [MIRRI 2019].

Companies struggle with the skills and qualifications needed to foster innovation in increasingly globalised labour markets. Investing in skills and qualifications can turn digitalisation into a net provider of jobs, boosting innovation, productivity, growth and employment [MIRRI 2019].

5 CONCLUSION

Human society is evolving. It can be said that the building of the material world has come to an end, and we are moving into the period of the information world. In practice, this means that the building of the information society will place man outside the immediate production process; the importance of man will increase because all the means he produces will serve him alone. In the same way, the world is changing, not only in technical terms but also in terms of values. From a technical point of view, the primary qualitative characteristic will be to be intelligent and, from a mental point of view, to have a set of core professional and expert competencies. To ensure the required level of human capital development, it will be necessary to redesign traditional education systems to the new conditions resulting from Industry 4.0. Only in this way will it be possible to ensure a skilled workforce capable of carrying out many new activities.

There are already acute labour shortages in some sectors. This may be a good indicator of the future need for labour that must be prepared for the labour market as soon as possible. Preparing the workforce will require cooperation and coordination between several actors, such as the education system, the labour department, economic enterprises and other business and governmental organisations. Employers expect the future labour market to be more oriented towards specific vocational training as new technologies will increasingly displace low-skilled, and manual work and emerging job roles will place ever greater demands on human intellect. Changing the skills or raising the population's educational level will be

critical conditions for remaining competitive in the global labour market.

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REFERENCES

- [Dima 2010] Dima, I.C., et al. Using the expert systems in the operational management of production. In: Recent Advances in Mathematics and Computers in Business, Economics, Biology & Chemistry. Book Series: Mathematics and Computers in Science and Engineering, 2010, p. 307. ISBN 978-960-474-194-6. ISSN 1792-4308.
- [Dyadyura 2021] Dyadyura, K., et al. Modeling of the Manufacturing Systems State in the Conditions of the Lean Production. MM Science Journal, 2021, Vol. June, pp. 4408-4413.
- [Grencikova 2020] Grencikova, A., Berkovic, V. The impact of Industry 4.0 on changes in the structure of jobs (Vplyv Industry 4.0 na zmeny v strukture pracovnych miest). Trencin: TnUAD, 2020. 154 p. ISBN 978-80-8075-916-2. (in Slovak)
- [HR Services 2022] Work 4.0 – the challenge for the employer 2022 [online]. 2022, [cit. 14.11.2022]. Available at: <https://arts.eu/en/insights/article/work-40-the-challenge-for-the-employer/>
- [Industry 4 2021] Industry 4. Magazin Industry 4.0. [online]. [cit. 14.11.2022]. Available at: https://industry4.sk/magazin/industry4-0-na-reformu-vzdelavania-pre-potreby-industry-4-0-je-najvyssi-cas/?fbclid=IwAR1nQdPuQ_fMHYq2n2jOAf0huwnbyum-PrbIYSqPJGU-ffNBvJaii2Ed (in Slovak)
- [Karbach 2019] Karbach, R., Krajnakova, E., Horvathova, A. Enterprise Training in Conditions of Smart Manufacturing. In: Proc. of Intern. Sci. Conf. The Impact of Industry 4.0 on Job Creation 2019. Trencin: Publish. House A. Dubcek Univ. in Trencin, 2020, pp. 192-199. ISBN 978-80-8075-903-2.
- [Karierainfo 2022] Karierainfo: 8 important skills that will ensure you a better paid job (8 dôležitých zručností, ktoré vám zabezpečia lepšie platenu pracu). [online]. [cit. 14.11.2022]. Available at: <https://karierainfo.zoznam.sk/cl/1000139/2209325/8-dolezitych-zrucnosti--ktore-vam-zabezpecia-lepsie-platenu-pracu> (in Slovak)
- [Khosravi 2022] Khosravi, A., et al. Customer Knowledge Management in Enterprise Software Development Companies: Organizational, Human and Technological Perspective. Management Systems in Production Engineering, 2022, Vol. 30, No. 4, pp. 291-297. <https://doi.org/10.2478/mspe-2022-0037>
- [Krajnakova 2020] Krajnakova, E. and Vyhnicka, J. Impact of Industry 4.0 on Changes in the Structure and

Number of Jobs. In: Proc. of Intern. Sci. Conf. The Impact of Industry 4.0 on Job Creation 2019. Trenčín: Publish. House A. Dubček Univ. in Trenčín, 2020, pp. 247-253. ISBN 978-80-8075-903-2.

[Krenický 2022] Krenický, T., Hrebenýk, L., Chernobrovchenko, V. Application of Concepts of the Analytic Hierarchy Process in Decision-Making. *Management Systems in Production Engineering*, 2022, Vol. 30, No. 4, pp. 304-310. <https://doi.org/10.2478/mspe-2022-0039>

[Man 2011] Man, M., Modrák, V., Grabara, J.K. Marginal Cost of Industrial Production. *Polish Journal of Management Studies*, 2011, Vol. 3, pp. 62-69.

[Masarova 2021] Masarova, J., Koiso, E., Ivanova, E. Digital economy development and job structure changes. In: Proc. of Conf. Challenges, Trends and Inspirations within the Labor Market 2021. November 11, 2021; Trenčín, Slovakia. Trenčín: Publish. House A. Dubček Univ. in Trenčín, 2022. ISBN 978-80-8075-967-4.

[MIRRI 2019] 2030 Digital Transformation Strategy for Slovakia, 2019. [online]. [cit. 14.10.2022]. Available at: <https://www.mirri.gov.sk/wp-content/uploads/2019/10/SDT-English-Version-FINAL.pdf>

[Modrák 2017] Modrák, V., Soltýsova, Z., Modrák, J., Behúňová, A. Reducing Impact of Negative Complexity on Sustainability of Mass Customization. *Sustainability*, 2017, Vol. 9, No. 11, 2014.

[Porubcinová 2021] Porubcinová, M., Fero, M., Fidlerová, H., Novotná, I. Industry 4.0 in the human capital optics-empirical findings of work 4.0 competencies development within the Slovak automotive sector. *Prognostické práce – Foresight, Analysis and Recommendations (PP – FAR)*, Vol. 13, No. 2, pp. 44-67. DOI: 10.31577/PPFAR.2021.13.007

[Serafin 2019] Serafin, C. Digitization – paradigm shift in teacher training. In: Proc. 4th Inter. Sci. Conf. Scholanova, quo vadis? Prague: Extrasystem, 2019, pp. 150-155. ISBN 978-80-87570-44-9.

[Smeringaiova 2021] Smeringaiova, A. Experience for Curriculum Design and Innovation for Technical Subjects with regard to Distance Learning. In: Proc. ICETA 2021: 19th IEEE Inter. Conf. on Emerging eLearning Technologies and Applications. IEEE, Denver, USA, 2021, pp. 345-350. ISBN 978-1-6654-2101-0.

[Tumidalska 2019] Tumidalska, V. Industry 4.0 and Its Impact on Labour Market. In: Proc. of 4th Student's Symp. "Employee protection from the perspective of industrial revolution 4.0.". April 5-6, 2019, Danisovce, Slovakia. [online]. [cit. 14.11.2022]. Available at: dusevnezdravie.upjs.sk/wp-content/uploads/2019/11/ochrana-zamestnanca-s-perspekt%C3%ADvou-priem-revolucie-final.pdf (in Slovak)

[Tupa 2020] Tupa, M. 2020. Impact of Industry 4.0 on the Labor Market of the Slovak Republic in the Context of Labor Migration. In: Proc. of Intern. Sci. Conf. The Impact of Industry 4.0 on Job Creation 2019. Trenčín: Publish. House A. Dubček Univ. in Trenčín, 2020, pp. 414-422.

[Jobs for Work 2022] Jobs for Work 4.0 – The Future of Employment. [online]. 2022, [cit. 14.11.2022]. Available at: www.qualified.net/cms/index.php?id=119&L=1

[Zalezakova 2018] Zalezakova, E. Industry Output 4.0. *Managment podnikania a veci verejnych*, 2018, Vol. 13, Issue 7, pp. 1-9. ISSN 2453-8167.

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