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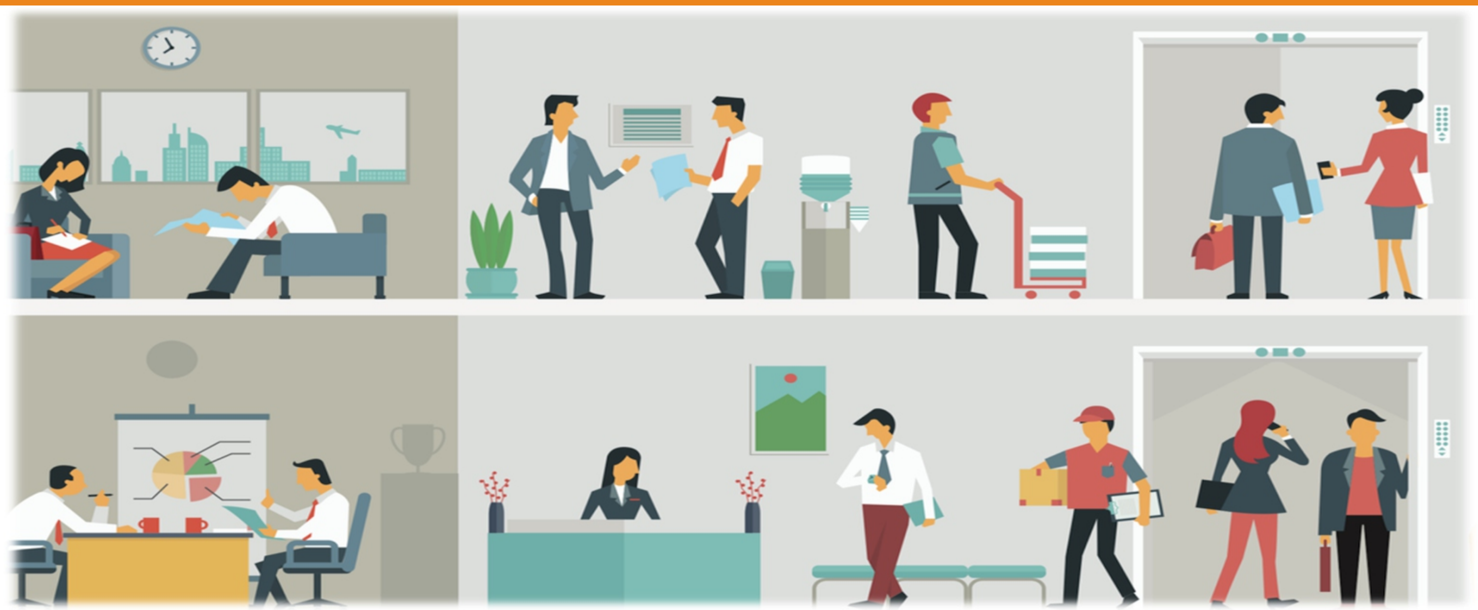

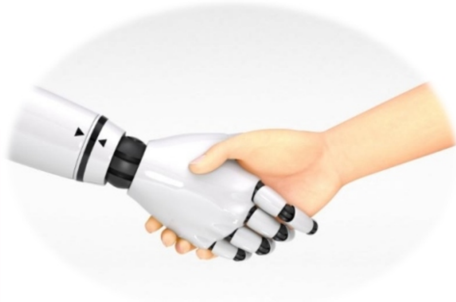

Editoriál

Žijeme v dobe, kedy sme vystavení mnohým výzvam. Ľudstvo momentálne bojuje s pandémiou, ktorá zásadným spôsobom ovplyvnila naše fungovanie nielen v súkromnom ale aj v pracovnom živote. Zisťujeme, že človek je v podstate krehký tvor, ktorý je vystavený pôsobeniu prostredia, ktoré ho obklopuje. V pracovnom procese je človek limitujúcim faktorom ale bez jeho účasti v súčasnosti nie je možné pracovnú činnosť realizovať. Vplyvom aktuálnej situácie boli podniky nútené presunúť časť pracovnej činnosti do online priestoru. Avšak vo všetkých priemyselných odvetviach nie je možné zaviesť takéto opatrenia, pretože je stále potrebná priama účasť človeka. Odpoveďou na tieto aktuálne problémy by mohlo byť postupné zavádzanie Industry 4.0. Technológie ako sú umelá inteligencia či mobilné platformy priniesli revolúciu v spôsobe, akým žijeme, pracujeme a komunikujeme. Jednoduché a monotónne procesy sa automatizujú. Preto sú potrebné nové stratégie pre súčasnú pracovnú silu. Zamestnanci musia byť schopní prevziať strategickejšie, koordinovanejšie a tvorivejšie činnosti. Svet sa mení a my sa meníme s ním. Má to rozsiahle dôsledky na naše pracovné aj osobné životy – je však na nás, aby sme nestratili jedinečného ducha, využívali moderný pokrok v náš prospech a nedovolili mu, aby sa stal naším pánom.

Ako povedal Steve Jobs: „Vaša práca vyplní veľkú časť vášho života a jediný spôsob, ako byť naozaj spokojný, je robiť veci, ktoré považujete za skutočne skvelé. A jediným spôsobom ako vykonávať skvelú prácu je milovať to, čo robíte.“ V zmysle tejto myšlienky je spracovaný príspevok, ktorý sa zaoberá vyšpecifikovaním a subjektívnym hodnotením pracovných faktorov pôsobiacich na zamestnancov v pracovnom procese a ovplyvňujúcich kvalitu vykonávanej práce a spokojnosť zamestnancov na pracovisku.

Zavádzanie konceptu Industry 4.0 mení pohľad na riadenie ľudských zdrojov. Nové technológie, nové prístupy k fungovaniu podniku, vznik nových typov pracovných miest s novými kompetenciami a zručnosťami sú výzvou pre riadenie ľudských zdrojov v podniku. Teoretické zhrnutie hlavných zistení o zmenách a účinkoch nových technológií spĺňajúcich požiadavky Industry 4.0 a ich vplyv na zmenu na trhu práce a v oblasti riadenia ľudských zdrojov je predmetom riešenia príspevku „Vplyv Industry 4.0 na trh práce a riadenie HR“.

V súvislosti s pokrokom informačno-komunikačných technológií a nárastom množstva informácií, údajov, ktoré je na dennej báze potrebné spracovať, vyvstáva otázka nedostatku relevantných nástrojov na hromadné spracovanie informácií, údajov a vedomostí na úrovni jednotlivcov. V príspevku venovanom danej problematike sa autori zamerali na testovania dizajnu informatických nástrojov s konkrétnymi praktickými ukážkami riešenia softvérovej podpory vybraných činností.

Ďalší príspevok, ktorý v aktuálnom čísle časopisu nájdete, sa zaoberá problematikou logistiky budúcnosti a jej kľúčovej funkcii pre obchodnú činnosť podnikov. Poukazuje na zmeny v charaktere riadenia dodávateľského reťazca a z toho vyplývajúce úlohy a výzvy na jeho riadenie.

V príspevku autora Oláha je predstavená analýza citlivosti operátorov kríženia ním vyvinutého originálneho genetického algoritmu na problémy s plánovaním permutačného flow shop. Skúma účinnosť algoritmu pri zmenách niektorých hodnôt operátorov kríženia a hodnotí získané výsledky a hľadá vzťahy pre jeho efektívnejšiu aplikáciu.

Trnava, december 2020

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IMPACT OF WORK ENVIRONMENT FACTORS ON EMPLOYEES IN SELECTED SMALL ENGINEERING COMPANIES IN SLOVAK REPUBLIC

Viera BESTVINOVÁ, Petra MARKOVÁ

ABSTRACT
A person by work performance interacts with the work environment, work equipment, work objects and, last but not least, with a number of risk factors. These result from the nature of the work activity and also from the work environment. The paper deals with the investigation of the impact of working environmental factors on the performance and comfort of employees in selected small engineering companies in the Slovak Republic. Paper is based on subjective evaluate work factors from employees that affect the performance of their work.
The obtained information is used to develop an idea of the work environment factors affecting employees of the small engineering companies. The aim was to find out whether the factors of the work environment influence the work performance of employees in terms of the quality of work performed. The results of the analysis indicate that the examined factors of the working environment have an impact on employees. Based on more detailed research of work comfort factors in engineering operations, it will be possible to assign importance to work factors and examine their interactions and to develop a combined procedure for indexing work comfort factors.

KEYWORDS
working environment, work factors, comfort, employee, workplace

INTRODUCTION

In engineering plants, there are dangerous factors of the working environment that can damage their health by prolonged and repeated exposure to employees. Development of production, insufficient use of personal protective equipment, work in stress, prolongation of working-age etc. it can be seen as a negative impact of the working environment on the health of employees in all industries. Therefore, the emphasis is on adopting technical, organizational and other measures to eliminate or reduce to a minimum the impact of hazardous environmental factors on employees. The most important tasks of employers in this area are to create a safe working environment, to ensure workability and working comfort of employees. Remove, respectively reducing the impact of unfavourable factors in the working environment improves the working comfort of employees and also improves employee performance.

Many studies have recognised the important role played by the organisation's management in reducing accidents because of that, accidents have adverse effects in terms of productivity and quality decreasements, deterioration of the organisation's public image and internal climate (Fernández-Muñiz, B. et al., 2009). Thus, many authors have already established numerous factors that have a strong influence on OH&SMS, including leadership, employee involvement, work environment, stress management and OHS training (Vulanovic, S. et. al., 2019).

EXAMINATION OF THE WORKING ENVIRONMENT FACTORS

Generally speaking, working conditions cover a broad range of topics and issues, from working time (hours of work, rest periods, and work schedules) to remuneration, as well as the physical conditions and mental demands that exist in the workplace (www.ilo.ch).

The working environment is a summary of all material conditions of work (machinery and equipment, handling equipment, personal protective equipment, raw materials, material and other work equipment), which together with other conditions (technology, work organization, social conditions of work) create factors of the working environment - physical, chemical, biological, socio-psychological and others that affect the employee during the work process (www.istp.sk). The most frequently evaluated factors in engineering include noise, vibration, lighting, microclimatic conditions in the workplace, etc. Each of them may present a health risk in certain circumstances. Prolonged exposure of workers to excessive noise can cause hearing loss or impairment of hearing or hearing loss from noise. Working in a forced position with frequent repetition of individual actions with force can lead to musculoskeletal disorders. The vibrations can cause nausea and discomfort. What this tells us is that working in a non-adequate environment affects the health condition of the employees on a high level (Aleksić, A. et al., 2009). The problem is a comprehensive assessment of the working environment to assess the interaction of individual factors on employees in working in the working environment.

At present, the project is based on research results eg. VEGA project "Transformation of the ergonomic program into a company management structure by integration and use of QMS, EMS, HSMS modules", APVV project "Transformation of Industry in Slovakia by using Participatory Ergonomics", bilateral USA - Slovak project "Transforming Industry in Slovakia Through Participatory Ergonomics.

They pointed out the need for a comprehensive evaluation of ergonomic indicators in industrial plants. Despite efforts to express the synergic effect of physical and ergonomic factors with using mathematical and statistical methods, there is still no model that would allow their combination and recombination with regard to individual needs of employees, especially in industrial companies (Paulíková, A., Ubárová, M. 2018).

The problems closely related to the evaluation of working comfort in terms of assessing the workload of employees caused by individual factors of the working environment are found in the work of several authors. Benefit in this area was the paper of M. Kapustová (Kapustová, M., 2004) which describes the mathematical model of the evaluation of workload of employees, which explains the overall impact of factors of the working environment on the employee and also allows to evaluate the complex burden of a human organism during working hours.
The issue of the working environment is paid not only in the field of theoretical research and the application of its results into business practice but organizations on transnational and national level exams in a broad context the impact of working conditions on human. Eurofound foundation is an EU agency dedicated to improving living and working conditions. One of the three research areas of this agency is the European Working Conditions Survey (EWCS). The European Working Conditions Survey is the longest ongoing survey and has become a recognized source of information on working conditions and the quality of work and employment. It allows monitoring of long-term trends in working conditions in Europe. This survey covers the areas of the physical environment, work intensity, working time schedule, workplace relationships, skills, authority and employment status and working life perspectives (www.eurofound.europa.eu).

The last survey of working conditions (2015), which included other European countries in addition to the EU Member States, revealed a diversity of working conditions by country, occupation, gender and age group. The findings of the survey highlight the areas to be pursued at EU and country level to achieve sustainable development of working conditions. Based on respondents' answers, the Slovak Republic achieved an average score in almost all assessment areas, with the highest score in terms of work stability and lowest in terms of the use of personal protective equipment, fast-working and lack of time to work, justice, cooperation and trust. Employee participation in improving work organization and working practices. Slovakia needs competitive companies that create decent working conditions for its employees because the working environment is one of the important factors that influence people in making decisions and staying in it.

MATERIALS AND METHODOLOGY

We chose companies for our survey which are comparable companies in terms of the number of employees, organization of production and equipping of enterprises with means of production. To determine the impact of work environment factors on employees with regard to their work comfort, two engineering companies employing less than 50 employees were randomly selected. The annual turnover and balance sheet total amount to EUR 10 million and thus belong to the small business group. In addition to standard machine tools such as horizontal and coordinate boring machines, conventional lathes, welding machines, various types of grinding machines, etc. companies are equipped with special technological equipment for electro-erosive cutting and sinking and CNC machine tools. In the surveyed enterprises, there is a nesting arrangement of workplaces for the performance of the specialized technological processes. The business activities of the companies are mainly toolmaking, metalworking, locksmithing, production of metal products, and production of simple machines for economic sectors, maintenance and modification of injection moulds for plastic mouldings for the automotive and electrical industries.

In companies, we conducted a questionnaire survey to determine the impact of factors of the working environment in terms of work comfort of employees based on the subjective assessment of employees. In addition to the questionnaire method, we used the method of interview and direct observation to assess the impact of modifiable factors of the working environment. 62 respondents (63.07%) out of 98 participated in the questionnaire survey. The selected sample of respondents is homogeneous in terms of gender, as all employees are men. Respondents were divided into four groups. They differ in the degree of workload, the scope of work and also the type of workplace.

Due to the fact that these are small companies and the selected sample does not have a sufficient number, it is not possible to make a statistical evaluation based on the results, but it is possible to observe the development of a certain trend. The information obtained is sufficient to confirm that there are factors in the working environment that affect the working comfort of employees. For the interpretation of the purpose of the outputs of the questionnaire survey, we used a cross-sectional descriptive study. Table 1 shows the exact number of representations in each group, the percentage conversion and the professions in the group.

Tab. 1 - *Division of respondents into professional working groups*

Profession	Acronym	Frequency	Percentage
Employees on CNC machines	CNC	18	29.28 %
Employees on conventional machines	CM	10	17.08 %
Manual workers	MW	20	31.70 %
Technical and economic staff	TES	14	21.94 %
Together		62	100.00%

RESULTS

The characteristic of non-modifiable factors with a direct effect on the health and performance of employees, can be seen in Table 2. The respondents were examined for non-modifiable or personality factors. In terms of gender, the sample was not divided as all respondents are men. Almost all the employees, who involved in the survey are of productive age but are more likely to be older workers, who have been employed in a given job for a long time, are incorporated, and based on an assessment of their responses, it is possible to assess the real impact of the working environment factors affecting them. In the examined sample of employees are represented mostly tall men with higher body weight that was reflected in a higher Body Mass Index value. Defining the examined sample of employees makes it possible to assess the influence of work comfort factors in terms of non-modifiable factors affecting employees. Their impact must be taken into account when implementing corrective measures to reduce or eliminate negative factors in the work environment.

Tab. 2 *- Basic statistical characteristics of somatic data of respondents*

Parameter	Work group acronym	Statistical characteristics							
		n	$\bar{x}$	S.D	Min.	25%il	Median	75%il	Max
Age	**CNC**	18	36.08	10.69	21.00	29.00	34.50	41.25	58.00
	CM	10	55.43	6.18	47.00	48.00	56.00	62.00	64.00
	MW	20	53.77	8.55	35.00	49.50	57.00	61.00	62.00
	TES	14	49.78	12.66	29.00	35.00	54.00	59.00	66.00
Working exposure [years]	**CNC**	18	8.25	4.49	2.00	5.00	8.50	10.75	19.00
	CM	10	17.71	5.88	15.00	16.00	20.00	23.00	32.00
	MW	20	14.15	7.57	5.00	9.00	15.00	19.00	25.00
	TES	14	11.77	4.64	5.00	7.00	12.00	15.50	19.00
Body height [cm]	**CNC**	18	180.25	7.93	169.00	176.00	178.00	187.00	198.00
	CM	10	179.71	6.32	167.00	176.00	181.00	183.00	189.00
	MW	20	174.77	6.28	167.00	170.00	173.00	180.00	189.00
	TES	14	181,78	6.14	172.00	175.00	183.00	186.00	192.00
Body weight [kg]	**CNC**	18	87.83	23.27	66.00	73.00	86.50	89.75	160.00
	CM	10	84.42	16.03	70.00	71.00	82.00	90.00	120.00
	MW	20	84.92	15.27	71.00	71.00	85.00	99.50	115.00
	TES	14	84.67	11.53	56.00	80.50	88.00	92.50	97.00
BMI	**CNC**	18	26.70	4.62	21.60	24.90	25.20	27.50	40.80
	CM	10	26.10	4.70	20.90	23.90	25.20	25.50	37.00
	MW	20	27.70	4.17	21.90	24.50	27.70	30.20	31.70
	TES	14	25.58	3.11	18.30	24.31	26.60	27.76	29.70
Rohrer index	**CNC**	18	1.48	0.21	1.23	1.32	1.44	1.54	2.06
	CM	10	1.46	0.27	1.14	1.33	1.38	1.52	2.06
	MW	20	1.58	0.23	1.31	1.39	1.52	1.66	2.22
	TES	14	1.41	0.18	1.04	1.31	1.42	1.51	1.73

Work comfort of employees is influenced mainly by factors of work, working environment and mental stress. Respondents rated the load levels of these groups stress factors on a scale of 1 to 10 (minimum, small, medium, high and very heavy load). These are modifiable factors that may affect the occurrence of MS difficulties. Due to the low number of members in the analysed groups, it wasn´t possible to count odds ratio values or 95% confidence limits for all factors that may affect the health of employees.

In table 3 shows the average score of the factors of work, which in the monitored groups of employees (according to a subjective evaluation) cause their workload and reduce their working comfort.

Tab. 3 *- Impact of work factors on workload subjectively evaluated by employees*

Work factors	**Work group acronym**			
	CNC	**CM**	**MW**	**TES**
1. Performing the same work operations (monotony)	3.00	3.86	4.29	2.44
2. Handling heavy, respectively spacious objects	3.82	5.71	4.64	0.22
3. Insufficient rest breaks during the work shift	1.82	3.00	3.93	0.67
4. Over time, irregular shifts	0.73	2.29	1.21	1.89
5. Work in the same position for a long time (standing, leaning forward, turning the hull sideways)	4.36	5.71	4.64	2.89
6. Work with hands over your head or away from the body	1.36	2.14	3.14	0.22
7. Working on the border of physical abilities	0.45	4.26	4.64	0.22
8. Insufficient equipment with quality tools	4.73	4.57	7.5	2.11
9. Unevenly distributed work (once a lot of work, sometimes little)	4.18	4.71	6.36	4.00
10. Other (what kind)	0.00	0.00	0.00	0.00

The following table shows the importance of the factors of the working environment on the workload of respondents. These are mainly microclimatic conditions in the workplace and the organization of workplaces. The survey shows that microclimatic conditions are a frequent cause of workplace discomfort. However, these are shortcomings that can be reduced or eliminated by appropriately selected technical measures. Workplace environmental factors such as noise, heat and poor ventilation are the cause of moderate workload for manufacturing employees. Manual workers also stated that the reason for their increased workload is the lack of workplace illumination. The factors monitored by the technical and economic staff cause little or no workload. Some employees working on CNC machines said, in a supplementary option, that discarded tools, which occur in their workplace, are the problem but cause only minimum workload, rather slow them down, when they search necessary tool.

Tab. 4 *- Influence of microclimatic factors on workload subjectively evaluated by employees*

Microclimatic factors	**Work group acronym**			
	CNC	**CM**	**MW**	**TES**
1. Noise exposure	5.73	5.86	5.21	2.11
2. Vibration exposure	1.45	3.00	2.64	0.89
3. Cold load	1.18	1.29	3.14	1.00
4. Heat load	4.25	4.29	5.29	2.22
5. Insufficient ventilation	5.45	4.86	5.93	2.67
6. Insufficient workplace lighting	3.64	3.71	5.64	0.78
7. Inappropriate organized workspace	1.36	1.29	3.14	1.67
8. Insufficient handling space	0.91	0.86	3.57	1.33
9. Hazards related to the operation of the equipment	5.45	6.00	2.36	2.00
10. Other (what kind)	0.55	0.00	0.00	0.00

Psychological stress factors also occurred in the monitored companies. Workers most often marked individual factors as a mean value from the scale, which documents the occurrence of the risk, but not significant. The nature of the factors of mental stress is different according to the way of work of individual working groups, as shown in table 5. It is interesting to note that factors affecting the psychological burden of technical-economic staff affect more than factors of work and working environment, which we assume are related to the nature of their work. These risks can be reduced by introducing training and appropriate personal protective equipment.

Tab. 5 *- Influence of factors of psychological stress subjectively evaluated by employees*

Mental stress factors	**Work group acronym**			
	CNC	**CM**	**MW**	**TES**
1. Working under time pressure	4.09	4.86	5.57	6.11
2. The forced pace of work	2.36	4.86	3.57	4.11
3. Shift work	0.91	1.57	2.57	1.11
4. Concentration-disturbing effects at work	1.55	1.27	2.79	4.77
5. Improper communication with employees	2.45	0.91	4.14	2.27
6. Inappropriate communication with superiors	3.00	1.82	2.50	4.44
7. Workload, fulfilling demanding tasks	2.82	2.91	3.64	4.89
8. The risk to your own life and health	4.64	3.36	3.93	3.00
The risk to life and health of others	3.00	4.71	3.43	2.00
10. Other (what kind)	0.00	0.00	0.00	0.00

DISCUSSION

As the results of the pilot survey show, there are factors in the workplace that affect the work performance and comfort of employees. It suggests that it makes sense to address the reduction and elimination of the negative impact of work environment factors. In the sample of respondents selected by us from the analysis of randomly selected companies, it turned out that it is necessary to address the impact of work environment factors on the employee because due to the similar nature of work activities, there are similar shortcomings in workplaces. However, these are factors that can be reduced or eliminated by appropriate technical and organizational measures.

Due to the low sample size in the pilot survey, it is necessary to perform a more detailed analysis in small engineering companies to confirm the impact of selected factors of the work environment in the workplace in order to be able to generalize the results. In addition to the indicated trend of the influence of selected factors of the working environment on employees, it is also necessary to quantify the values of the odds ratio and 95% confidence limits for all factors that may affect the health of employees.

The next step will be to gather information on the factors of the working environment in medium and large companies. It is necessary to verify whether the occurrence and intensity of selected factors of the working environment depends on the size of the company or whether the type of industry in which the company operates has a significant impact. Based on a detailed analysis of work environment factors, it will be possible to quantify the impact of selected factors. The results will be used in the creation of the methodology of combination and recombination factors of work comfort of employees, which is the goal of the project VEGA 1/0101/18 - Proposal of the combination and recombination methodology for the work comfort index in mechanical engineering industrial plants.

CONCLUSION

The paper describes the experience and results of the survey in small engineering companies. The survey was used to identify frequently occurring work environment factors affecting the employees´ work comfort. The starting point was the analysis of work factors, work environment and workload of the employees, the severity of which is a possible evaluate through the impact on employee´s health. It will be necessary to carry out a detailed epidemiological study aimed at evaluating the factors influencing the work comfort of employees in medium and large companies. The results will be included in the proposal of the combination and recombination methodology for the work comfort index in mechanical engineering industrial companies.

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REFERENCES

ALEKSIĆ, A. et al.: 2009, *Bezbednost i zdravlje na radu*. Monograph. Novi Sad, Serbia.

European Working Conditions Survey, 2019. Available on: https://www.eurofound.europa.eu/sk/surveys, Accessed from: 2020-11-02

FERNÁNDEZ-MUÑIZ, B., MONTES-PEÓN, J. M. AND VÁZQUEZ- ORDÁS, C. J.: 2009, '*Relation between occupational safety management and firm performance', Safety Science*. Elsevier Ltd, 47(7), pp. 980–991. doi: 10.1016-/j.ssci.2008.10.022.

Internet labor market guide. Work environment, 2019. Available from: https://www.istp.sk/clanok/35/pracovne-prostredie, Accessed on: 2020-11-02

KAPUSTOVÁ, M., 2004, *Application of mathematical methods in ecological work environment in engineering operations*. Available from: https://www.mtf.stuba.sk/buxus/docs/internetovy_casopis/2004/2/kapustova.pdf, Accessed: 2020-11-02

PAULÍKOVÁ, A., UBÁROVÁ, M.: 2018, *Proposal of indexing process of working comfort factors in operations*. In: VIII. medzinárodná vedecká konferencia, Bratislava, 9. november 2018, ISBN 978-80-89753-24-6

VULANOVIC, S., ZIZAKOV, M., VASIC, S., DELIC, M. & SREMCEV, N.: 2019, *The Impact of Occupational Health and Safety (OH&S) Management Systems on Risk Management Practices.* Proceedings of the 30th DAAAM International Symposium, pp.1188-1195, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-22-8, ISSN 1726-9679, Vienna, Austria DOI: 10.2507/30th.daaam.proceedings.167

Working conditions, 2020. Available from: http://www.ilo.ch/global/topics/working-conditions/lang--en/index.htm, Accessed on: 2020-11-10

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INDUSTRY 4.0 IMPACT ON LABOUR MARKET AND HR MANAGEMENT

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ABSTRACT

Each industrial revolution has caused changes in most parts of the world in its own way. However, the latest revolution, the so-called Industry 4.0, with its depth and breadth, absolutely changed the thinking and functioning of organizations, including human resources in companies. The aim of the paper is to theoretically summarize the main findings about the changes and effects from new technologies according to Industry 4.0 requirements that have been recorded in the Labour Market and in the Human Resource Management. New technologies are bringing a new era, new business, new approaches to functioning, as well as new jobs that require new competencies and promising skills. The findings show that HR professionals play a key role in developing their competencies to create opportunities and mitigate the challenges that Industry 4.0 brings to HR. Study also state that several authors began to deal with the various influences of Industry 4.0 on Human Resources and agree that the impact of Industry 4.0 on HR is understudied than in other areas. However, it is necessary in the future to determine the more precise changes that companies have to make in field of HR.

KEY WORDS

Industry 4.0, Human Resource Management, Labour Market, Competencies and Skills

1 INTRODUCTION

Nowadays we are living in a time of technological revolution that is fundamentally changing the way we live, work and communicate with each other. In its extent, scope and complexity, this transformation is the most fundamental for whole world in recent times. The speed of current discoveries and changies has no historical precedent, compared to previous industrial revolutions (Wojčák, et al., 2018).

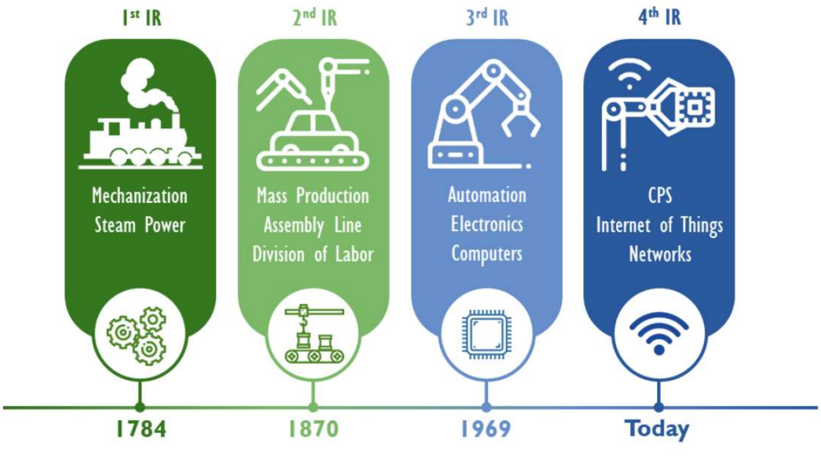

***Figure 1**: The Four Industrial Revolutions (Speringer; Schnelzer, 2019)*

The first industrial revolution used steam to mechanize production, the second used electricity and belt production to create series production, the third already used electronics and information technologies for production automation. The current fourth industrial revolution, the so-called Industry 4.0, also known as the digital revolution, is characterized by the fusion of technologies that blur the boundaries between the physical, digital and biological spheres (Speringer; Schnelzer, 2019).

There is currently no precise definition of the term Industry 4.0 (Richnárik, 2019). We encounter various forms of its definition, the main idea is the digital connection of production machines, manufactured products, information systems, support activities and other parts of the manufacturing company. Thanks to the complete digitization of production elements, processes and control systems, it allows to create a virtual company that identifies with the real one, which allows continuous improvement of production structure, use of Smart data, communication and cooperation of intelligent elements, as well as learning and self-organization.

Industry 4.0 is evolving at an exponential rather than a linear pace and is affecting every industry in countries around the world (Schwab, 2016). Changes in this scope and depth predetermine the transformation of entire production and management systems. The possibilities of billions of people connected by mobile devices, with unprecedented computing power, data storage capacity and access to information and knowledge, are unlimited and are amplified by constantly emerging new technical discoveries in various areas such as artificial intelligence, robotics, internet of things, autonomous vehicles, 3D printing, nanotechnologies, biotechnologies, materials science, energy storage and quantum calculations.

By combining information technology and operational technologies, companies are beginning to look for new ways to connect, and data collected from suppliers, customers and the company can be reconciled with detailed production information, enabling real-time connectivity. The digital and physical worlds are connected, all activities are irreversibly linked to machines, systems and people who are able to exchange information and adapt automatically (Wilkins, 2019). The ability to utilize the benefits that new technologies could bring will depend, among other challenges, on the labour market's ability to adapt (Kergroach, 2017). Currently technological change is one of the main factors influencing labour markets, skills demand and supply, and the structure of occupations.

1.1 INDUSTRY 4.0 AND LABOR MARKET

The labour market has undergone remarkable changes in terms of technological change. The influence of Industry 4.0 on the labour market has been researched by several authors with different views on the issue. According to Rotman (2013) the automation as a backbone of paradigm Industry 4.0, could be considered as a threat from one point of view. However, they could enhance the productivity of many workers, some occupations could be vulnerable and they are likely to be substituted, because of Artificial intelligence and Big data more human-like abilities. At the same time, skills problems can lead to the employment of the workforce in unsuitable jobs, which causes workers to be stressed, are constantly under pressure, which is reflected in the performance of work (Lloyd; Payne, 2009).

Industry 4.0 from labour market point of view is particularly beneficial in developed countries with strong emphasis on technology and R&D (Nafchi, M. Z. et al. 2018), which are gaining a new competitive advantage but also causing unemployment due to the transition to automation. According to Frey and Osborne (2013) there are areas where the risk of replacing human resources with robots is almost certain, or more than 90%, but there are professions where replacement is unsolvable, could be rather supportive, although artificial intelligence is becoming more advanced and its ability level also increases the threat of replacing human resources with robots. Current trends show that the employment of the workforce in routine operations is reduced, these activities can be well algorithmized and thus easily replaced by intelligent machines (Autor, 2013). Structural changes in the labour market are increasingly visible. Workers are moving from middle-income jobs to lower-income professions and activities. These are essentially service professions that have the character of manual professional work, and are therefore less sensitive to computerization, as they require a greater degree of flexibility, creativity or physical adaptability. At the same time, the demand for a creative, workforce capable of skilfully solving problems is growing. Changes in labor market trends are also reflected in education, and there is a growing demand for institutions with high professional standards of education for professionals able to solve complex cognitive problems.

Progress in machine learning, big data, robotics, and artificial intelligence will inevitably prompt automation, changing labour demand and job description (McAfee, et al., 2011). However, technical progress and automation of processes will no longer be limited to physical or manual tasks, dirty, dangerous, boring or repetitive tasks without the need for reflection, but may jeopardize many intellectual, cognitive or analytical administrative tasks involving some common tasks, for example in areas such as transport, office support or consumer services (Arntz et al., 2016).

Because of new approach to business, new products and processes will new kinds of jobs appear. As an example, in field of digital transition and big data are increasing demand for data specialists and skills for data analysis that far exceeds current supply and as well current capacity of the education and learning and development systems. Although the occupational structure has already evolved in many countries, with job creation polarizing high- and low-skilled occupation groups and job losses concentrated in middle-skilled routine occupations, the areas, scope and scale of the occupation in field of creative work are still unknown (Autor; Dorn, 2013). Given the potentially significant implications and uncertainty in predicting technology R&D that current technological transformations could have on manufacturing systems and companies as a whole, policy makers need evidence and preliminary information to predict at least the approximate impact of technological change on job skills and working conditions, as well as for the design and evaluation of science, technology and innovation policy (Kergroach, 2017). Emerging jobs may differ from the original standard model of full-time employment and may take various forms such as part-time, temporary employment, on-call time, etc. Emerging technologies make it possible to divide existing jobs into smaller tasks to support global and digital production. Increasing and improving not only the manufacturing sector but also services in the economy further supports the fragmentation of employment into smaller units of self-employment. Work has already become more fragmented with a growing number of workers holding non-standard jobs or operating non-standard jobs as a subsidiary to supplement income from their normal work activities (Bőgenhold, et. al. 2017).

1.2 COMPETENCES AND SKILLS IN INDUSTRY 4.0

New technologies are bringing a new era, a new business, new approaches to functioning, as well as new jobs that require new competencies and promising skills. While new jobs will require new knowledge and new skills, the right combination of skills needed to perform in modern societies is becoming increasingly complex and will continue to evolve with the development of a technologically advanced work environment, requiring future generations of workers to develop digital skills and competences for lifelong learning at an early age. More difficult automation tasks so far include problem-solving skills, intuition, creativity, and persuasion (Frey; Osborne, 2013).

In the developing world, soft skills such as organization, management, teamwork or communication skills are also likely to grow in importance. Changing educational profiles will require renewed education and training policies and new ever-improving approaches to teacher training (Shamsi, 2017). Companies will build their human capital on the basis of new skills, they will also implement organizational changes and adopt new management procedures in order to ensure the effective use of their intangible assets (Zavyalova, et. al. 2017). Overall, inequalities and social fragmentation, which could potentially arise from emerging technological change, are a matter of great concern, as inequalities will not only result from job losses and job polarization, but also from weaker social mobility and the persistent digital divide. The polarization of the work is likely to affect the middle class of the white collars. Social inequality is also likely to worsen in different industries, regions or occupations, as the digital divide between those who can and those unable to keep pace with widening technological changes (Kergroach, 2017). For example, women have historically been under-represented in science and technology, and digitalization is helping to bridge gender gaps in all labour markets. The economy of digital platforms could provide opportunities for greater work flexibility and at the same time a better work-life balance or to reduce cultural barriers and equal conditions for women and men. Of particular concern is the potential dismantling of the 20th century employment model, which has increased with mass production and links contract employment to salaries and the social system. Employment, pension, health care and social security systems are closely interlinked, with salary-based taxes accounting for a significant share of public resources and budgetary sustainability. Ensuring the resilience, adaptability and efficiency of labour markets is therefore not only a matter of focusing on the skills needed for the future production revolution, but also a prerequisite for social stability and cohesion.

Generally according to Feng and Richards (2018), the competencies required for Industry 4.0 are divided into three basic groups:

- **technical competences** refer to knowledge, skill or abilities needed to perform a specific task,
- **managerial competences** are defined as skills and abilities for general problem solving and decision-making,
- **social competences** are defined as maintaining interpersonal relationships in an organization, which in turn requires communication skills.

Under other conditions, Závadský and Závadská (2020) divided managerial competences that affect the deployment of the concept Industry 4.0 into two groups:

- first group of personnel management factors **apply to the employee** and have included general and professional competence, practical and application skills, social and professional maturity, ability to teach and the powers, responsibilities and duties of the staff member.
- second group **relate to the induced organizational innovation** and have included the following types of organizational innovations: innovation of management methods and tools, innovation of work places (not technological), innovation of organizational structure, innovation of internal and external communication, innovation of information system and innovation of organizational culture.

Most researches and studies are based on hypothesis that human resource represent a significant driving force and challenge for the Industry 4.0 enterprises. On the contrary, some authors point out that they do not see human resources as a driving force but rather as an obstacle to Industry 4.0 implementation when they lack necessary competences and skills (Herceg, et al. 2020). Digital transformation leads to more complex tasks and processes from HR point of view, which needs to be discussed more deeply.

1.3 INDUSTRY 4.0 AND HUMAN RESOURCE MANAGEMENT

All these turbulent changes and arrival of the new technologies point to the growing importance of readiness of human resources, which are the most important engine of companies (Koubek, 2007). HR preparedness is necessary not only in terms of connection of their knowledge management and the information technologies used in organizations (Bellanca, 2010) but also due to a change in the view to perform the work itself and the competencies that are necessary to perform the work.

The problem of changes in the competence framework presupposes a three-dimensional approach involving (Erol, et al.,2016):

- level of management of the company,
- areas of the production process,
- types of competencies.

According to Gan and Yusof (2019), there are six types of human resource activities that play key roles in organizations with respect to Industry 4.0, namely knowledge management, human resource policy making, training, recruitment, compensation and benefit system, job design. All these areas should improve the company's performance if they build on each other and ensure that the workforce has the necessary and key skills currently available. However, it is necessary to identify strategies for change while preparing for their responses to adaptation (Ahmad, 2020). An interesting change in the view of technology and effective exchange of information is the new model of the system of interconnection of key factors of business operation (Sima, et al., 2020). From the original model where the interconnection of information, knowledge and innovation dominated, Industry 4.0 brings a model where it focuses on the interconnection of human intelligence, new information technologies, information and innovation.

However, Dohale and Kumar (2018) in their review of the literature on industry 4.0 point out that only a small and thus insufficient part of the research deals with the connection of industry 4.0 with human resource management and therefore consider this area suitable for research in future studies. According to Wojčák, Copuš and Majtánová (2018) an appropriate source for the analysis and definition of HR requirements for these days could be a theoretical analysis and summarization of changes related to human resources during previous industrial revolutions, as well as outlining current trends in management in terms of knowledge under the influence of technological developments in IT. In connection with the issue of human resources and their knowledge in the context of industry 4.0, there are several unexplored areas. One of the most important tasks within HR management is to define the requirements that will be placed on human resources in terms of their knowledge in the context of Industry 4.0 (Šajgalíková; Copuš, 2018).

The study of HR competencies by Ulrich, Younger, Brockbank and Ulrich (2012) narrows this broad overview and identifies several basic domains of competencies. The first is the **strategic positioner** and will include the ability to interpret external trends focused mainly on technological progress, integrate them into internal actions and clearly communicate their impact on their workforce. In addition, the **capability builder** should have the ability to build critical organizational skills. With the many changes that are taking place as a result of Industry 4.0 (Jesuthasan, 2017), being a **champion of change** is a crucial competence - the ability to implement organizational change and implement change processes at the same pace as happening externally. Finally, **technology proponents** are very important because of the fact that we are in the digital age.

In addition to the above competencies, total reward stewards, analytics and compliance managers are also essential. The total reward manager is concerned with implementing a scheme that is meaningful and exciting for existing employees while attracting potential employees (Prikshat, et. al., 2018). The competence of the analyst and interpreter describes the skill of the HR specialist in using analytics to improve decision-making. Finally, the compliance manager refers to the ability to use regulatory guidelines to manage compliance processes.

As the deployment of automation is accelerated, the required number of employees performing redundant process-based tasks is reduced, whether in a production or office environment. Industry 4.0 is supported by technology and development, but HR remains a cornerstone of all this (Liboni, et al., 2019), encompassing the way people interact, the technology and inventions evolving in the industry and the way they relate to new business. model. Companies urgently need to align their human resources practices and plans with Industry 4.0, including areas such as skills development and workforce employment (Sivathanu; Pillai, 2018). The role of the HR department in the organization is to manage all aspects related to the employee cycle, from the recruitment to the exit phase. Although the role of HR is important for organizational development, recently, human resources departments have been perceived as operational departments with unproductive practices that are exacerbated by outdated technology. Therefore, the HR department itself should consider a major organizational change in all procedures for solving everyday tasks. HR professionals are forced to evaluate the functions and roles they play in Industry 4.0, because they need to be the first to navigate their direction in this technologically driven revolution (Łupicka; Grzybowska, 2018).

On the other hand, several authors agree that the role of top management, leadership style, competence and skills is an area where more input, analyses, hypotheses and studies are needed, together with the role of human resource management in Industry 4.0, which is still an understudied topic with not enough results useful for companies (Chang; Yeh, 2018).

2 CONCLUSION

This study set out to understand the influence of Industry 4.0 on Human Resources as well as role of HR professionals in Industry 4.0. The study makes an important, practical and scientific contribution to the understanding of labour market and Human Resources Management with regard to the requirements of Industry 4.0. The findings show that HR professionals play a key role in developing their competencies to create opportunities and mitigate the challenges that Industry 4.0 brings to HR. Industry 4.0 presents uncertainties such as job loss, making it necessary for HR professionals to put human capital at ease and equip them with the skills needed to navigate industry 4.0. Study also state that several authors began to deal with the various influences of Industry 4.0 on Human Resources, though the analyses by Dohale and Kumar, and Chang and Yeh agree that the impact of Industry 4.0 on HR is understudied than in other areas. Since these are Human Resources, which are often unpredictable and at the same time new technological changes, which are also more difficult to predict, it is not easy to research and assume what affects and does not affect the commitment of Industry 4.0 to society. However, it is necessary in the future to determine the more precise changes that companies have to make with regard to human resources. In this regard, space is being created to create a so-called HR 4.0 strategy, which will determine how companies should behave when implementing Industry 4.0, how they should approach HR properly in these turbulent times and what to look out for. The HR 4.0 strategy should be focused on existing employees, the possibilities of how to digitize their positions and at the same time train them as needed, or on retraining for a new position or termination of employment. In the case of new potential employees, new plans and procedures should be defined as part of the HR 4.0 strategy on how to acquire interesting talent, or if the labour market does not provide sufficiently qualified employees, such as created training plans for new employees to be able to perform work under Industry 4.0 requirements.

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REFERENCES

AHMAD, N.; SHAMSUDDIN, A.; ASLINDA, A.S. 2018. Industry 4.0 Implications on Human Capital: A Review. In: *Journal for Studies in Management and Planning*. 2018, 4, p220–235. ISSN: 2395-0463

ARNTZ, M., GREGORY, T., ZIERAHN, U., 2017. Revisiting the risk of automation. *Economics Letters.* 159, p.157–160. ISSN: 0165-1765

AUTOR, D. AND DORN, D. 2013. The growth of low skill service jobs and the polarization of the US labor market. *American Economic Review*, 103(5). ISSN 1944-7981

BELLANCA, J. A., Brandt, R., 2010. *21st Century Skills: Rethinking How Students Learn*. Solution Tree Press, 409p. ISBN-13: 978-1935249900

BŐGENHOLD, D., KLINGLMAIR, R., KANDUTSCH, F. 2017. Solo-Self-Employment, Human Capital and Hybrid Labour in the Gig Economy In: *Foresight and STI Governance*, 11(4), p.23–32. ISSN 2500-2597

CHANG, Y.H.; YEH, Y.J.Y. 2018. Industry 4.0 and the need for talent: A multiple case study of Taiwan's companies. *International Journal of Product Development*. 22, p.314–332. ISSN: 1741-8178

DOHALE, V. , KUMAR, S. 2018. A Review of Literature on Industry 4.0. In: *National Convention of IIIE and International Conference* at: Bhubneswar.

EROL, S.; JÄGER, A.; HOLD, P.; OTT, K.; SIHN,W. 2016. Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production. *Procedia CIRP* 2016, 54, p.13–18. ISSN: 2212-8271

FENG, Y., & RICHARDS, L. 2018. A review of digital curation professional competencies: Theory and current practices. *Records Management Journal*, 28(1), 62–78. ISSN: 0956-5698

FREY C.B., OSBORNE M.A. 2013. *The future of employment: How susceptible are jobs to computerisation?*, Oxford, UK: University of Oxford. 79p. [cit. 2020-11-11] Available online: https://www.oxfordmartin.ox.ac.uk/downloads/academic/future-of-employment.pdf

GAN, J.L., YUSOF, H.M. 2019. Industrial Revolution 4.0: The Human Resource Practices. *International Journal of Recent Technology and Engineering*, 8, p.620–624. ISSN: 2277-3878.

HERCEG, I. V., KUČ, V., MIJUŠKOVIC, V. M., HERCEG, T., 2020. Challenges and Driving Forces for Industry 4.0 Implementation in: *Sustainability.* 12. 22s.

JESUTHASAN, R. 2017. HR's new role: Rethinking and enabling digital engagement. *Strategic HR Review*, 16(2), 60–65. ISSN: 1475-4398

KERGROACH, S. 2017. Industry 4.0: New Challenges and Opportunities for the Labour Market. *Foresight and STI Governance*, vol. 11, no 4, pp. 6–8. ISSN 2500-2597

KOUBEK, J. 2007. Řízení lidských zdrojů. 4.vyd. Praha: Management Press. 399s. ISBN 80-7261-033-3.

LIBONI, L.B., CEZARINO, L.O., JABBOUR, C.J.C., OLIVEIRA, B.G., STEFANELLI, N.O. 2019. Smart industry and the pathways to HRM 4.0: Implications for SCM. *Supply Chain Management: An International Journal,* 24(1), 124–146. ISSN: 1359-8546

LISÝ, J. A KOL. 2007. *Ekonómia v novej ekonomike*. 2. vyd. Bratislava : IURA EDITION. 634 s. ISBN 978-80-8078-164-4.

LLOYD, C., PAYNE, J., 2009. Full of sound and fury, signifying nothing': interrogating new skill concepts in service work — the view from two UK call centres. *Work Employment and Society*. 23 (4), p.617–634. ISSN: 09500170

ŁUPICKA, A., & GRZYBOWSKA, K. 2018. Key managerial competencies for industry 4.0-practitioners', researchers' and students' opinions. *Logistics and Transport*, 3(39), p.39–46. ISSN: 1366-5545

MCAFEE, A., BRYNJOLFSSON, E., DAVENPORT, T.H., PATIL, D.J., BARTON, D., 2012. Big data: the management revolution. Harvard Business Review. 90 (10), p.60–68.

NAFCHI, M.Z.; MOHELSKÁ, H. E: 2018. Effects of Industry 4.0 on the Labor Markets of Iran and Japan. *Economies*, 6, p.39. ISSN 2227-7099

PRIKSHAT, V., BISWAS, K., NANKERVIS, A., HOQUE, M.R. (2018). Bangladesh HR professionals' competencies: Impact on firm performance and moderating effects of organisation life cycle. *Evidence-Based HRM: A Global Forum for Empirical Scholarship*, 6(2), p.203–220. ISSN: 2049-3983

RICHNÁRIK, P., SARMÁNY, J. 2019. Vývoj a postavenie Industry 4.0 vo svete a na Slovensku*. Manažment podnikania a vecí verejných*, 14 (2), 3-9. ISSN 2453-8167

ROTMAN, D. 2013. How Technology Is Destroying Jobs. *MIT Technology Review*. [cit. 2020-11-11] Available online: http://www.technologyreview.com/featuredstory/515926/how-technology-is-destroying-jobs/

SAMUELSON, P. A., NORDHAUS, W. D., 2010. Economics. 19.vyd. New York: McGraw-Hill/Irwin. 745 s. ISBN 978-0-07-351129-0

SCHWAB, K. 2016*.* The Fourth Industrial Revolution: what it means, how to respond in: *World Economic Forum*. [cit. 2020-11-11] Available online: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

SHAMSI, A. 2017. Relationship between Knowledge Management and Managerial Skills: The Role of Creative Thinking, *Foresight and STI Governance*, vol. 11(4), p.44-51. ISSN 2500-2597

SIMA, V., GHEORGHE, I.G., SUBIC, J., NANCU, D., 2020 Influences of the Industry 4.0 Revolution on the Human Capital Development and Consumer Behavior: A Systematic Review: *Sustainability*, 2020 12, 4035 p.3. ISSN: 1475-4398

SIVATHANU, B., PILLAI, R. 2018. Smart HR 4.0 – How industry 4.0 is disrupting HR. *Human Resource Management International Digest*, 26(4), 7–11. ISSN: 0967-0734

SPERINGER, M., SCHNELZER, J., 2019. Differentiation of Industry 4.0 Models. The 4th Industrial Revolution from different Regional Perspectives in the Global North and Global South, In: *Regional Academy on the United Nations (RAUN)* "Innovations for Development: Towards Sustainable, Inclusive, and Peaceful Societies." Vienna. [cit. 2020-11-11] Available online: http://www.ra-un.org/publications

ŠAJGALÍKOVÁ, H., COPUŠ, L. 2018. Heroes as Predictors of Future Employees' Behaviour. Proceedings of 3rd International Conference on Economic and Business Management (FEBM 2018), Hohhot, China. p. 388-391. ISBN 978-94-6252-623-5

ULRICH, D., YOUNGER, J., BROCKBANK, W., ULRICH, M. 2012. HR talent and the new HR competencies. *Strategic HR Review*, 11(4), p.217–222. ISSN: 1475-4398

WILKINS, J. 2020. How Industry 4.0 Is Impacting Globalization: *RELIABLE PLANT*. [cit. 2020-11-11] Available online: https://www.reliableplant.com/Read/31002/industry-4-globalization

WOJČÁK, E., COPUŠ, L., MAJTÁNOVÁ, M. 2018. Requirements on Human Resources in Context of Industry 4.0:*GRANT journal*, 7(2), p.6-11. ISSN 1805-0638

ZÁVADSKÁ, Z., ZÁVADSKÝ, J. 2020*. Industry 4.0 a inteligentné technológie v rozvoji manažmentu výroby podniku.* Banská Bystrica:Belianum.p.114. ISBN 978-80-557-1732-6

ZAVYALOVA, E., KUCHEROV, D., TSYBOVA, V. 2017. Human Resource Management at Russian Companies — Leaders of the Global Economy In: *Foresight and STI Governance*, 11(4), p.52-61. ISSN 2500-2597

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EVERY SECOND COUNTS – BIG DATA ASA FUTURE-ORIENTED ONE OTIMNIZATION FACTOR IN LOGISTICS

Thomas MEIER, Helena MAKYŠOVÁ

Abstract
The aim of the article is to identify potential in logistics in the context of Big Data. The previous article 'Higher, faster, further, more efficient - the future of logistics' serves as the intellectual foundation of the analyzes. Current articles, interviews and conference reports are structured and analyzed from various databases. In essence, it is about the optimization potential of processes in a business context. The references of the identified papers are examined and critically assessed. In particular, Supply Chain Management (SCM) should be examined in more detail and to what extent large data sets can lead to optimization potential. The change in the nature of supply chain management should act as a central message of the article. Has SCM changed, if so, to what extent and how? In addition, tasks and challenges facing supply chain management should be defined and an outlook on future developments in the industry should be given. The article is intended to show that the logistics of the future is not a self-contained discipline of business administration isolated from the outside world, but is growing or has already grown into a key function of the economic trade of companies.

Keywords
Big Data; Supply chain management; Customer relationship; Potential of Big Data; demand production

Globalized logistics

The logistics industry has been shaped by increasing globalization in recent years. This results in ever increasing average transport distances. In addition, logistics companies are forced to follow their clients in their offshoring activities - i.e. when they relocate production to remote, low-wage countries. For this purpose, appropriate path potentials must be made possible and the complexity in strategic, operational and legal matters is increasing. The changed geographic market structures are also forcing logistics service providers to rethink existing network strategies. With growing globalization and the associated competitive pressure, companies are subject to the challenges of efficient planning and control. It is therefore important, for example, to avoid empty transports, to design deployment plans as efficiently as possible and to minimize turnover rates, turnover times and damage to goods and personnel costs. The entire process planning must therefore be optimized, stocks reduced and administrative costs reduced as much as possible. However, the requirements of the client must always be guaranteed, e.g. B. in terms of deadline reliability, delivery reliability, service level, low purchase prices, short order processing times, flexibility, availability, capacity utilization and productivity. In the past few years it has been possible to reduce the proportion of empty journeys in long-distance transport to around 10 percent. In addition, there has been a steady trend towards increased environmental awareness for a number of years - and the associated increased aversion to road traffic, which is extremely polluting. Challenges that could be mastered with an intelligent structuring and analysis of large amounts of data - Big Data.

The role of Supply Chain Management

For Tine Dalby, Director Germany in the field of supply chain consulting at the market analysis company Gartner, Supply Chain Management (SCM) is about to become the key function of the future.[1] Dalby posits that in many leading companies that invest in the maturity of their supply chain, it is already the case that they not only survive, but grow continuously. “The supply chain function is no longer just a provision apparatus, but a pioneer for excellence throughout the company.” Companies are expected to do much more than offer differentiated customer experiences, they should also increase the speed to the consumer, the costs and continuously improve the quality of the logistics service while still appearing in an ecologically correct manner. The latter aspect in particular will play a decisive role in the battle for competitive advantages in the future. A company that does not meet these criteria will be excluded from the market and politics. A key factor for companies to do business sustainably could be rethinking their procurement strategies. The implementation of Big Data will also be faster than ever in the field of logistics and Supply Chain Management. On the one hand, the digital transformation is catching on quickly due to new and more mature technologies and, on the other hand, because companies are more and more using data handling and analysis. Qualified employees who specialize in the analysis of large amounts of data are sought-after employees in companies with the necessary resources. A growing number of companies are still experimenting with blockchain technology and artificial intelligence, mostly on a project basis. Traditional approaches to delivery management are still being pursued in parallel. Here, however, the gap between the classic approach and the market leaders seems to be wide. Medium-sized companies in particular have some catching up to do in this area. 'Anyone who wants to improve decision-making processes or make better decisions in their company must use analytical methods and some form of business intelligence or artificial intelligence (AI)'[1].

Supply Chain Management versus logistics

The creation of object rivers along the process steps of a chain of delivery summarizes the definition of Supply Chain Management probably best of all. The Supply Chain Management can be described simplistically as a sequence or chain by activities to serve customers and/or markets successfully – to work more efficiently and more actually. However, in contrast to classical logistics concept, SCM goes out the borders of the company. Logistics as well as Supply Chain management are aimed at the increase of the customer use as well as at a better cost use relation. Modern SCM includes the structuralising and coordination autonomous of operating enterprise unities in an added value system explicitly in the Analyse. Thus, for instance, areas of the business administration are integrated like purchase, production or also marketing and Controlling and the process along the chain of delivery comprehensively evaluate. Besides, the SCM leaves tactical questions to the single representatives of the subranges. Therefore, SCM guarantees the planning going out the enterprise along the processes and allows the control. A modernization is further, or an extension of the logistics draft come during the years – which wins the most favorable / most dependable draft – from miseries. The customers call this and therefore the factor becomes customer contentment also in the logistics the task.[2] An example of it is on-line trade which booms topically in the Pandemic. If the order process has been optimized as such from that point of view to do it to the customer so simply as possible to deliver an order and to allow this in addition still round-the-clock, now he also wants to be supplied quite individually. A known annoying problem is present that a parcel finds just the destination when the principal is not to be found. Also, the real duration of delivery plays a determining role to the increase of the customer contentment. Among the rest, a comparative competition advantage of a classical retail shop consists in the fact that the customer must wait as a rule just not for his product. Loose the conclusions from which delivery time a customer would choose the alternative of the classical retail shop can be derived from the following statistics. The graphic arts show the result of a survey to the satisfactory duration of delivery with on-line ordered product in well-chosen European lands in 2019.

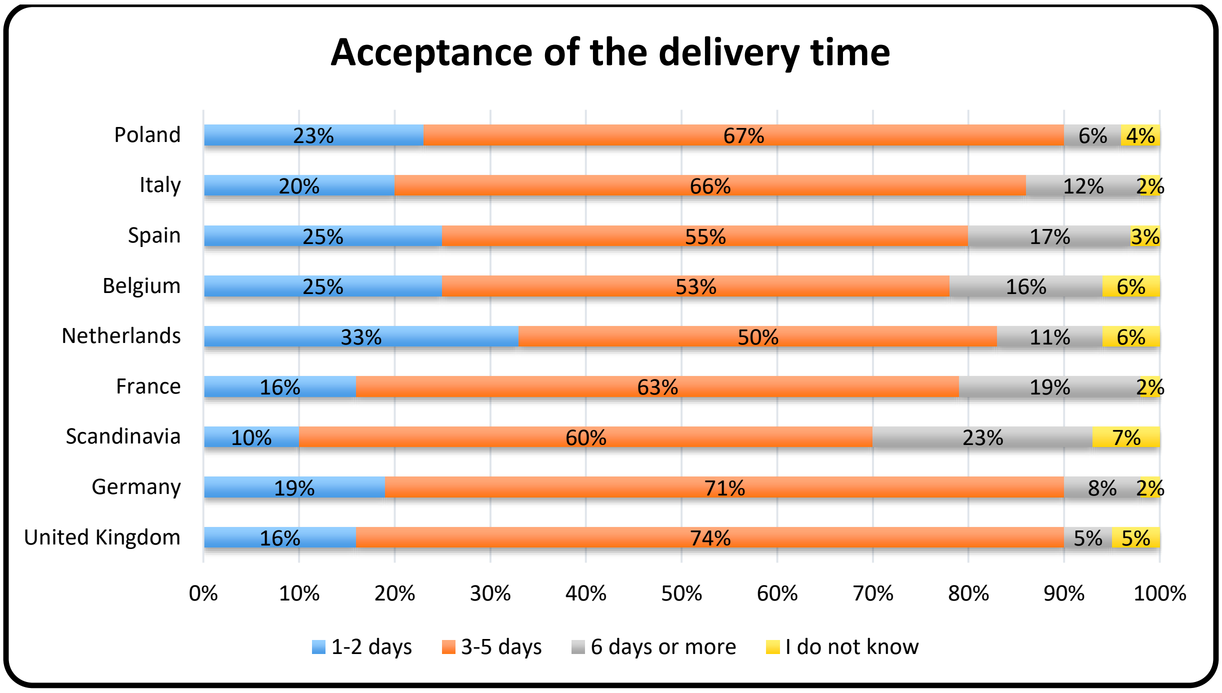

***Figure 1** - Acceptance of the delivery time (own presentation) – own representation [3]*

The customer acceptance for longer vantage point or delivery times seems to decrease from 5 days clearly. Only about 13 percent (as an average) of the questioned customers are ready to wait longer than 6 days for her product and a standard divergence of about 6 percent allows to suppose not exactly unity about these circumstances. The Scandinavians are almost three times more patient with 23 percent than the German on-line customers. To look at missing patience as a gap in the market and with-it commercial model, or to generate at least competitive advantages, is sure only one potential challenge of a comprehensive logistics. Big Data could be here the key to the success. A package that "knows" whether and when its customer is at home is a big step in the future of modern logistics.

New tasks in the Supply Chain management

Now further the shorter and shorter product life cycles must be also looked beside the customer contentment. A subject what was left earlier to the strategical management. Narrow so that are connected flows of information and monetary streams which must be steered and be formed. This has a direct influence on supplier's relations which refer no more only to the logistic part in the classical sense. New tasks in the Supply Chain can be derived from the shortened challenges now management.[4]

1.) Customer-Relationship-Management as a new task

The probably biggest potential of Big Data in the enterprise sense is to be met the property prereciting what customers will consume in future. Specific advertisement, allows by huge data amounts the clusters which can define target groups precisely generate. Thus, a logical adjustment can occur in the inquiry, consequently in the needs of the customers. The circle of the target group can be drawn out even more sharply, in so far as that not only the topical needs are recognized, but also are taken into consideration the future wishes can. Further it can be still checked whether the end customer is generally able to consume a product offered to him. Does it permit the economic situation of the customer his individual needs to cover generally? An important consideration which is decisively for the prize creation of a product or service. Decisively for this shown new task, are the apparently always rising customer requirements to which just in the logistic area only now attention is given. In the logistics one has argued to date less with the customer and his needs in himself but to optimize rather with it, the internal-operational processes, movements and the stock management.

2.) Flexibility and meeting demand production

Individualism is the new magic word with the range of products. Only in the automobile industry the buyer can order countless variations of the one and same model. If not only the color or equipment can vary greatly, individual parts / assemblies such as a steering wheel are also blocked individually if the customer requests it. However, individuality in the production contradicts at first the principle that reduction in costs potentials are to be aimed by scale effects. Economies of scale are usually achieved through standardization and control of perception. With it is possible to distribute the fixed costs to a bigger number of pieces. In the logistic context an inquiry cooperation could be aimed here as a partial solution.[5] The purpose of such an approach is to have multiple procurers buy together. This action be unfolded potential concerning the scale effects when it takes an organization-covering perspective. The independent organizations which themselves can operate branch-covering would be conceivable. The high complexity of such a strategy, which has to be reconciled with the specific needs of the individual companies, requires highly efficient data processing and data analysis of gigantic amounts of data - Big Data. In the service industry where the customer is a part of the process the complexity is exactly thereby raised once again. For the economic success of a company, it is of crucial importance to optimize the cost structure of the processes and precisely such information flows. The digital landlord's shaft is particularly important for highly innovative companies. The digitization of information enables these processes to take place in significantly higher quantities and at incomparably lower costs and distributions than was possible with data processing on the basis of physical data carriers.[6]
Thus, the logistics, or more precisely the Supply Chain Management, got a new interface with the controlling. Permanent cost reduction and resource optimization no longer just fill the classic job of product controller, but is integrated as an important sub-area of logistics - and this across all stages of the value chain.

3.) Synchronization of supply with demand

The third new task in Supply Chain Management is closely linked to the points already mentioned: adapting the supply to real requirements. Here, too, the difficulty lies in the accuracy of the prediction. How accurate is a forecast with regard to the future demand for products and services per target group? Jünemann's definition, as already mentioned, does provide the content framework here, but no possible solutions, what “right” means in relation to the right amount, in the right place at the right time, etc. A synchronization can therefore only take place if the exact requirement is known or at least can be estimated with a certain error probability. Closely interwoven with customer relationship management as a task of Supply Chain Management, this challenge poses new questions for Big Data. For example, in the textile industry, production is being relocated to China. Competitive advantages were achieved through inexpensive mass production or the low wage costs. However, especially with fast-moving trends such as fashion, the long transport routes are not advantageous and logisticians try to significantly shorten the supply chains in order to be able to react faster and more flexibly to changes or disruptions. According to the case study on the success story of the Inditex model, Inditex sources over half of its products from Spain, Portugal and Morocco.[7] This initially results in higher costs, but these are offset in the long term because it is much faster to react to trends. There is no speculation about the next trend and production is suspended until there is certainty about what the customer is buying. This means that the goods can be offered at the best price without any discounts and stocks remain minimal.

Potential of Big Data and AI in logistics

Logistics has advanced to the secret supreme discipline of business administration in recent years. Excellent strategic management is as much a prerequisite for the success of a company as a solid financing model, but hardly any other area has come into the priority focus of customers as logistics. If, for example, supply chains are not adhered to, the entire value chain is frozen, which in the worst case means the company becomes insolvent. Large companies, especially in industry, also see potential savings of up to 20 percent. However, a survey addressed to 100 logistics decision-makers from large industrial companies revealed that, despite increasing digitalization, 75 percent of companies do not have an overview of their cost structure, and 80 percent stated that the processes related to the supply chain are not yet sufficiently automated.[8]

One of the most promising potentials that Big Data has to offer is the identification of needs, which in the 'old world of logistics' was understood more as art than science. The latest computing technology and analytics paired with machine learning and artificial intelligence help companies that use these methods to achieve great competitive advantages. However, leading companies here come more from the consumer goods sector or from the high-tech sector.

Another potential arises from the possibilities of networking. These possibilities are currently largely unused due to non-standardized data interfaces and non-integrated planning. This applies both to the internal consideration of the company's own supply chain and to the external consideration when it comes to the integration and networking of business partners.

Decision management can also be expanded. Decision-oriented management is essentially based on the intention to obtain descriptive or prescriptive statements. It is precisely this normative decision theory that does not want to describe decision-making processes as such, but rather to give advice on how to solve decision problems.[9] Companies that do not want to fall behind in this area should - or have to - invest in business intelligence or AI. The focus here is not only on improving performance, but also on the speed at which certain information is received in order to gain knowledge from it. Gartner expert Dalby assumes that many AI projects will be launched in 2020/2021 or implemented in the digital plans of the supply chain department.[1]

Intelligent software and innovative storage technology are necessary to exploit such potential. Due to increasing processor speeds, quantum computing and in-memory databases, ever larger amounts of data can be processed quickly and, above all, inexpensively.

Big Data and the BMW Group

BMW has been using a smart data solution in the company since 2017. The data system accesses all information that occurs in the entire value chain of a car production. At the same time, not only is the process of this value chain analyzed, but also an eye on progress and further development always kept in view. The constant analysis of all areas not only contributes to the improvement of the value chain, but also continuously improves the quality standards.

During quality control, the entire vehicle surface is scanned by a robot. The system is able to recognize at a high level of precision whether a surface is defective. A process that could not be carried out by human hands with this high-quality standard. From the resulting scan, conclusions are drawn about the paintwork, for example, so the processes can be continuously optimized and the potential for errors can be recognized in good time. Constant quality control is not only carried out in the painting, the system also keeps an eye on the execution of the several hundred screw connections. Using a cause-and-effect diagram, the program can analyze types of errors and their sources as precisely as possible and thus adjust production. The algorithms required for this were specially developed by BMW and have been used in all assembly areas on over 3200 systems since July 2017 to analyze screw connections. Investigating such quality processes creates huge amounts of data that have to be collected, structured and finally evaluated. This creates clusters that reveal the main flaws, whereupon the employees can be specifically trained to systematically eliminate these causes of errors. The cost savings potential is enormous.
In connection with Big Data, sensor technology is another important application area in the BMW production chain. Thanks to the favorable price-performance ratio, sensors can be used over a large area to measure temperature, vibrations and electrical power. Huge amounts of data are visualized and analyzed in real time and sent to BMW's intranet of things via live stream. For example, in the production of precision blanks that are obtained from steel rolls, minimal deviations in the blanks in terms of thickness, quality and strength can be decisive for the process with the entire delivery being canceled in the press shop, i.e. at the beginning of the production chain and not just during the quality control of the almost finished component. This saves valuable time and therefore a lot of money.
The prevention of a failure in the highly automated production areas is also possible by reading out and collecting data that result from past system downtimes - true to the motto: A mistake that has not been made does not have to be corrected. System downtimes can be prevented with early detection and targeted maintenance interventions and thus reduced to a minimum. The optimal and real actual state can only be determined and changed to an ideal target state through the extensive reading of sensor data and process data. If these changes are made too early or too late, a production standstill and, in other cases, a waste of resources can be expected.
In production facilities without Big Data, actual wear orientations and standardized change times were the reason for maintenance, and the above-mentioned failures were the result. According to Christian Patron from the BMW Group, "[...] every second counts. If a part is not available on time or a system has a defect, this quickly leads to a delay in the production process and the value chain is disrupted. The intelligent handling of production data ensures a stable and efficient process. With smart data analytics we see great potential to incorporate feedback from our customers into development and production even faster. '[10]

Conclusion- Recommendations for action for companies and a look into the future

Logistics is well on the way to becoming the supreme discipline of business activities. It will become more and more important for the success of a company, especially due to digitization, Big Data and the associated increase in efficiency. A competitive advantage lies, for example, in the procurement of raw materials whose primary form hardly differs in terms of cost from those of the competition. Here, inexpensive, efficient logistics are the key to success. This also applies to products with very short innovation cycles, where profit margins can only be achieved through efficient logistics. Avoiding errors also has huge potential right from the start. If a path is not followed from the start because it is highly likely to be faulty, this saves valuable time and thus a lot of money. Big Data helps identify the cause and adapts all other processes. The supply chain is not stopped, it is not even triggered. Especially in transport, but also in warehousing, a modern supply chain management

includes the structuring and coordination of autonomously acting entrepreneurial units in the analysis. Especially in the field of logistics, the development of the SCM from in-house 'loner' to cross-company all-rounder is particularly noticeable. Holistic logistics not only pose new challenges and new tasks to the SCM, but also transforms the entire logistics area. The implementation of information, material and process logistics requires a readjustment of the individual chain links. Lot sizes, framework agreements and customer acceptance conditions must be recorded and adjusted if necessary. Customers must be able to customize their orders. The analysis of large amounts of data is essential here. All adjustments must be communicated within the company promptly. Time-saving IT connections between decision-makers and the supply chain are therefore essential investments. In return, a large-volume transport business should be avoided. The profit margins are too low to build up the necessary risk buffers. In-house investments in their own transport and terminal capacities should be reduced in favor of IT investments. Information technology and the efficient evaluation of large amounts of data (Big Data)[11] will be the decisive lever for innovations in the future.
How we as a society deal with constant acceleration remains unclear here. However, it seems that we take this development for granted. The large amount of data that we have collected can be used in new ways through Big Data and thus create new value. For whom this value represents real added value remains to be seen.

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Literatur

1. Dalby, T.: Gartner-Expertin: „Künstliche Intelligenz macht große Sprünge möglich“. DVZ Online (2020).
2. Scherf, J.: Selbstbewusste Konsumenten zwingen die Logistik zum Umdenken. MM Logistik, 07.03.2017. https://www.mm-logistik.vogel.de/selbstbewusste-konsumenten-zwingen-die-logistik-zum-umdenken-a-587916/. Zugriff am 02.11.2020
3. Statista: Online-Bestellung - Annehmbare Lieferdauer in Europa 2019 | Statista, 02.11.2020. https://de.statista.com/statistik/daten/studie/652489/umfrage/annehmbare-lieferdauer-bei-online-bestellungen-in-europa/. Zugriff am 02.11.2020.
4. Hofmann, S.: Was ist Supply Chain Management? Definition, Beispiel & Ziele! MM Logistik, 16.01.2019. https://www.mm-logistik.vogel.de/was-ist-supply-chain-management-definition-beispiel-ziele-a-614558/. Zugriff am 02.11.2020.
5. HESS, G.: STRATEGISCHER DIENSTLEISTUNGSEINKAUF. Leitfaden zur systematischen umsetzung im supply management. GABLER, [S.l.] 2020.
6. HOLTFORTH, D.: SCHLSSELFAKTOREN IM E-COMMERCE. Innovationen, skaleneffekte, datenorientierung und… kundenzentrierung. GABLER, [S.l.] 2020.
7. Ferdows, K; Lewis, M; Machuca, J.: Rapid-Fire Fulfillment. Harvard Business Review (2020).
8. Jüngst, I.: Einsparpotenziale in der Logistik, 30.04.2019. https://www.eurotransport.de/artikel/studie-zur-lieferkette-einsparpotenziale-in-der-logistik-10756404.html. Zugriff am 30.10.2020.
9. Laux, H; Gillenkirch, R; Schenk-Mathes, H.: Entscheidungstheorie. Springer Berlin Heidelberg, Berlin, Heidelberg 2018.

10. Kirchbeck, B.: Smart Data Analytics: Jede gewonnene Minute bedeutet ein zusätzliches Fahrzeug. next-mobility.news, 02.10.2017. https://www.next-mobility.de/smart-data-analytics-jede-gewonnene-minute-bedeutet-ein-zusaetzliches-fahrzeug-a-649216/?p=3. Zugriff am 30.10.2020.
11. Makyšová, H; Meier, T.: Big Data: An inventory and the constant search for a definition. International Journal of Recent Engineering Research and Development (IJRERD) (2020) Volume 05 – Issue 07, S. 40–45.

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SENSITIVITY ANALYSIS OF CROSSOVER OPERATORS OF A GENETIC ALGORITHM FOR THE FLOW-SHOP SCHEDULING PROBLEMS

Béla *OLÁH*

Abstract:
The main goal of this scientific work is the sensitivity analysis of crossover operators of my own genetic algorithm (GA) for the permutation flow-shop scheduling problems (FSSP). This paper covers the comparison of the different crossover operators such as Cycle-Crossover (CX) and Order-Crossover (OX) used by the algorithm in function of the efficiency of the near optimal solutions. I analyze how the efficiency of the algorithm changes by some values of the crossover operators, I evaluate the obtained results and I search for relations that help to apply the GA more effectively and efficiently. The practical importance of my research results is to determine in what setting the crossover operators have to be used in order to supply near optimal solutions at the fastest possible time.

Keywords: *genetic algorithm, scheduling, idle time, crossover, cloning*

1. Flow-shop scheduling problem

The flow-shop scheduling problem can be defined as follows: **n** jobs are given which must be processed on **m** machines; all jobs having the same routing. A sequence must be determined which is the best according to certain logistic conditions (Figure 1). The problem can be represented by an (n×m) matrix T, where t_{ij} is the processing time of job i on the machine j. Depending on the problems the unit of time can be optional (eg: minute, hour, day). Further, I assume that the time needed for more jobs between machines is negligible.
The most important aspect of the scheduling problem is the identification of criteria [Evans, 1993] which are used to evaluate schedules. Common scheduling criteria are as follows:
- minimize make-span.
- maximize machine utilization.
- minimize work-in-process inventories.

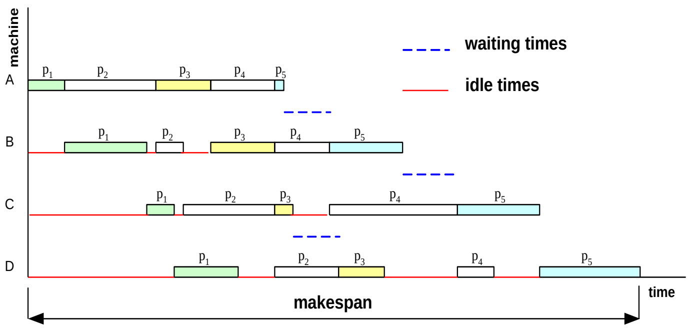

Figure 1 *Gantt chart for a permutation flow-shop scheduling problem.*

The maximum utilization of machines is consistent with minimum idle times of machines. The minimum for work-in-process inventories is the same as minimum waiting time of jobs.

2. Genetic algorithm

Genetic algorithms were mainly developed in the USA by J. H. Holland [Holland, 1975]. They can be used very well for certain solutions of optimization problems like transportation problems, the travelling salesman problem, scheduling, etc.

Figure 2 shows the structure of a simple genetic algorithm [Pohlheim, 2006]. The algorithm works on populations of individuals instead of single solutions. At the beginning of the computation a number of individuals are randomly initialised. Each individual (genotype) represents a potential solution to the problem. These individuals in a population are also called strings or chromosomes [Goldberg, 1989]. The objective function is then evaluated for these individuals. Selecting the best individuals according to their level of fitness forms a new population. Some members of this new population undergo alterations by means of crossover and mutation. This cycle is performed until the optimisation criteria are satisfied. Holland's method is especially effective because the crossover operators greatly improve the capability of the algorithm to approach, and eventually find, the optimum.

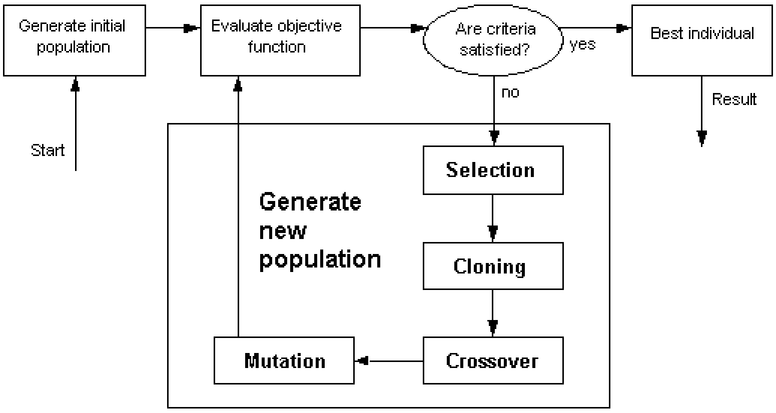

***Figure 2** Structure of a simple genetic algorithm*

3. The computer program

In Delphi [Cantu, 1999], I implemented a program, which solves the scheduling problem using a genetic algorithm and other heuristic methods. The algorithm dynamically handles the number of jobs, machines and iterations, the size of the population, the ratio of the genetic operators as well as the objective function. Processing times can be fed into the computer automatically and manually. The program makes it possible to save, load and print parameters and results. So the software can lead to excellent results in practical application. In Figure 3 the program can be seen while running. The algorithm keeps indicating the results in the information board and draws the value of the best individual (bottom graph) and the average fitness of the population (top graph) iteration by iteration. Because parents may be replaced by offspring with a lower fitness, the average fitness of the population can increase, but the fitness of the best chromosome decreases steadily.

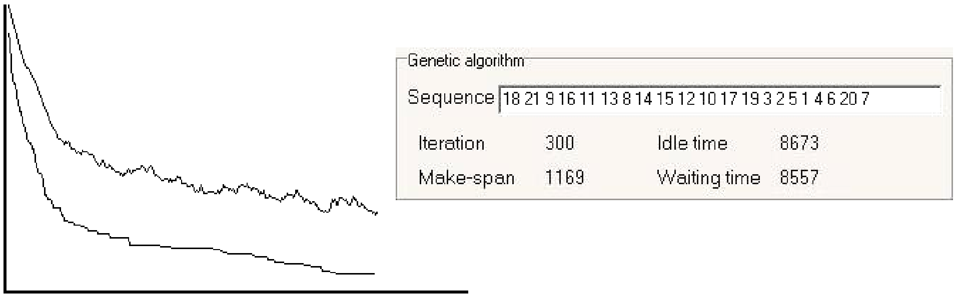

Figure 3 *Evolution of the results, information board of the GA*

I use an integer vector as a chromosome to represent a sequence as a list of n jobs. The path representation is perhaps the most natural representation of a sequence. For example, a sequence 8-5-3-7-4-2-1-6-9 is represented simply as (8 5 3 7 4 2 1 6 9). The initialization process is very simple: I create a population of chromosomes by a random sample of permutations of (1 2 … n). The value of the make-span, machines utilization and the work-in-process inventories can be calculated if we put the vector into the evaluating algorithm worked out by me in an earlier paper [Oláh, 2009]. The program uses two classical genetic operators: mutation and crossover.

Mutation creates new individuals by a small change with a low probability in a single individual. Four different mutation operators are always used in the same proportion in the program:

- *insertion* – selects a job and inserts it in a random place [Michalewich, 1996].
- *displacement* – selects a subsequence and inserts it in the opposite direction.
- *reciprocal exchange* – swaps two jobs.
- *swap* – splits the selected chromosome into two parts and swaps these parts.

Crossover creates new individuals by combining parts from two individuals. I used the next two crossovers for the representation: order crossover and cycle crossover. Usually these crossover operators are also in the same proportion to each other.

Selection is another important genetic operator that chooses a chromosome from the current population for inclusion in the next population. The following types of selection are handled by the software:

- *random*: a selection operator which randomly selects the chromosomes from the population.
- *roulette-wheel*: a selection operator in which the chance of a chromosome getting selected is proportional to its fitness.
- *best*: selects the best chromosomes from the population.

3.1. The used crossover operators

- *order crossover (OX)* – proposed by Davis – builds offspring by choosing a subsequence from one parent and preserving the relative order of jobs from the other [Davis, 1985]. For example, the two parents
  p_1=(5 7 |2 1 9 3| 6 8 4) and
  p_2=(8 6 |3 7 1 5| 4 2 9).
  First, the segments between cut points are copied into offspring
  o_1=(_ _ 2 1 9 3 _ _ _) and
  o_2=(_ _ 3 7 1 5 _ _ _).
  Next, starting from the second cut point of p_1 parent, the jobs from the other parent are copied, except those which are already in offspring o_1, so we get 4-8-6-7-5. This sequence is placed in the first offspring.
  o_1=(7 5 2 1 9 3 4 8 6). Similarly

we get the other offspring: o_2=(2 9 3 7 1 5 6 8 4).

- *cycle crossover (CX)* – proposed by Oliver – builds offspring in such a way that each job and its position comes from one of the parents [Oliver et al., 1987]. For example:
  p_1=(5 7 |2 1 9 3| 6 8 4) and
  p_2=(8 6 |3 7 1 5| 4 2 9).
  First point of parent p_1 is selected:
  o_1=(5 _ _ _ _ _ _ _ _).
  Next, we jump to job 8, as the job from the parent p_2 just below the selected job 5.
  Thus o_1=(5 _ _ _ _ _ _ 8 _).
  Following this rule we have completed a cycle
  o_1=(5 _ 2 _ _ 3 _ 8 _).
  The remaining jobs are filled from the other parent
  o_1=(5 6 2 7 1 3 4 8 9).
  Similarly, o_2=(8 7 3 1 9 5 6 2 4).

4. Comparison of the crossover operators

In my earlier papers I compared the genetic algorithm to other heuristic methods for the flow-shop scheduling problem [Oláh, 2009] and I performed sensitivity analysis of the genetic parameters such as the population size and the iteration number [Oláh, 2010; Oláh, 2011]. In this scientific work I analyse the efficiency of each crossover operator.

Naturally, my analyses are carried out for the same (20-machine, 25-job) permutation flow-shop scheduling problem, during which I completely leave out the mutation operator and only create the next population by cloning and crossing the selected best individuals. This ensures that the development of results can be attributable only to the crossover, allowing for an exact comparison. In the first step, I use the two crossover operators (Cycle-Crossover and Order-Crossover) used by the program in the proportion of half to half. The program was run 30 times for each crossover rate (99, 98, 96, ..., 2 percent of the population) represented in Figure 4. The average values of the objective function (idle time) resulted by the genetic algorithm using 100 population-size and the best selection strategy after 150 iterations are the following:

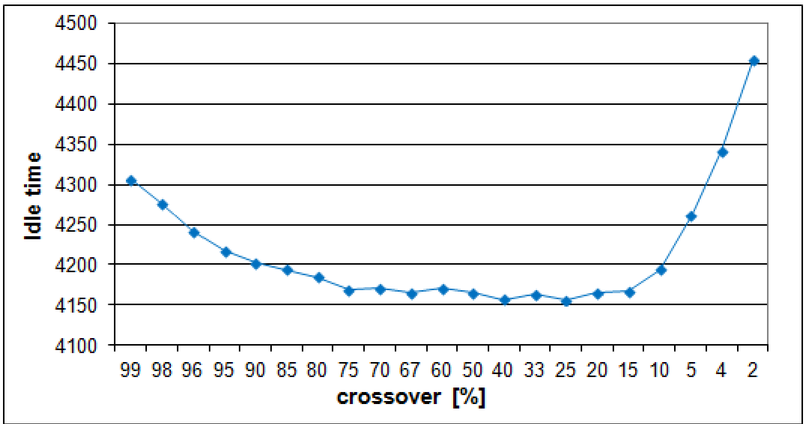

Figure 4 *Idle times resulted by the GA in the function crossover rate*

The chart shows the idle time of the machines along the vertical axis and the decreasing number of crossover rate from 99 to 2 along the horizontal axis. In this chart we can see that the program generates better and better solutions with decreases in the crossover rate up to 25%, but following this the efficiency of the algorithm fails fast.

Consequently, the optimum (4,155) occurs when the crossover rate is 25% (and cloning is 75%). It can be established that the GA with 2 percent crossing (without mutation) converges toward the optimum much (about 6.5%) worse than with 15 percent crossover rate.
Naturally, the following study should also be performed for cases where only one crossover operator is used during the crossing, and we could see in these cases where the optimum occurs, and which operator produces better results and by how much.

For the previously examined task, the averages of the idle time values provided by the 30 runs of the program with exactly the same settings as before using only the Cycle-Crossover (CX) operator are the following (Figure 5).

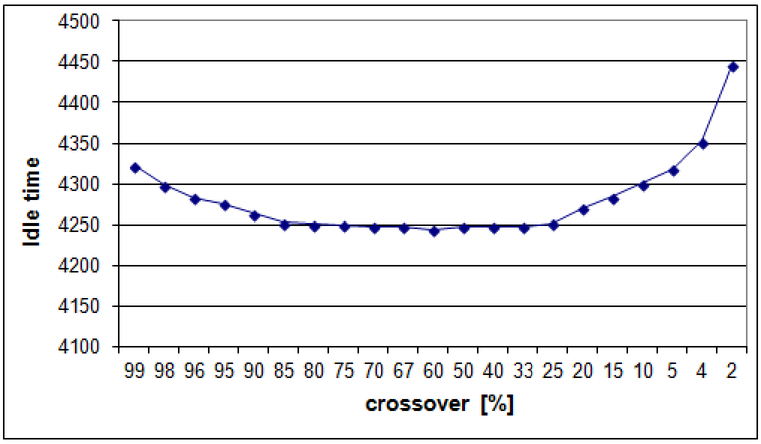

Figure 5 *Idle times resulted by the GA with only Cycle-Crossover*

It can be stated that we obtain a curve very similar in nature to the previous one. Initially, a rapid improvement can be observed with the decrease of the crossover rate, then from 85% to 25% the average fitness value of the best individuals no longer approaches the optimum better (the minimum value of the objective function (4244) can be found by 60%), but when the crossover rate falls below 25%, the program again provides increasingly worse solutions. Overall, it can be concluded that the CX operator provides average 2 per cent worse results than a crossing that uses both operators equally. From this fact, it can be thought that the Order-Crossover operator is more efficient than the CX. The last analysis is intended to confirm or refute this statement.

Finally, for the previously examined scheduling task, the averages of the idle time values provided by the 30 runs of the program with exactly the same settings as before, using only the Order-Crossover (OX) can be seen in Figure 6. The horizontal axis still shows the applied crossover rate (from 99 to 2 %), while the vertical axis shows idle times.

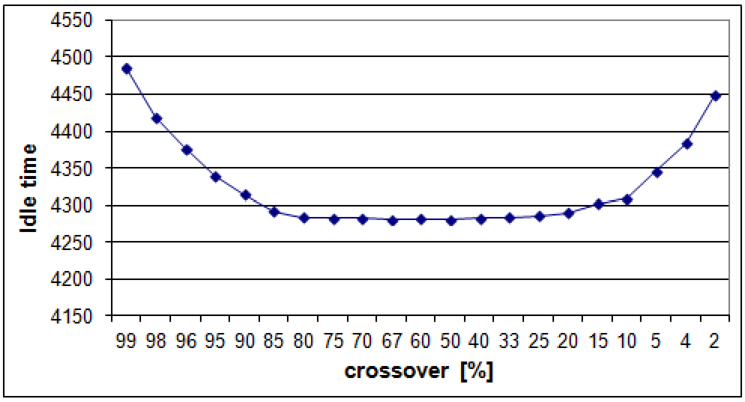

Figure 6 *Idle times resulted by the GA with only Order-Crossover*

Unlike before, we can see a quick development (up to 80%) at the beginning (the 80% crossing already results more favorable solutions with 4.6% compared to 99%), and then (up to 20%) the average fitness value has now settled, but in the end there is a more moderate increase than before. Although the lowest idle time value (4280) is 67% crossing (and thus 33% cloning), but the exact ratio can still be anywhere between 80 and 20%. However, contrary to my expectations, the data displayed on the graph show that the OX crossover operator is not better than the CX (and the mixed) crossing, but also provides even 1.1% worse results on average. In light of this, it is surprising that when applied both operators in a half-to-half ratio, the average fitness value is closer to the optimal value than in either case alone. It follows that it is worthwhile to use a wide range of crossover procedures for a given task, because neither weaker one debases the other, but together they can achieve even better development.

5. Conclusion

Comparing the two crossover operators, overall it can be stated, that the better solution for flow-shop scheduling is provided by the Cycle-Crossover, and the worse result is given by the OX, which is the complete opposite of the sequence known for the travelling salesman problem (TSP) (Oliver showed that the OX operator is 15% more efficient than the CX). This discrepancy can be explained by the fact that while at the TSP the neighborhood information matters, but at the FSSP the order is interesting. This is the reason why the sequence is represented by the list of products in the scheduling problem, which is the most natural description of an individual, simply listed the number of jobs in the order of processing.

References

CANTU, M. (1999): Mastering Delphi 5, Sybex Inc.

DAVIS, L. (1985): Job Shop Scheduling with Genetic Algorithms. International Conference on Genetic Algorithms and their Applications, Erlbaum, 1985. 136-140. p.

EVANS, J. R. (1993): Applied Production and Operations Management, West Publishing Company, Minneapolis.

GOLDBERG, D. E. (1989): Genetic Algorithms in Search, Optimization and Machine Learning, Addison-Wesley, Reading.

HOLLAND, J. H. (1975): Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology Control, and Artificial Intelligence, The University of Michigan Press, Chicago.

MICHALEWICH, Z. (1996): Genetic Algorithms + Data Structures = Evolution Programs, Springer, Berlin.

OLÁH, B. (2009): Genetic Algorithm vs. Reinforcement Learning, Chapter 80 in DAAAM International Scientific Book 2009, Vol. 8, Published by DAAAM International, Vienna, Austria, 831-844. p.

OLÁH, B. (2010): Efficiency analysis of a genetic algorithm for the flow-shop scheduling problems. “Science without borders” The International Conference of the College of Szolnok on the day of Hungarian Science, Szolnok, 325-331. p.

OLÁH, B. (2011): Sensitivity analysis of a genetic algorithm in function of the population size. XXV. microCAD International Scientific Conference, University of Miskolc, Miskolc, Hungary, 113–118. p.

OLIVER, I. M. – SMITH, D. J. – HOLLAND, J. R. C. (1987): A Study of Permutation Crossover Operators on the Traveling Salesman Problem. 2nd International Conference on Genetic Algorithms, Lawrence Erlbaum Associates, Hillsdale, New Jersey, 224-230. p.

POHLHEIM, H. (2006): Evolutionary Algorithms, *Available from:* http://www.geatbx.com/docu/algindex-01.html#TopOfPage *Accessed:* 2020-03-11

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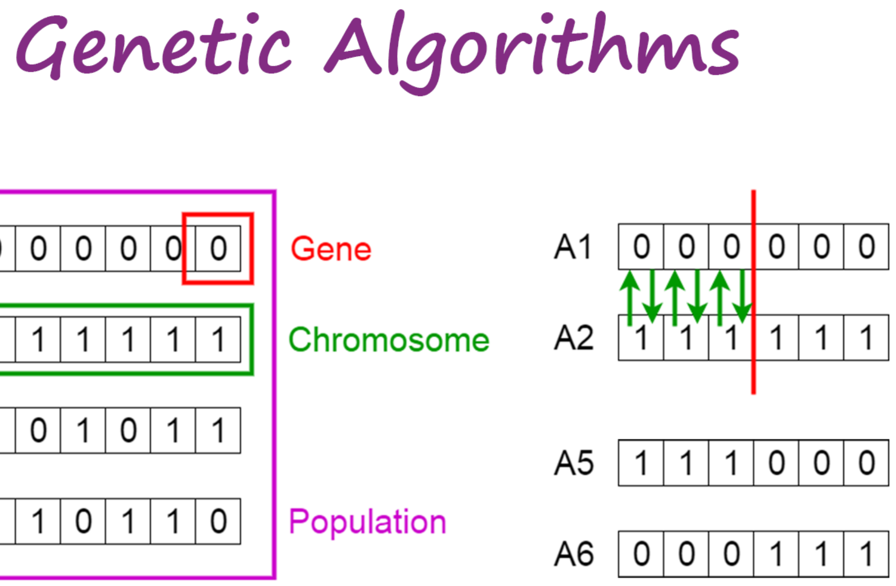


VYBRANÉ ASPEKTY DIZAJNU INFORMATICKÝCH NÁSTROJOV NA PODPORU MANAŽÉRSKYCH PROCESOV MONITOROVANIA A MERANIA FAKTOROV PRACOVNÉHO PROSTREDIA V STROJÁRSKYCH PREVÁDZKACH

SELECTED ASPECTS OF THE DESIGN OF INFORMATIVE TOOLS IN SUPPORT OF MANAGEMENT PROCESSES OF MONITORING AND MEASUREMENT OF WORK ENVIRONMENT FACTORS IN MACHINERY OPERATIONS

Štefan SVETSKÝ, Alena PAULIKOVÁ, Augustín STAREČEK, Oliver MORAVĆÍK

ABSTRAKT

Manažérske procesy reprezentujú komplexný súbor procesov založených na know-how jednotlivcov, priemyselných podnikov ako aj subjektov zabezpečujúcich vzdelávanie. Napriek značnému pokroku informačno-komunikačných technológií je stále nedostatok relevantných nástrojov na hromadné spracovanie informácií, údajov a vedomostí na úrovni jednotlivcov, ktorí denne čelia spracovaniu množstvu pribúdajúcich nových údajov. Uvedený problém je čiastočne riešený na Materiálovotechnologickej fakulte so sídlom v Trnave na báze novej paradigmy dávkového spracovania informácií a vedomostí, ktorá na ich spracovane využíva fixnú aktuálnu štruktúru, ktorá je súčasne čitateľná strojom aj človekom (s paradigmou súvisia aj dva úžitkové vzory). Hlavným cieľom predkladaného príspevku je ukázať na praktickú implementáciu paradigmy pri dizajne IT podpory manažérskych činností v projekte VEGA 1/0101/18 na báze využitia vlastného softvéru WPadv4, ktorý funguje aj ako osobný manažérsky informatický nástroj („Knowledge Management System“ - systém manažmentu vedomostí). Pri plnení hlavného cieľa príspevku sa aplikuje testovanie dizajnu informatických nástrojov a pridaná hodnota manažmentu obsahu a projektovému manažmentu je ilustrovaná formou viacerých snímok obrazovky monitora počítača, ktoré sú praktickými ukážkami riešenia softvérovej podpory vybraných činností.

KĽÚČOVÉ SLOVÁ: *IT podpora, manažérske procesy výskumné projekty, zdieľanie informácii.*

ABSTRACT

Management processes represent a comprehensive set of processes based on the know-how of individuals, industrial companies as well as entities providing education. Despite significant advances in ICT, there is still a lack of relevant tools for the bulk processing of information, data, and knowledge at the level of individuals who face processing of a large amount of new data on a daily basis. This problem is partially addressed at the Faculty of Materials Technology in Trnava, Slovak Republic. It is solved by a new paradigm of batch processing of information and knowledge, which uses a fixed default structure for their processing. The structure is simultaneously machine and human-readable (two utility models are related to the paradigm). The main goal of this paper is to demonstrate the practical implementation of the paradigm in the design of IT support for management activities in the project VEGA 1/0101/18 based on the use of its own software WPadv4. The software also functions as personal management IT tool ("Knowledge Management System"). In fulfilling the main goal of the paper, testing the design of IT tools is applied. The added value of content management and project management is illustrated in the form of several screenshots. These are practical examples of software support solutions for selected activities.

KEY WORDS: *IT support, management processes, research projects, information sharing.*

1 ÚVOD

Publikácie zamerané na dizajn softvérovej podpory konceptu Industry 4.0 sa väčšinou zameriavajú na oblasť Internetu vecí (IoT), kde zvyčajne ide len o spracovávanie veľkého množstva údajov snímaného senzormi. Súčasťou Industry 4.0 sú však aj Internet vecí (IoT), alebo aj Logistika 4.0, kde už nejde o spracovanie snímaných údajov, ale o spracovávanie informácií pre riešenie manažérskych procesov (Platform Industrie 4.0, 2020; Kagermann a kol., 2013; Stareček a kol., 2018). V prípade takzvaných Big Data ide o spracovávanie veľkého množstva informácií, hoci manažéri potrebujú na rozhodovanie len „smart data“, vyextrahovať údaje respektíve informácie, ktoré im pomáhajú pri rozhodovacích procesoch. Z uvedeného hľadiska sa aj v literatúre zmieňuje, že existuje veľké množstvo informačných systémov využívajúcich ostré dáta, napríklad z výrobnej prevádzky, no smerom k vrcholovému manažmentu ich je menej (Merna, Al-Thany, 2007). To súvisí s tým, že personálne dáta sú neurčité, takže počítače nevedia spracovávať niečo, čo nie je dané alebo je neúplné. Nedostatok softvérov je aj pre oblasť „Technology-enhanced learning“, ktoré sú vhodné na podporu vzdelávania (Martens, 2014). V podobnej oblasti akou je „Education technology“ sa zmieňuje aj absencia teoretických prístupov, čo tiež bráni počítačovej podpore (Oliver, 2013).

Základom programovania informačných systémov (IS) vo vyspelých podnikoch je preto taký postup, že v prvej fáze sa informatici musia oboznámiť so systémom v danom podniku, analyzovať a definovať procesy a stanoviť algoritmy, aby IS čo najviac reflektoval na požiadavky organizácie. Obdobný postup by sa mal praktizovať aj pri riešení výskumných alebo akademických projektov, ale riešitelia nie sú programátori a preto väčšinou využívajú existujúce softvéry a prispôsobujú im počítačovú podporu. Bežné je preto použitie kancelárskych balíkov a rôznych špecializovaných softvérov a systémov, napríklad v podmienkach STU je to systém AIS (akademický informačný systém), alebo Moodle, MATLAB a podobne. V posledných rokoch sa začali používať aj internetové služby od spoločnosti Google a v období epidémie COVID-19 sa začali používať aj komunikačné softwary (nejde však o informačné systémy) (Wahid a kol., 2020). V manažérskej praxi sa začali používať aj cloudové systémy pre manažment obsahu (BOX na Cloud /Enterprise Content Management).

Na základe uvedeného sa pri riešení IT podpory manažérsky procesov alebo projektov, akým je riešený projekt VEGA 1/0101/18 musí vychádzať z odbornej podstaty projektu a následne je potrebné identifikovať procesy a algoritmy. Ďalej je potrebné jednotlivo posudzovať vhodnosť softvérov na automatizáciu manažérskych činností. Keďže manažérske procesy patria k procesom založeným na vedomostiach, kľúčovou otázkou je zvládnutie programovania spracovania (ľudských) vedomostí. Problémom je, že neexistuje univerzálna definícia vedomosti. V oblasti manažmentu sa používajú termíny ako sú tacitné a explicitné vedomosti (Nonaka, 1994; Cagaňová, Szilva, 2018).

V uvedenom kontexte sa v jednotlivých kapitolách príspevku priblíži odborný zámer projektu, špecifikujú vybrané manažérske procesy (určené na počítačovú podporu) a opíše sa stav a progres výskumu na Materiálovotechnologickej fakulte, riešiaci automatizáciu procesov založených na vedomostiach. Pre niektoré manažérske procesy sa uvádzajú praktické ukážky z testovania a implementácie IT podpory s využitím domáceho softvéru WPadV4, ktorý je základným IT nástrojom pre „Knowledge management“ (manažment vedomostí).

2 CHARAKTERISTIKA PROJEKTU VEGA 1/0101/18

Predmet riešenia projektu charakterizuje inovatívny prístup skúmania systému pracovného prostredia priemyselnej výrobnej prevádzky ako nedeliteľnej časti nášho environmentu. V uvedenom kontexte sa projekt zameriava na postupy a zadefinovanie *„indexu* *pracovného komfortu"* ako komplexného ukazovateľa synergických efektov meraných faktorov v priemyselných výrobných prevádzkach. Dôraz sa kladie na také kombinovanie faktorov pracovnej pohody v strojárskych prevádzkach, ktoré by umožnilo ich vzájomné kombinovanie a rekombináciu podľa typu operácie a vekovej kategórie *„Index pohodlia práce"* by mal umožniť zamestnancom v strojárskych prevádzkach individuálne nastavenie pracovnej záťaže a pracovného prostredia, a tým zabezpečiť ich stabilnú výkonnosť pri najvyššej možnej bezpečnosti a ochrane zdravia. Význam takéhoto individuálneho nastavenia pracovného zaťaženia je dôležitý aj v súvislosti so zmenami demografického zloženia obyvateľstva a predpokladanej koexistencií štyroch generácií v priemyselných prevádzkach, konkrétne so zameraním na výrobu produktov (Gyurák Babeľová a kol., 2020; Vraňaková, Chlpeková, 2020). Tu je dôležitá predovšetkým integrácia systémov manažérstva kvality, ochrany a bezpečnosti zdravia v synergickej súčinnosti s plynulým podnikaním, ergonómiou, ako aj právnymi predpismi týkajúcich sa pracovných záťaží a pracovného komfortu (Nováková a kol., 2019).

Zmysel zadefinovania dizajnu *„indexu pracovného komfortu"* - ako komplexného ukazovateľa synergických efektov meraných faktorov v priemyselných výrobných prevádzkach, súvisí s prínosmi pre prax ako sú:

- Zavedenie hodnotenia synergického efektu faktorov vplývajúcich na pracovné zaťaženie.
- Individuálne nastavenie parametrov pracovného prostredia a záťaže s využitím indexu pracovného prostredia.
- Zvýšenie pracovného komfortu.
- Stabilizácia pracovného výkonu nezávisle na vekovej kategórii a pohlavia.
- Zníženie rizika úrazov a chorôb z povolania.
- Využitie indexu pracovného komfortu v simulačných programoch.
- Vytvorenie predpokladov pre širšie uplatnenie chytrých objektov pri tvorbe inteligentného pracovného prostredia.

V projekte sa predpokladá, že heterogénne a zdanlivo nesúvisiace problémy priemyselného inžinierstva, ako sú vybrané ergonomické, fyzikálne, chemické, biologické, senzorické a psychologické vlastnosti v pracovnom prostredí, môžu stimulovať formuláciu a riešenie problémov súvisiacich s hodnotením pracovného výkonu. Samotné riešenie projektu by malo byť v podstate novým pohľadom a pridanou hodnotou k tradičnej kombinácii problematiky F-CH-B-E (fyzikálno-chemické-biologicko-ergonomické aspekty). Za tým účelom sa aplikujú nasledujúce metodické postupy:

- Empirické metódy: pozorovanie a meranie.
- Štatistické metódy hlavne AHP a Fuzzy AHP.
- Empirické metódy: pozorovanie a meranie.
- Vypracovanie kombinačného postupu indexovania faktorov pracovného komfortu vo vybraných prevádzkach.
- Vypracovanie rekombinačného postupu indexovania faktorov pracovného komfortu vo vybraných prevádzkach.

Záujemca o uvedenú problematiku nájde podrobnejšie detaily v publikáciách (Pauliková, Ubárová, 2018; Nováková a kol. 2019).

3 ŠPECIFIKÁCIA MANAŽÉRSKYCH PROCESOV

Z predchádzajúcej charakteristiky projektu VEGA 1/0101/18 vyplýva, že z hľadiska riešenia dizajnu informatických nástrojov na podporu manažérskych procesov je potrebné procesy najskôr identifikovať a analyzovať ich algoritmy, aby boli počítačovo spracovateľné. Z hľadiska projektového manažmentu a manažmentu obsahu by sa dali činnosti rozdeliť do nasledujúcich kategórií:

1. Spracovanie nameraných hodnôt z objektivizácie pracovného prostredia jednotlivých priemyselných prevádzok.
2. Porovnanie nameraných hodnôt z objektivizácie pracovného prostredia medzi jednotlivými prevádzkami vzhľadom na pracovné pozície.
3. Spracovanie dotazníkových údajov zo subjektivizácie pracovného prostredia jednotlivých zamestnancov na vybraných pozíciách v priemyselných prevádzkach.
4. Porovnanie výsledkov dotazníkových údajov zo subjektivizácie pracovného prostredia zamestnancov na podobných pozíciách v priemyselných prevádzkach.
5. Spracovanie údajov (nameraných a dokazovaných) do relácii medzi objektivizáciou a subjektivizáciou pracovného prostredia ako podklad pre efektívnejšie manažérske rozhodovanie.
6. Manažérske rozhodovanie pre - zabezpečenie OOPP (osobných ochranných pracovných pomôcok), úprav pracovného prostredia, aby priemyselná výroba bola zdravotne udržateľná (zamestnanci sa neinvalidizovali vykonávanými činnosťami), nastavenie príplatkov za sťažené pracovné podmienky, plán zdravotných prehliadok, rekondičných pobytov
7. Legislatívna podpora
8. Normatívna podpora
9. Technologické plánovanie pre inovovanie pracovného prostredia s najvyšším kombinovaným faktorom pracovného prostredia.
10. Kombinácie a rekombinácie jednotlivých faktorov pracovného prostredia podľa zadanej požiadavky z priemyselnej výroby.

Uvedené kategórie činností sa viac alebo menej prekrývajú so štandardnými činnosťami, ako sú vlastné projektové plánovanie, jeho implementáciu, riadenie, finančný manažment a marketing. Avšak už z ich stručného popisu vidieť, že požiadavky na IT podporu a nástroje sú veľmi široké. Inak povedané, že *„Google“* ani kancelárske balíky Microsoftu to nevyriešia. Ideálnym prípadom by preto bol univerzálny all-in-one softvér, ktorý by fungoval ako osobný alebo kolektívny informačný systém. Dôležité je však aby nefungoval len ako statický pamäťový zásobník, ale podporoval aj konverziu tacitných vedomostí na explicitné, vrátane prenosu ich obsahu v rôznych heterogénnych a nekompatibilných počítačových formátoch, ako ja medzi off-line prostredím (osobné počítače jednotlivcov, intranet) a on-line prostredím (WEB, počítačové siete, virtuálne stroje, virtuálne databázy a systémy).

Ide aj o to, že riešenie projektov si vyžaduje expertné know-how riešiteľov, ktoré vychádza z ich znalostí o legislatíve a technickej normalizácie. Čiže je potrebné, aby mali k dispozícii informačný systém, v ktorom môžu vyhľadávať, a z ktorého môžu čerpať podľa potrieb projektu.

3.1 LEGISLATÍVA BOZP A TECHNICKÁ NORMALIZÁCIA

Medzi základnú legislatívu v oblasti bezpečnosti a ochrany zdravia pri práci môžeme zaradiť v nadväznosti na psychickú, fyzickú a senzorickú záťaž. Už ústava SR zakotvuje jedno zo základných ľudských práv a to právo na ochranu bezpečnosti a zdravia pri práci, spravodlivé a uspokojivé pracovné podmienky. Na ňu nadväzujú ďalšie zákony, nariadenia vlády, vyhlášky ministerstiev a taktiež smernice, pokyny alebo záväzné opatrenia. A s tým úzko súvisí aj Zákonník práce, ktorý pokrýva všetky činnosti súvisiace s výrobou, prevádzkou a inými aktivitami vo vzťahu zamestnávateľa – zamestnanec. Keďže Slovenská republika je súčasťou EU, dôležité sú aj novelizácia národnej legislatívy, ako to bolo v prípade Zákona č. 124/2006 Z. z. o BOZP. Tento zákon ustanovuje základné podmienky BOZP, vylúčenie alebo zníženie pracovných úrazov, chorôb z povolania a pod., práva a povinnosti ako aj pravidlá, ktoré musia dodržiavať zamestnanci a zamestnávatelia, aby bola zabezpečená BOZP. Taktiež zabezpečuje jednotnú aplikáciu a výkon dozoru nad dodržiavaním prijímaných opatrení na úseku BOZP. Obdobne, Smernica 89/391/EHS o zavádzaní opatrení na podporu zlepšenia bezpečnosti a ochrany zdravia pracovníkov pri práci", zaručuje minimálne požiadavky na bezpečnosť a ochranu zdravia v krajinách EÚ, pričom členské štáty môžu zachovať v platnosti uvedené opatrenia alebo zaviesť prísnejšie opatrenia. Prioritnou zásadou BOZP je dôraz na prevenciu a previazanosť jednotlivých zákonov. Napríklad Zákon NR SR č. 355/ 2007 Z. z. ustanovuje organizáciu a výkon verejného zdravotníctva, vykonávanie prevencie ochorení a iných porúch zdravia, opatrenia orgánov štátnej správy na úseku verejného zdravotníctva pri ohrozeniach verejného zdravia a povinnosti fyzických a právnických osôb pri ochrane, podpore a rozvoji verejného zdravia a výkon štátneho zdravotného dozoru a požiadavky na zdravé životné a pracovné podmienky. Možno zmieniť aj Vyhlášku MZ SR č.542/2007 Z. z. o podrobnostiach o ochrane zdravia pred fyzickou záťažou pri práci, psychickou pracovnou záťažou a senzorickou záťažou pri práci, ustanovuje požiadavky na miesto výkonu práce v súvislosti s obmedzovaním zvýšenej fyzickej záťaže pri práci, prípustné hodnoty celkovej fyzickej záťaže zamestnancov, opatrenia, ktoré vylúčia alebo znížia na najnižšiu možnú a dosiahnuteľnú mieru zvýšenú fyzickú záťaž pri práci, postup pri hodnotení psychickej pracovnej záťaže. Ďalej je potrebné uviesť skutočnosť, že tieto faktory môžu ovplyvňovať aj procesy rozhodovania (Pauliková, Ubárová, 2018; Blahová, Paulíková, 2019; Paulíková, Ubárová, 2018).

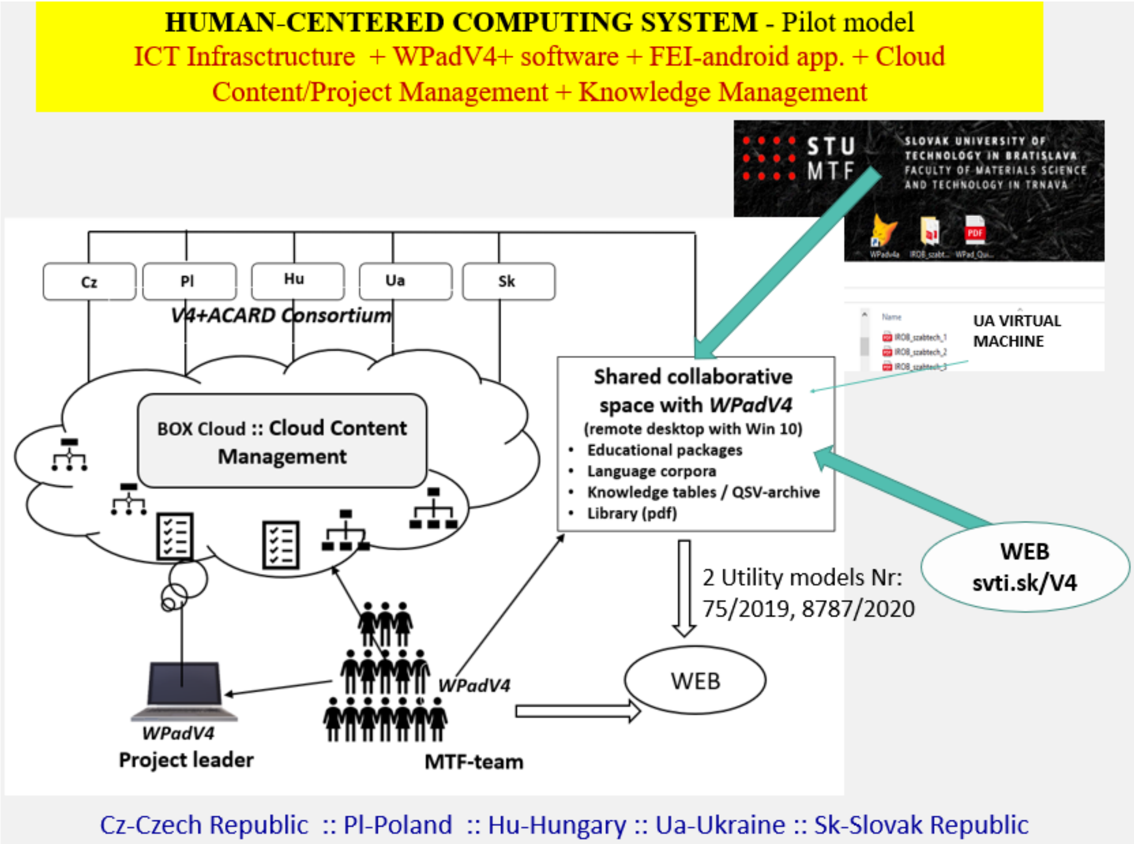
Z kontextu predkladaného príspevku treba zdôrazniť, že ide o jedinú vyhlášku zaoberajúcu sa psychickou, fyzickou a senzorickou záťažou. Už z uvedeného krátkeho popisu legislatívy vyplýva, že riešitelia, respektíve experti potrebujú aj dokumentačný systém, v ktorom by mohli rýchlo a operatívne vyhľadávať informácie potrebné pre manažérske a inžinierske procesy. Takýto *„encyklopedický"* systém by okrem zmienených nariadení a vyhlášok obsahoval aj ďalšie, ako sú napr. Nariadenie vlády SR č. 281/2006 Z. z (ručná manipulácia s bremenami); Vyhláška č.99/2016 Z.z. (záťaž teplom a chladom pri práci); Vyhláška č. 549/2007 Z.z. (hluk, infrazvuk a vibrácie); Nariadenie vlády SR č. 355/2006 Z. z. (chemické faktory pri práci); Nariadenie vlády SR č. 115/2006 Z.z. (riziká z hluku pri práci); Nariadenie vlády SR č. 276/2006 Z. z.(zobrazovacie jednotky).

Pre vykonávanie kontrolných a hodnotiacich činností sú dôležité technické normy pre auditovanie, počnúc základnou normou ISO STN 9001:2015 Systémy manažérstva kvality a súvisiacimi, napríklad pre zjednodušenie auditovania podľa ISO 45001:2019 Systémy manažérstva bezpečnosti a ochrany zdravia pri práci. Z hľadiska environmentu je dôležitá analogická norma ISO STN 14001:2015 Systémy manažérstva environmentu. Možno zmieniť aj EN ISO 22301:2020 Systémy manažérstva plynulého podnikania, taktiež EN ISO 10 075 Ergonomické princípy vo vzťahu k mentálnemu pracovnému zaťaženiu.

4 VYBRANÉ ASPEKTY AUTOMATIZÁCIE SPRACOVANIA INFORMÁCIÍ A VEDOMOSTÍ (KNOW-HOW) JEDNOTLIVCAMI

Problematika osobného manažmentu vedomostí (Personal Knowledge Management) je stále aktuálna a jej riešenie má ešte rezervy (Razmerita a kol., 2009; Schmitt, 2012). V tomto kontexte sa už dávnejšia zaoberala publikácia (Svetský a kol. 2010), ktorá opísala problematiku automatizácie činností pedagógov, výskumníkov a manažérov pre spracovávanie informácií a vedomostí na úrovni know-how jednotlivcov. Konštatovalo sa, že z hľadiska IT podpory jednotlivcov alebo zamestnancov s vedomosťami (knowledge workers), neexistujú univerzálne softvéry na spracovanie informácií a vedomostí a to aj napriek extrémne rýchlemu pokroku informačných a komunikačných technológií. Ako jednou z príčin sa uvádzala skutočnosť, že sa predchádzajúci vývoj desktopových aplikácií uberal na úkor jednotlivca smerom ku jednoúčelovým komerčným aplikáciám. Z dostupných informatických nástrojov sa zmieňovali hlavne kancelárske balíky a internetové prehliadače, ktoré jednotlivca prepájajú so *„svetom internetu"*. Paradoxne, tento stav pretrváva aj dnes, keď stav pred desiatimi rokmi sa radikálne zmenil po zavedení globálnych služieb, cloudových aplikácií a sociálnych sietí, respektíve aj po nástupe mobilov, tabletov a obdobných e-nosičov. Rovnako radikálne sa zmenilo desktopové predprogramované informaticko-pedagogické prostredie, popísané v uvedenej práci.

Paradigma hromadného spracovávania informácií a vedomostí sa v rámci empirického výskumu transformovala na systematickú automatizáciu - IT podporu duševných činností jednotlivca a kolaboratívnych činností skupiny pedagógov a výskumníkov na vyvinutej a spoločne zdieľanej IT infraštruktúre, ktorá je zobrazená na Obrázku 1 nižšie.



Obrázok 1: *IT infraštruktúra vyvinutá v projekte V4+ACARDC (Svetský a kol., 2020)*

Uvedená pilotná infraštruktúra sa vytvorila v rámci riešenia projektu V4+ACARDC, ktorý koordinovala MTF (išlo o grant Medzinárodného vyšehradského fondu). Ako vidieť z Obrázku 1, pozostáva z kombinácie domáceho softvéru WPadV4, inštalovaného na počítačoch riešiteľov, ktoré sú prepojené s cloudovým prostredím tzv. virtuálneho stroja (Windows 10), na ktorom je inštalovaný centrálny a spoločne zdieľaný WPadV4. Na spoločné zdieľanie súborov sa využíva cloudová služba BOX-CCM (Cloud Content Management), ktorú poskytla spoločnosť IBM Slovakia. Ďalším prvkom je WEB, ktorý slúži na verejne dostupné publikovanie obsahu, napr. vytvorených viacjazyčných edukačných balíkov (BOX aj virtuálny stroj nie sú verejne dostupné. Práve v súčinnosti s projektom VEGA 1/0101/18 sa v čase písania článku začal testovať aj „prototyp" komunikačného kanála PIKS (Personal Information and Knowledge System), ktorého cieľom je prepojiť obsah s komunikáciou.

V súčasnej dobe epidémie COVID-19, kedy sa prechádza na online komunikáciu (dištančné vzdelávanie, home-office, virtuálne konferencie a stretnutia) by malo byť každému zrejmé, že treba zásadne odlišovať *„komunikačné IT služby"* od tvorby a spracovania obsahu. Ako už bolo zdôraznené v uvedenej práci (Svetský a kol., 2020) obsah informácie a vedomosti treba nielen vytvoriť, ale aj manažovať.

Pre laika v oblasti IKT je v tomto kontexte potrebné si uvedomiť, že počítače neboli vytvorené na podporu výučby, výskumu, či manažérskych činností. V podstate vznikli z predstavy, že ak sa dajú stroju určité pravidlá, tak stroj by mohol realizovať aj činnosti človeka, ako je počítanie, čiže to čo sa považuje za inteligentné činnosti. Počítače síce vznikli ako stroje na spracovanie informácií, no pod informáciou rozumejú len sled obrovského množstva núl a jednotiek. Postupne s progresom ich vývoja sa bloky takýchto núl a jednotiek zostavujú do defaultných informatických blokov, ktoré my užívatelia vnímame, ako text, tabuľku, obrázok a počítačové súbory. Dnes už aj laik vie, že je veľké množstvo súborových formátov, ktoré sú vzájomne nekompatibilné. Inak povedané iné formáty sa používajú pre texty, iné pre obrázky, databázy, hudobné súbory, videá. Čiže ide o súbory, ktoré si bežne vymieňame, napr. s príponami .doc, .docx (majú zakomponovaný XML-formát), .pdf, .txt, .mp3, .mp4, .dbf. Takže obsah musí byť uložený v týchto heterogénnych formátoch. Obecne sa používa pre strojové činnosti pojem heterogénne dáta, ktoré sú teda určené na prenos informácií medzi strojmi (počítačmi a sieťami).

Takže, ak by sa to zhrnulo, stroj vie expresne rýchlo spracovávať dátové štruktúry, čiže to, čo má zabudované ako šablóny, ktoré spracováva nejaký softvér, no žiaden počítač nevie čo je to ľudská informácia a vedomosť. Na tieto účely sa musia počítaču zostavovať tzv. reprezentácie informácií, či vedomostí. Pokiaľ ju človek dokáže sformulovať, tak na základe takejto izomorfie stroj extrémne rýchlo takúto informáciu, resp. vedomosť spracuje (ich reprezentáciu). Čiže každý rozumie, že každý počítač, čo máme na stole, dokáže vypočítať za chvíľu to, čo by človek nedokázal trebárs ani za pár rokov. No a obdobne je to aj so spracovaním informácií a vedomostí, pretože aby ich stroj mohol spracovávať, musia byť najskôr definované. Komplikácia sa prejavuje v absencii univerzálnej definícií vedomostí.

Otázka dizajnu takejto izomorfnej šablóny sa riešila v rámci dlhodobého výskumu automatizácie „knowledge based“ procesov, teda procesov založených na vedomostiach. Do nich patria výučba, samoštúdium, výskumné činnosti, ako aj akejkoľvek kategória manažérskych procesov. Prvým krokom k riešeniu bolo „teoretické podloženie“ predchodcu softvéru WPadV4, ktorý sa vyvinul v rámci riešenia úlohy APVV (Svetský a kol., 2007) a ktorý bol zameraný na výskum životného cyklu a ekologizáciu obrábania. Práve pri praktickom riešení tohto projektu vznikla potreba riešiť viacero činností, ako boli:

a) spracovanie nameraných dát
b) manažment a prenos technických informácií
c) tvorba dokumentačnej databázy (repozitára)
d) koncentrovanie dát, informácií a súborov za účelom vývoja riadiaceho softvéru
e) modelovanie riešení v off-line a online režime – databázová aplikácia pod FPW2.6a a aplikácie PHP/MySQL (avšak ešte ako verzia PHP3, ktorá už dnes nefunguje)
f) dizajn samostatného bloku projektu, ktorý sa preniesol na interný „APVV- portál“ na serveri MTF-KAIA (teraz UIAM).

Uvedený portál sa následne až do roku 2017 využíval na výučbu viacerých študijných programoch MTF a modelovanie malých informačných systémov v rámci desiatky diplomových prác. V úvodnej fáze išlo o empirický výskum, podľa terminológie amerických univerzít o participačný akčný výskum, kedy si pedagóg vyberá vhodnú technológiu v rámci svojej výučby (Goodman, 2002). Pridanou hodnotou bolo, že v našom prípade sa táto technológia aj programovala pedagógom, ktorý si robil výskum v oblasti „Technology-enhanced learning“. Zásadným prelomom bolo, že sa *vedomosť* zadefinovala ako *množina štruktúrovaných a neštruktúrovaných informácií s určitým vedecko – inžinierskym obsahom vloženým do aktuálnej štruktúry* domáceho softvéru *(autorom programu je jeden z autorov príspevku, Š. Svetský)*. Predmetná databázová štruktúra nazvaná ako *„virtuálna vedomosť“*, totiž funguje presne ako izomorfná šablóna slúžiaca na komunikáciu človeka so strojom – počítačom v prirodzenom jazyku. Tým sa aj oddelila problematika „vedomostí“ od „informácií“ a „dát“, tak ako ich chápe človek. To umožnilo lepšie pochopiť, že softvér na spracovanie vedomostí musí používať inú paradigmu práce než softvér na spracovanie jednoduchých dát alebo informácií. V rámci obhájenej habilitačnej práce (Svetský, 2012) sa predpokladalo, že dizajn takejto aktuálnej štruktúry môže byť patentovateľný, takže sa podal návrh, ktorý sa zaregistroval ako úžitkový vzor 7340/2014 (Svetský, Moravčík, 2016).

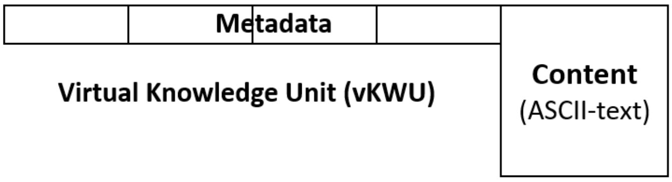
V ďalšom období sa vďaka zadefinovaniu „virtuálnej vedomosti“ riešil pôvodný empirický výskum už na systematickej báze, pričom výsledky sa priebežne publikovali s výstupmi do vzdelávania, viacjazyčnej podpory na informatických konferenciách (Svetský, Moravčík, 2017) a do oblasti „Knowledge management“ na manažérskych konferenciách ICICKM (Svetský a kol, 2017; Svetský a kol, 2018). Domáci softvér, v súčasnosti beta-verzia WPadV4 sa prezentoval aj ako „Knowledge Management System“, čo sa v aplikovanej informatike rozumie ako kategória softvéru pre oblasť manažmentu. V období 2018-2019 sa v rámci riešenia projektu V4+ACARDC, ktorý viedla Materiálovotechnologická fakulta so sídlom v Trnave, sa aplikačné menu softvéru WPadV4 rozšírilo o tvorbu tzv. edukačných balíčkov, ktoré predstavujú balíčky „edukačných vedomostí“ a začalo sa riešiť hlasové ovládanie softvéru, ktoré spustí nejakú aktivitu, ktorej výstupom je počítačový súbor, ktorý sa prenesie na internet, odkiaľ sa dá čítať napr. prehliadačom Microsoft Edge alebo s androidovou aplikáciou z mobilu, ktorú vyvinul partner STU FEI. Ako jazyk sa zvolila angličtina, pretože globálne softvéry ešte so slovenčinou nerobia. Konverzia dát na štruktúrované a semi-štruktúrované, ktorá sa využila, je zaregistrovaná ako úžitkový vzor č. 8787/2019 (Svetský, Moravčík, 2020). Majiteľom je STU a je to vo fáze, kedy teda STU by to mala ponúknuť svojim fakultám alebo externým vzdelávacím organizáciám.

5 PRÍKLADY Z RIEŠENIA A TESTOVANIA IT NÁSTROJOV PROJEKTU VEGA 1/0101/18

Nadväzujúc na predchádzajúcu kapitolu budú v nasledujúcej časti príspevku stručne popísané rôzne praktické aplikácie z dizajnu IT podpory vybraných manažérskych procesov. Je potrebné zdôrazniť, že rozsah rôznych kategórií manažérskych činností je veľmi rozsiahly. Rovnako aj spracovanie údajov, doplnkových informácií a digitálnych zručností má každé úplne odlišnú paradigmu pre SW riešenia. Nasledujúce ukážky sú z oblasti manažmentu obsahu, ale môžu byť zaujímavé aj pre špecifické riešenia projektového manažmentu, aké sú popísané v (Hrablik Chovanová a kol., 2020).

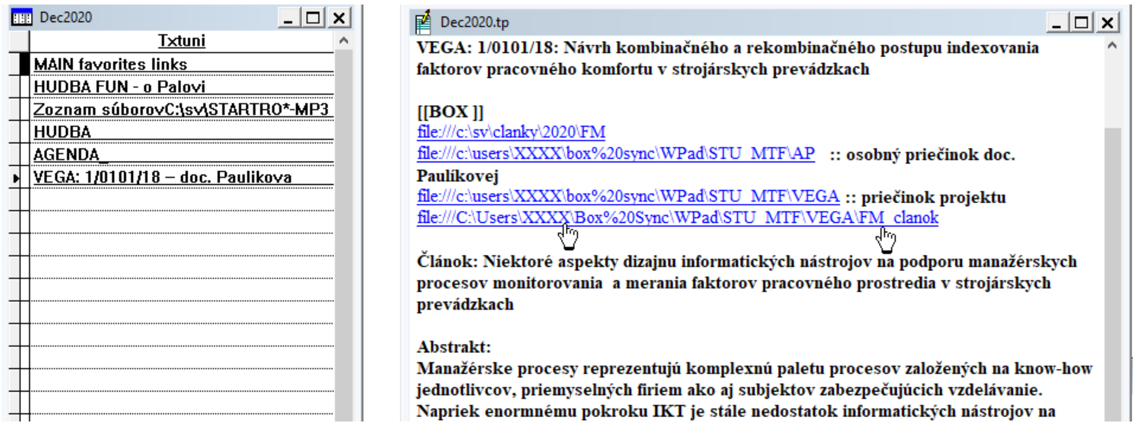
5.1 VIRTUÁLNA VEDOMOSŤ - TABUĽKY

Na Obrázku 2 je schéma virtuálnej vedomosti, čiže reprezentácie vedomosti, ktorá slúži ako izomorfná šablóna (súčasne strojom aj človekom čitateľná), do ktorej (ľudskú) vedomosť vkladá v prirodzenom jazyku.



Obrázok 2: *Model virtuálnej jednotky vedomosti (metadata + content) (Svetský a kol., 2020)*

Z praktického hľadiska to môže byť databázová tabuľka, kde jeden riadok je jedna virtuálna vedomosť, pričom kľúčom k hromadnému spracovaniu informácií je to ako si dokáže užívateľ rozvrhnúť a popísať svoje informácie a (tacitné) vedomosti. Jednu z možností ilustruje ukážka na Obrázok 3, použitá pri kolaboratívnom písaní predkladaného príspevku.



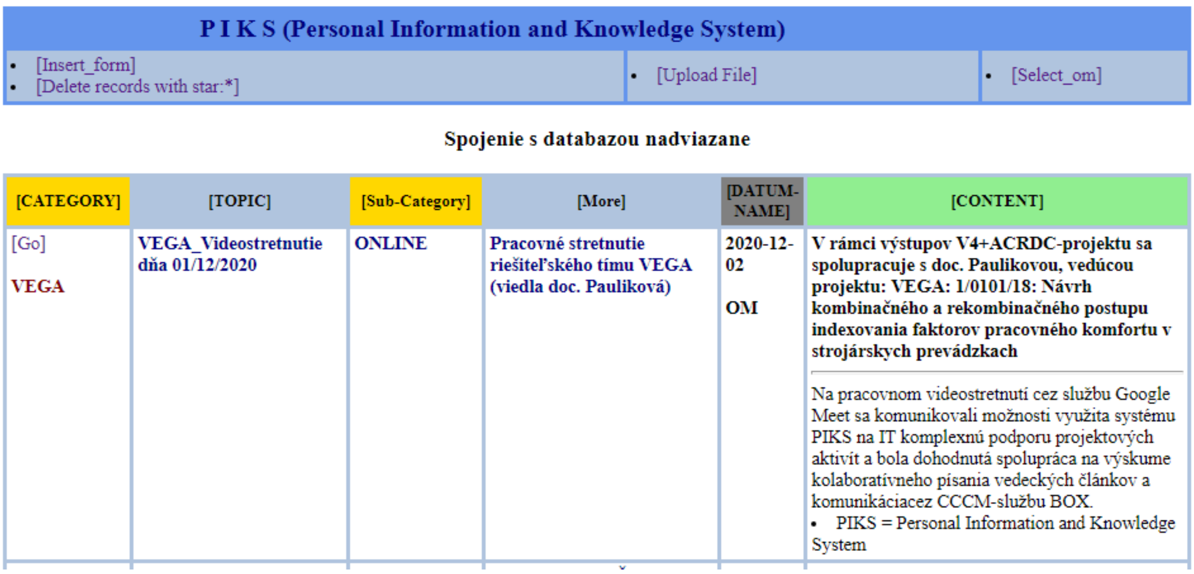
Obrázok 3: *Tabuľka s „vedomosťami" použitá pri písaní tohto článku (vlastné spracovanie, 2020)*

V pravom okne Obrázku 3 je obsah vedomostí, kde je rozpísaný koncept článku a kde sú aj cesty k súborom, čiže ak užívateľ klikne napr. na adresár „FM_clanok " (označené ručičkou), tak sa preklikne do adresára, kde je .doc-súbor, ktorý si otvorí a ktorý sa spoločne zdieľa s ostatnými spoluautormi. Takže akonáhle si dá uložiť súbor, alebo to automaticky robí Microsoft Word, tak sa súbor prenesie automaticky na BOX-cloud, kde si ho môžu spoluautori prezerať alebo stiahnuť, pridať svoj text a nahodiť späť na na BOX.

BOX-cloud je služba, ktorá je určená pre tzv. CCM (Cloud Content Management) alebo ECM (Enterprise Content Management), čiže pre manažment obsahu alebo podnikový manažment na cloude. Pre projekt V4+ACARDC ho dala k dispozícii spoločnosť IBM Slovakia a tento systém používa napr. aj letisko Dubai.

5.2 KOMUNIKAČNÝ KANÁL - PERSONAL INFORMATION AND KNOWLEDGE SYSTEM

PIKS (osobný systém informácií a vedomostí) je najnovšie riešenie aplikácie napísanej v PHP/MySQL, kde teda vedomostná tabuľka má rovnakú štruktúru ako v prostredí domáceho softvéru WPadV4, ktorý je zobrazený na Obrázku 4.



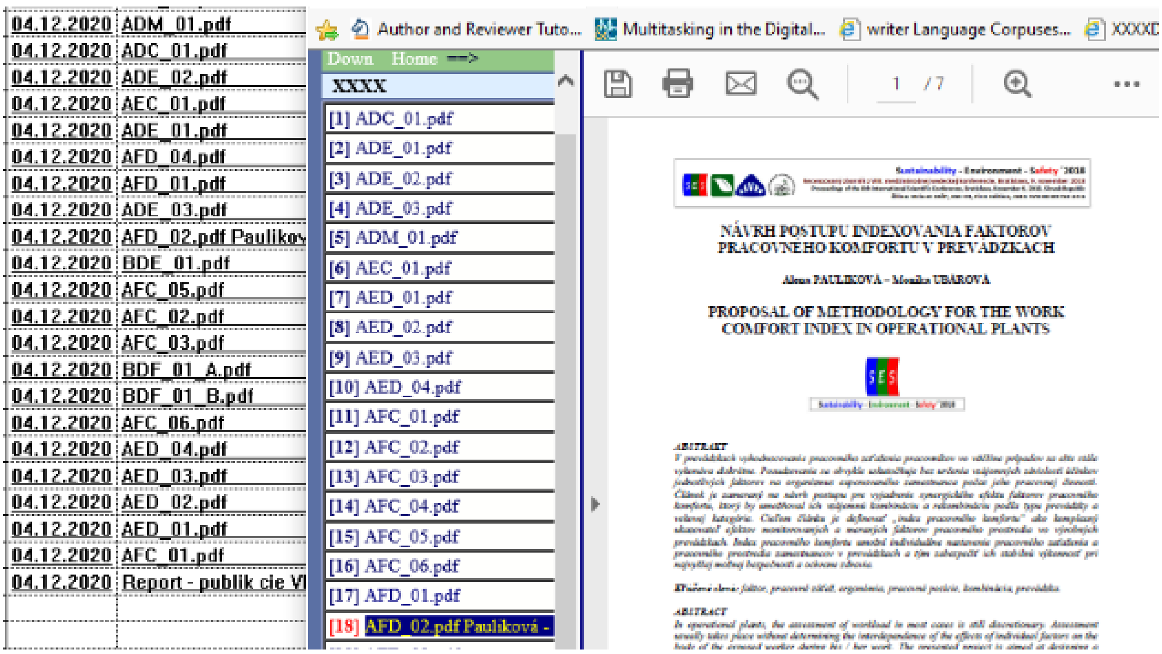
Obrázok 4: *Ukážka záznamu v systéme PIKS (vlastné spracovanie, 2020)*

Odlišnosť je v tom, že táto aplikácie funguje na internete ako komunikačný kanál, t.j. zápis bol urobený na internete. Zjednodušene povedané funguje to ako „inteligentný chat".

Tento systém sa používal na dištančnú výučbu už v období 2010-2017) a bol testovaný aj na diaľkovú skúšku študenta dennej kombinovanej metódy (DKM) alebo v učebni na detašovanom pracovisku MTF v Dubnici nad Váhom. Čiže z hľadiska dištančného vzdelávania v čase pandémie to predstavuje hotové a odskúšané riešenie v kombinácii s WPadom a Virtuálnym vzdelávacím prostredím (Svetský, 2007) (využívalo sa taktiež v Dubnici na výučbu predmetov Základy environmentalistiky, Semestrálne projekty, Programovacie jazyky, Chémia, BOZP, IPP a pre desiatky diplomových prác na malé informačné systémy pre tri ústavy STU MTF). Aj laikovi umožňuje spúšťať a pohybovať sa v STU AIS priamo z tabuliek WPAdV4. Tu treba zdôrazniť, že komunikačné služby ako sú Google Meet, Microsoft Team, ZOOM sú určené na komunikáciu a neriešia tvorbu vzdelávacích materiálov, čiže prezentované nástroje sú ich doplnkom. V princípe jednotlivcovi stačia spolu s AIS na dištančnú výučbu autonómne.

5.3 BALÍČKY VEDOMOSTÍ (TVORBA KNIŽNICE VEGA)

V rámci projektu VEGA sa publikovalo viacero publikácií rôznych kategórií. Aby ich bolo možné si operatívne prezerať využil sa systém tvorby edukačných balíčkov pilotne testovaných v projekte V4+ACARDC (napr. poľský riešiteľ si spracoval virtuálne skriptá). Na Obrázku 5 je ukážka ako vypadá takýto „vedomostný balíček“.



Obrázok 5: *Ukážka tvorby balíčkov vedomostí na tvorbu knižnice (vlastné spracovanie, 2020)*

V ľavej časti Obrázku 5 je vidieť, ako vypadá taká tabuľka v prostredí WPadV4, odkiaľ sa dá článok z daného riadka priamo otvoriť kombináciou kláves Alt-F9. Ak užívateľ chce to mať ako HTML-formát, tak stačí kliknúť Ctrl-F a dôjde ku konverzii tabuľky na html-súbory, ktoré si môže preniesť cez FTP protokol súborového manažéra (Total Commander) na internet (alebo ich používa len na svojom počítači, študenti si môžu takéto súbory prenášať domov aj cez USB-kľúče – starší systém bol využívaný v minulosti vo výučbe uvedených predmetov, keď časť študentov a ani učebne nemali ešte internet – čiže vtedy ešte metóda tvorby edukačných balíkov ešte nebola a išlo o eLearningové materiály generované v predchodcovi softvéru Zápisníku pre výučbu metódami DKM a DPM).

6 ZÁVER

V príspevku sa prezentovali princípy dizajnu IT podpory niektorých kategórií manažérskych procesov a ilustrovali praktické ukážky riešení pre projekt VEGA 1/0101/18. Na rozdiel od používania rôznych všeobecných a globálnych softvérov a služieb, táto IT podpora využíva ako manažérsky nástroj vlastný softvér WPadV4, osobný informačný systém PIKS a kombinovanú online a off-line infraštruktúru (je kompatibilná aj s akademickým informačným systémom AIS). Paradigma hromadného spracovávania informácií a vedomostí, ktorú využíva tento domáci softvér, je založená na izomorfnej reprezentácií vedomostí, ktorá umožňuje koncentráciu obsahu a hromadné spracovávanie akýchkoľvek procesov založených na vedomostiach. „Izomorfne“ znamená z oblasti kybernetiky, že ide o *„prepínač“* medzi mentálnymi činnosťami človeka a fyzickými činnosťami stroja (počítača), ktoré počítač spracuje expresne rýchlo a zobrazí vo forme pre človeka zrozumiteľnej. Ide o riešenie vhodné pre jednotlivca, čo umožňuje synchronizovať spracovávanie obsahu s manažérskymi činnosťami (rozhodovanie). V podstate každý užívateľ počítačov pracuje dnes s rozsiahlym množstvom súborov, informácií a vedomostí, takže bude prinútený zmeniť štýl práce na počítači, prejsť na ich hromadné spracovávanie a transfer medzi off-line a online. Z tohto hľadiska budúceho progresu je cieľom rozvíjať doterajšie riešenia na podporou viacjazyčných kolaboratívnych činností, najmä rozvíjaním tém projektu V4+ACARDC (viacjazyčný portál V4) alebo v rámci iného výskumného projektu, vrátane zavedenia výsledkov do vysokoškolskej výučby.

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REFERENCIE

BLAHOVÁ, J., PAULIKOVÁ, A. 2019. *Psychosocial work strain and its influence on decision-making processes*. In ICERI 2019 Proceedings [elektronický zdroj]: 12th International Conference of Education, Research and Innovation: Seville (Spain) 11-13 November 2019. Seville: IATED Academy, 2019, s. 3898-3905.

CAGÁŇOVÁ, D. AND SZILVA, I. 2018. *Proposal of a Knowledge Management Tool for Tacit and Explicit Knowledge Capture within the Assembly Process*. ÁMOS: Ostrava, 118 s. ISBN: 978-80-906362-3-1.

GOODMAN, S. P. 2002. *Technology-Enhanced Learning: Opportunities for Change*, Laurence Erlbaum Associates, Mahwah, NJ, USA, s. 330, ISBN: 978-080-583-6660.

GYURÁK BABEĽOVÁ, Z., STAREČEK, A., KOLTNEROVÁ, K. AND CAGÁŇOVÁ, D. 2020. Perceived Organizational Performance in Recruiting and Retaining Employees with Respect to Different Generational Groups of Employees and Sustainable Human Resource Management. *Sustainability **12**(2)*, 574-597, ISSN: 2071-1050.

HRABLIK CHOVANOVÁ, H., HUSOVIČ, R., BABČANOVÁ, D., MAKYŠOVÁ, H. 2020. Agile Project Management - What is It? ICETA 2020: proceedings, 18th IEEE International conference on emerging elearning technologies and applications, November 12-13, 2020, virtual conference Košice, Slovakia. Danvers: IEEE, 2020, s. 167-175, ISBN 978-0-7381-2366-0.

KAGERMANN, H., W., WAHLSTER AND J. HELBIG. 2013: Recommendations for implementing the strategic initiative Industrie 4.0: Final report of the Industrie 4.0 Working Group. Dostupné na internete: (https://www.din.de/blob/76902/e8cac883f42bf28536e7e8165993f1fd/recommendations-for-implementing-industry-4-0-data.pdf).

MARTENS, A. 2014. *Software Engineering and Modeling in TEL.* The New Development of Technology Enhanced Learning. Lecture Notes in Educational Technology. Springer, Berlin, Heidelberg. ISBN: 978-3-642-38290-1.

MERNA, T., AL-THANY, F. 2007. *Risk management – Riadenie rizík vo firme*. Computer press, Prague, Czech Republic. 194 s. ISBN: 978-80-251-1547-3.

NONAKA, I. 1994. Dynamic Theory Knowledge of Organizational Creation, *Organization Science*, **5**(1), 14–37, ISSN: 1526-5455.

NOVÁKOVÁ, R., PAULIKOVÁ, A., CANET NOVÁKOVÁ, N. 2019. *The process of indexing working comfort factors in organizations of wood processing industry*. In Digitalisation and circular economy: forestry and forestry based industry implications [Proceedings of Scientific Papers. 12th International Scientific Conference WoodEMA, 11. - 13. 9. 2019, Varna, Bulgaria]. Zagreb: Union of Scientists of Bulgaria, WoodEMA, 2019, s. 269-275.

NOVÁKOVÁ, R., ŠUJANOVÁ, J., CANET NOVÁKOVÁ, N. 2019. Improving Quality Management - the Way Toward Economic Prosperity and Quality of Life, *Production Engineering Archives*. 24(2019), 10-13, ISSN: 2353-5156.

OLIVER, M. 2013. Learning technology: Theorising the tools we study. *British Journal of Educational Technology*, 44(1), 31–43, ISSN: 1467-8535.

PAULIKOVÁ, A., UBÁROVÁ, M. 2018. *Návrh postupu indexovania faktorov pracovného komfortu v prevádzkach*. Sustainability - Environment - Safety: recenzovaný zborník príspevkov z VIII. medzinárodnej vedeckej konferencie konanej 9. novembra 2018 v Bratislave. 1. vyd. Žilina: Strix, 2018, s. 174-180. ISBN 978-80-89753-24-6.

PAULIKOVÁ, A., UBÁROVÁ, M. 2018. Proposal of the combination methodology for the work comfort index in industrial plants. *Interdisciplinarity in theory and practice*, **17**(2018), 39-42, ISSN: 2344 – 2409.

PLATFORM INDUSTRIE 4.0. 2020: Dostupné na internete: (https://www.plattform-i40.de/PI40/Navigation/EN/Home/home.html).

RAZMERITA, L., KIRCHNER, K. AND SUDZINA, F. 2009. Personal knowledge management: The role of Web 2.0 tools for managing knowledge at individual and organisational levels, *Online Information Review*, **33**(6), 1021-1039, ISSN: 1468-4527.

RIDZAL W., FLORENCE P., BERLIAN E. W. 2020. Digital Activism: Covid-19 Effects in Campus Learning, *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal,* **3**(3), 1336-1342, ISSN: 2655-1470.

SCHMITT, U. 2018. Effectuating Tacit and Explicit Knowledge via Personal Knowledge Management Frameworks and Devices, 15th International Conference on Intellectual Capital, Knowledge Management & Organizational Learning ICICKM 2018, s. 293-312.

STAREČEK, A., BACHAR, M., HORŇAKOVÁ, N., CAGAŇOVÁ, D., AND MAKYŚOVÁ, H. 2018. Trends in automatic logistic systems and logistic market in Slovakia, *Actalogistica – International Scientific Journal about Logistics*, **5**(1), 7-14, ISSN: 1339-5629.

SVETSKY, S. 2012. The practical aspects of knowledge construction and automation of teaching processes within technology-enhanced learning and eLearning, Habilitation thesis, Slovak University of Technology, 129 s.

SVETSKY, S., MORAVCIK, O. AND TANUSKA, P. 2017. *The knowledge management IT support: From personalized to collaborative approach*, Proceedings of the 14th International Conference on Intellectual Capital, Knowledge Management & Organisational Learning. ICICKM 2017. UK: Academic Conferences and Publishing International Limited, 2017, s. 253–260.

SVETSKY, S., MORAVCIK, O., TANUSKA, P. AND SAKAL, P. 2018. The IT support of knowledge management and transmission within community of researchers. Proceedings of the 15th International Conference on Intellectual Capital, Knowledge Management & Organisational Learning. ICICKM 2018. University of the Western Cape South Africa. Cape Town, South Africa, s. 312–318.

SVETSKÝ, Š. 2007. Modelling of Multilingual e-Learning and Virtual Learning space for R&D Staff. In ICETA 2007: 5th Int. Conference on Emerging e-Learning Technologies and Applications. Stará Lesná, Slovak Republic, 6.-8.9.2007. Košice : Elfa- 2007, s.1-4.

SVETSKÝ, Š., MORAVČÍK, O. 2020. Zapojenie systému na konverziu neštruktúrovaných dát na semištruktúrované dáta : prihláška úžitkového vzoru č. 75-2019, Vestník Ú- Vestník ÚPV SR č. 06/2020.

SVETSKÝ, Š., MORAVČÍK, O., MIKULOWSKI, D. AND SHYSHKINA, M. P. 2020. *The Design of IT Support of Intellectual Capital: Examples from the KM-Practice.* ICICKM 2020: 17th International Conference on Intellectual Capital, Knowledge-Management & Organisational Learning, 15. - 16. October 2020, Toronto. Toronto: University of Toronto, s. 354-362.

SVETSKÝ, Š., MORAVČÍK, Oliver. 2016. Zapojenie systému spracovania neštruktúrovaných dát, využívajúceho špecifickú dátovú štruktúru : prihláška úžitkového vzoru č.45-2014. Vestník ÚPV SR č. 02/2016.

SVETSKÝ, Š., MORAVČÍK, Oliver. 2017. The Universal Personalized Approach for Human Knowledge Processing. *Proceedings of the World Congress on Engineering 2017 (WCE 2017): The 2017 International Conference of Computer Science and Engineering (ICCSE'17), July 5-7, 2017, London, U.K.* IAENG, s. 247-251.

SVETSKÝ, Š., PAULIKOVÁ, A, BALOG, K., TUREKOVÁ, I. 2007. Záverečná správa k riešeniu úlohy APVV-99-P01905 Transfer: Výskum životného cyklu a ekologizácia obrábania. Trnava: MTF STU.

SVETSKÝ, Š., SAKÁL, P. AND HRDINOVÁ, G. 2010. Nové prístupy k riešeniu automatizácie činností výskumníkov, pedagógov a manažérov pri spracovávaní a manažmente informácií a vedomostí. *Fórum Manažéra*, **1** (2010), 9-12, ISSN: 1336-773.

VRAŇAKOVÁ, N., CHLPEKOVÁ, A. 2020. *Impact of Formal Education on the Age Management Concept in Industrial Enterprises.* In *ICETA 2020 : proceedings, 18th IEEE International conference on emerging elearning technologies and applications, November 12-13, 2020, virtual conference Košice, Slovakia*. Danvers : IEEE, 2020, s. 756-761. ISBN 978-0-7381-2366-0.

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