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The impact of Industry 4.0 implementation on required general competencies of employees in the automotive sector

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Abstract
In an effort to reduce operating costs and to increase the quality and efficiency of production, production organizations in the automotive sector are trying to implement the Industry 4.0 concept, which has become a phenomenon of the last two decades. These initiatives have a significant impact on the employees in production organizations, especially in automotive sector. The main aim of the presented study is to expertly assess the importance of general competencies for transforming job positions in the automotive industry in Slovakia. The starting point of the presented study were the results of research focused on emerging positions in the automotive industry and the competencies required by employers in Slovakia. Based on the expert assessment, the hierarchical structure of the solved problem was created and the importance of competencies for analysed job positions was assessed by applying the Analytical Hierarchical Process (AHP) method. The results pointed to the growing importance of non-technical competencies. Analyses have shown that actually the most important work competencies are: basic literacy, professional knowledge, problem solving, digital skills and analytical thinking. The development of the necessary competencies will be important both, from the point of view of employers, but also of employees working in professions that are in decline, become endangered and need to be transformed into the required professions.

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1. Introduction

The Fourth Industrial Revolution, widely known as Industry 4.0 has become a widespread idea in recent years as technology and digitization are integrated into manufacturing processes. The previous three industrial revolutions - the first associated with mechanization, the second with mass production processes and the third with electronics, automation and information technology, the fourth industrial revolution represents the introduction of radical innovations that affect the physical, digital and biological fields (Schwab, 2017; Schwab and Davis, 2018; Stachová et al., 2019; Castelo-Branco et al., 2022). The deployment of intelligent technologies of the fourth industrial revolution, such as automation and artificial intelligence, can bring different results at the level and in terms of economy, environment and social point of view (De Sousa Jabbour et al., 2018; Kamble, et al., 2018; Müller et al., 2018; El Baz et al., 2022). Companies around the world spend a lot of time, money and energy developing new technologies, while Industry 4.0 enables production lines, processes and teams to work together regardless of location, time zone and any other aspect (Javaid et al., 2022). In Slovakia, most companies are familiar with the issues of Industry 4.0 (Grenčíková et al., 2020; Snieška et al.,2020), or deal with it, companies analyse the possibilities of implementing smart industry elements into their processes or, to a greater or lesser extent, directly implement them (Grenčíková et al., 2020). As the automotive sector is one of the key pillars of the Slovak economy (Sütőová et al., 2020), this sector is the most affected by the Industry 4.0 concept. Driving forces and barriers in the implementation of Industry 4.0 can be divided into three groups: technological (intelligent manufacturing), economic and regulatory (changes in business models, concepts of financial and legal requirements) and social (focused on customers and employees) (Obiso et al., 2019; Bilgen, 2021). It is also important to emphasize the social dimension (Satyro et al., 2022), which has shown that technology and the Industry 4.0 concept bring social benefits through training, human skills development

and better social integration (Hermann et al., 2016; Ding et al., 2017). Digitization within industrial companies is changing workplaces and human resources. The implementation of Industry 4.0 transforms the way people work, learn, lead, manage, and communicate with each other (Da Silva et al., 2022). On the other hand, employees are also concerned about the ongoing changes resulting from the Industry 4.0, especially in terms of job loss, inability to cope with new procedures, loss of competencies and the problem of finding a suitable job (Zezulka et al., 2016; Satapathy, 2017; Shin et al., 2019; Cezarino et al., 2019; Adamková, 2020). The growing demands of technology are a challenge for different job categories, as the tasks they work on are less and less routine and require the constant development of knowledge and skills (Ras, et al., 2017). The result is the creation and change of curricula and, in terms of job positions, especially physically demanding positions will face extinction (Benešová and Tupa, 2017; Haleem and Javaid, 2019; Chin et al., 2019). They will be replaced by automated machines that will require maintenance staff and current staff will have to adopt retraining programs (Benešová, Tupa, 2017). There are more opportunities for higher-skilled workers (Hecklau et al., 2016) and for professions at risk of demise, there is a need for transformation (Trotta and Garengo, 2019). An important area is the need to identify areas of training and skills gaps, as well as to initiate competence development (Pinzone et al., 2017). The automotive workforce may not be sufficiently qualified at present, and it is therefore necessary to invest time and resources in skills development and staff training (James et al., 2022). The pace of technological change requires more educated and skilled employees, ready to respond flexibly to dynamic developments. The implementation of new technologies in the automotive industry will also have a significant impact on employees. New technologies require employees to acquire new knowledge, skills, or competencies needed to operate these technologies. These competencies may be specific for different technologies. In addition, it is desirable for employers that employees possess, in addition to professional competences typical for specific job positions, also general competences that enable them to adapt flexibly to changes and new challenges. The aim of the paper is therefore to assess what impact of the implementation of Industry 4.0 initiatives in the automotive production can be expected on the-general competencies required by employers operating in the automotive sector.

2. Fundamentals of addressed issues

The Slovak Republic is a highly industrialized country. Within Europe, it is one of the countries with the highest share of industry in total GDP (Gross domestic product). The industry in Slovakia is dominated mainly by the automotive, machine and engineering sectors, which, together with electrical engineering, are the main contributors to the growth of industrial production in the Slovak Republic. Figure 1 shows the number of cars produced per capita in European countries over a 7-year reference period. It is obvious that Slovakia is a leader among other countries in the number of cars produced per capita.

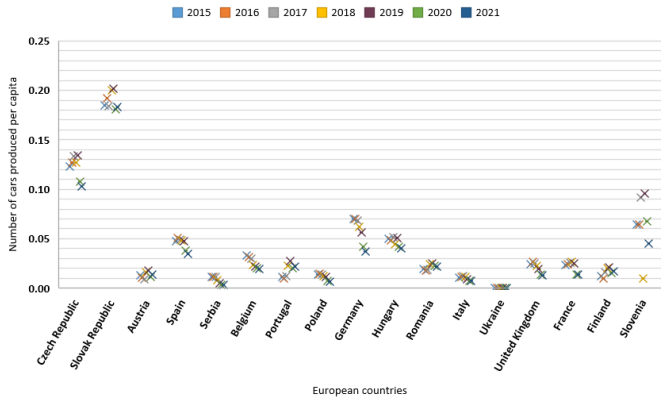

Fig. 1. Number of cars produced per capita within the European countries in 2015 - 2021

The data in the Figure 1 were compiled on the basis of statistics on the number of cars produced by the International Organization of Motor Vehicle Manufacturers (2022) and the number of population for individual years from the Eurostat database (2022). The automotive industry has a long and strong tradition in Slovakia. It gradually became the most important sector in terms of its share in Slovakia's total GDP, Slovakia's exports, but also job creation (Sario, 2022). Figure 2 shows the development of the number of passenger cars produced over the observed period of seven years (International Organization of Motor Vehicle Manufacturers, 2022). Although overall car production and sales have stagnated, a renewed increase in production can be observed.

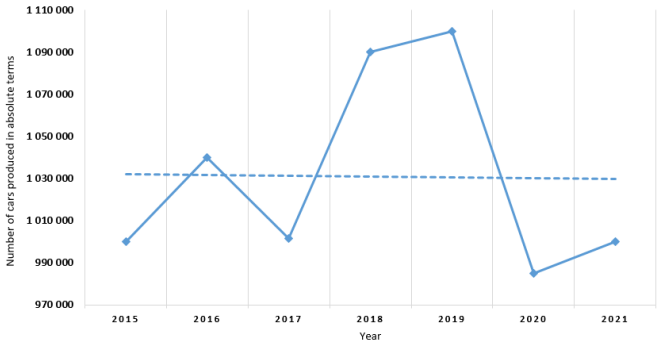

Fig. 2. Absolute number of cars produced in Slovakia 2015 - 2021

Industry 4.0 includes digitization, which is bringing change to today's industry. As part of the ongoing digital transformation of the economy and society, an industrial society is being transformed into an information society. This transformation brings the need for new skills. Based on data on the expected global average retraining need in the automotive industry from 2018 (ILO, 2020; WEF, 2020) and 2020 (Statista Research Department, 2022), the authors recalculated the expected need for retraining in the automotive industry for 2022 (Figure 3). In addition to labour shortages, organizations must address the need to adapt employees to the growing skill requirements of employees in the automotive industry. The need for development concerns professional, technical, digital but also non-technical skills. Necessary non-technical skills that need to be developed in the context of the Industry 4.0 concept

include language skills, flexibility, reliability, cognitive skills, planning, leadership skills, teamwork, analytical and logical thinking, emotional intelligence, critical thinking, problem solving (Benešová and Tupa, 2017; Cimini, 2017; Prifti et al., 2017; Whysall et al., 2019; Shet and Pereira, 2021).

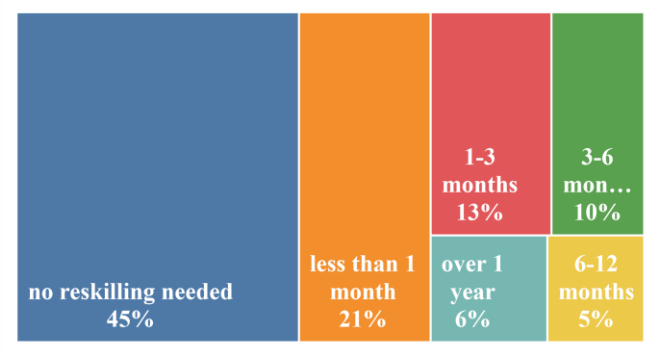

Fig. 3. Estimated percentage of staff retraining needs for 2022

Well-organized corporate training activities should help seize new opportunities in an ever-changing and highly competitive business environment (Giniuniene and Pundziene, 2020). Skills development and training are investments in employees' ability and are key to ensuring sustainable work in the automotive industry, but also to ensuring a fair transition to future work that contributes to sustainable development (ILO, 2020). Due to the structure of employment in industry, the Slovak Republic is one of the countries in which the most job positions will be affected by the development of Industry 4.0 (Trexima et al., 2022). One of the key factors that will affect the future of industry in Slovakia will be the lack of qualified employees. Rapid technological change will require employees who are more versatile, skilled and ready to deal with constant change. There is a significant lack of verbal, quantitative and intellectual abilities in the Slovak Republic. The Slovak Republic faces a lack of knowledge, especially in several areas such as computers and electronics, official and mathematical skills (OECD, 2021). Based on the above described fundamentals and addressed issues, the main aim of the presented study was formulated. The main aim of the study was to expertly assess the importance of general competencies for transforming job positions in the automotive industry in Slovakia.

3. Materials and methods

For the purposes of the study, professions in the automotive industry, whose representation is expected to increase, were selected. The expected increase was predicted for professions such as: Data Analysts and Scientists, Business Development Professionals, AI and Machine Learning Specialists, Strategic Advisors, Materials Engineers, Management and Organisation Analysts, Digital Transformation Specialists, Database and Network Professionals, Environmental Protection Professionals, Robotics Engineers (WEF, 2020). For the purposes of the study, it was also necessary to select competencies that will be expertly assessed. Some competency models have already been developed for employees in production, e.g. Engineering Competency Model (Employment and Training Administration, 2023). In Slovakia, a national system of occupations was created, which includes detailed competency models for concrete individual occupations, in the automotive industry as well (Národná sústava povolaní, 2023). In our contribution, we focused on general competencies, those competencies that will enable employees to work effectively and to acquire professional competencies.

Based on studies focused on skills required by employers in the automotive and engineering industries, processed in Slovakia (AZZSR, 2020; Hrnčiar, 2020), we selected competencies, the importance of which had to be assessed for selected emerging positions in the automotive industry.

The selected competencies were:

- Basic literacy – it is understood as the ability to read and listen with understanding, formulate and express ideas in a written text and do basic mathematical tasks (Olaniyi, 2015, Crooks et al., 2021) and operate common equipment.
- Professional knowledge application – represents the ability to practically apply the professional knowledge acquired through studies within the school system or lifelong learning in the work performance.
- Digital skills – include digital fluency, algorithmic thinking, cyber security literacy, data analytics and statistics, software use and development, and data understanding (Dondi et al., 2021).
- Communication – communication skills represent interpersonal communication and listening (Clokie and Fourie, 2016), the ability to formulate and verbalize ideas, express oneself clearly, use nonverbal communication, ask questions, paraphrase and summarize, and lead a conversation or discussion.
- Language skills – represents the ability to communicate, to read and to express in writing in a foreign language.
- Critical thinking - is careful goal-directed thinking, represents the ability to draw conclusions from available information, includes the ability to transform confusing information into a clear question, the ability to correctly explain a general phenomenon or a specific fact (Hitchcock, 2020).
- Analytical thinking - reasoned assessment of entitlements and benefits, includes analytical deliberation, comparing, decision making (Rusou et al., 2013).
- Creativity - represents the ability to generate new and useful results (Yuan et al., 2022).
- Managerial skills – are the skills that managers use to build, integrate, and reconfigure organizational resources and capabilities (Adner and Helfat, 2003). Managerial skills include the ability to interact and motivate, technical skills, and conceptual skills (Popescu et al., 2020).
- Teamwork - teamwork capability represents the ability to actively participate in the processes through which team members work together to achieve goals. Teamwork refers to the activities through which team tasks are performed (Driskell et al., 2018).

- Independence – is an indicator of a responsible, mature and enterprising person (Birecikli et al., 2016). It represents the ability to work independently, to meaningfully choose the way of working and to make the necessary decisions.
- Problem solving – represents cognitive skill. It involves applying rules learned from previous experience, finding and implementing new solutions to problems or obstacles that arise (Korkut, 2002). The problem to be solved is a certain discrepancy between the current state and the desired state (Erçevik and Köseoğlu, 2021).
- Flexibility – ability to adapt to change. Flexibility is manifested by the employee's ability to use different approaches to deal with new circumstances (Martín et al, 2013).

The Analytical Hierarchical Process (AHP) method was applied to assess the significance / importance of the selected and above described competencies needed to perform predicted the most (most frequently) emerging positions in the automotive industry. AHP makes it possible to make effective decisions in complicated situations, to simplify and speed up the natural decision-making process. AHP provides a complete and rational concept for structuring the problem, for quantifying its elements that are related to the final goals and for evaluating alternative solutions (Saaty, 2008; Laxman and Yeonbae, 2018). The concept of the method allows the use of the AHP method in several different areas. It is used worldwide in decision-making processes in various fields. It is an adequate method for business assessment, where the consideration of several criteria leads to the objectification of their evaluation. It has been applied in decision-making processes in a variety of research areas, as is shown in Figure 4 below.

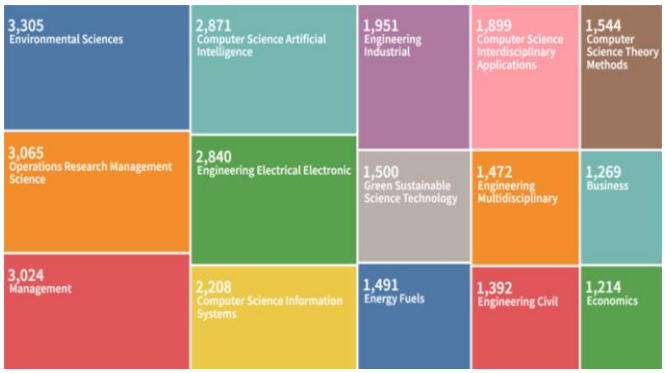

Fig. 4. Analysis of the keyword AHP occurrence in the WOS database

As part of analysis of the published papers on the AHP method application published in the Web of Sciences database, 28,828 publications (outputs) were searched. Based on the number of publications categorized by affiliation to the Web of Sciences categories, the most numerous areas are Environmental Sciences (3,305 outputs), Operations Research Management Science (3,065 outputs) and Management (3,024 outputs).

The prerequisite for the method application was the creation of a hierarchical structure of the problem based on the AHP method. The basis of this method is the division of a multicriteria problem into smaller parts and the subsequent creation of a hierarchical model. After creating a hierarchical model, experts made pairwise comparisons. After building the model, the decision maker at each level derives a square matrix of pairwise comparisons for each parent element. The values listed in the matrix will represent the given decision maker's preferences for the given pairwise comparison. The entire system of AHP application ends with the final synthesis, with the help of which the resulting priorities of alternatives to the goal are derived (Peregrin, Jablonský, 2015).

Used AHP method consisted of the following steps:

1. Defining the goal, the decision-making problem (assessment): Determination of competencies significance for emerging job roles in the automotive industry.

2. Identification of possible alternatives to the problem: In our study, these are the general competencies needed to perform the most (most frequently) emerging professions in the automotive industry and acquire required missing or not enough developed professional competencies. The mentioned competencies were determined on the basis of research results focused on the competencies required by employers in Slovakia (AZZSR, 2020; Hrnčiar, 2020).

3. Criteria determination for evaluation of solution alternatives. The criteria for assessing the importance of competencies are the expected emerging positions in the automotive industry according to (WEF, 2020), mentioned in the beginning of this chapter.

4. Creating relations between goal, alternatives and criteria and building a hierarchical structure (Figure 5).

Expert decision-making methods are based on the qualified opinions of experts. These opinions are subjective, but based on the opinions and recommendations of experts. Their importance lies mainly in the creation of forecasts or concepts. Due to the nature of the presented article, we chose the analytical hierarchical process method using the Expert Choice software.

The members selected to the expert team that created the hierarchical model were experts working at the university, experienced in cooperation with organizations operating in the field of the automotive industry, data analysis and predictions and prognosis on the labour market preparation. Experts for the assessment of competences importance were selected based on their pedagogical, research, consulting and managerial experience, knowledge and experience with competence-based management, Industry 4.0 and the related transformation of occupations. The selection of experts, in addition to knowledge and experience in the field, was conditioned by participation in national and international research projects related to the investigated areas. The team of experts was gender-balanced and age diversified. Due to the variability of the areas in which the team members had expertise, five experts were chosen in the last round of selection to participate in the creation and application of the AHP model as can be seen at Figure 5.

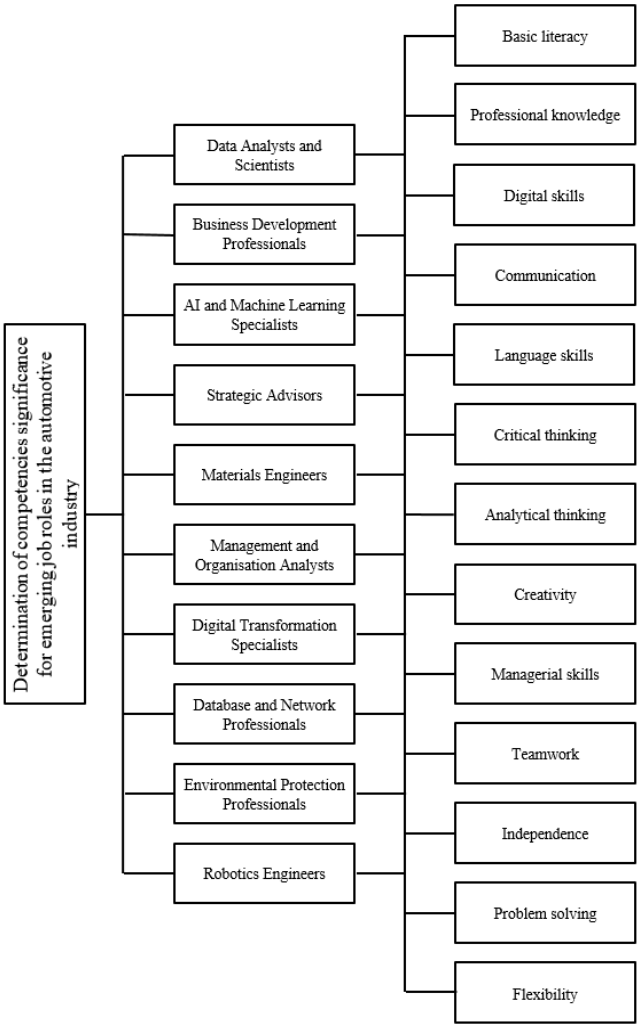

Fig. 5. Hierarchical structure of addressed issue

Figure 5 shows that for determination of competencies significance for emerging job roles in the automotive industry, the required competencies were chosen as an alternative and their assessment criterion was their importance for emerging job professions.

After the construction of the initial hierarchical structure, the experts proceeded to the evaluation. It was a face-to-face/contact group evaluation, which included a brief explanation of the evaluation method using the pair evaluation scale of the AHP method (values from 1 to 9). Subsequently, the experts commented on the criteria (future occupations) and competences that will be necessary for the fulfilment and performance of future occupations. After the partial adjustment (formulation) of the individual competences, to the experts were given 10 tables/matrices for pairwise comparison, where the experts compared in pairs required competencies according to individual future job positions. Subsequently, a joint, collective assessment by pairwise comparison was carried out, where the resulting values of the pairwise comparison were refined through discussion and expert consensus. Finally, the results of the collective assessment were entered into the Expert Choice program according to the procedure described in the next section.

4. Results

The Expert Choice program was used to solve the selected problem with the following procedure:

1. Determining and entering the goal, criteria and alternatives of problem solving.
2. Assigning the weight of individual criteria (emerging job positions) through pairwise comparison of criteria.
3. Evaluation of alternatives (significance/importance) of competencies needed to perform the most (with the highest frequency) emerging positions in the automotive industry by pairwise comparison of individual criteria.
4. Evaluation of the current state of competencies the system of within selected employees.

2. Assigning weight to individual criteria

Based on the pairwise comparison, a matrix of pairwise comparison of criteria was created. In the pairwise comparison matrix, the criteria are compared with each other based on the assessment scale. In the pairwise comparison, we used integer values in the range of 1 to 9 according to the Saaty principle (Saaty, 2008).

Based on a pairwise comparison, using the Expert Choice program was calculated the weight of the individual criteria, which can be seen in Figure 6. Industry 4.0 causes the transformation of the economy into a digital economy. These changes also affect the needs of the labour market and the structure and number of offers in specific jobs. Professions whose share is expected to be growing the most (those that should be emerging) in the automotive industry should be Data Analyst and Scientist, Business Development Professionals and Artificial Intelligence and Machine Learning Specialist. The overall order of the significance values is shown in Figure 6.

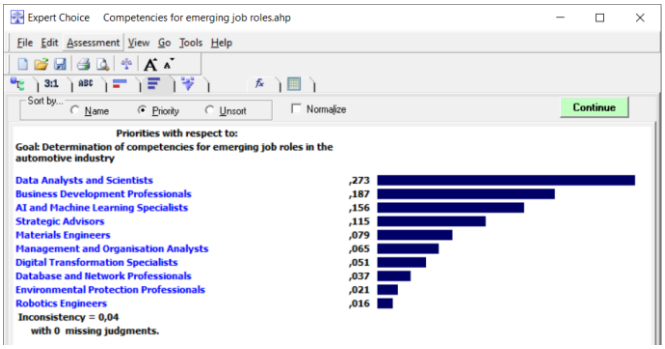

Fig. 6. Criteria (emerging positions) sorted by importance/significance

In addition to the evaluation of the significance of individual criteria, Figure 6 also shows the value and the consistency analysis, the value of which should be up to 0.1. In this case, the consistency value is 0.04, so the logical consistency in the pairwise comparison was maintained. Note: Expert choice software uses a (decimal) comma to separate decimal numbers from integers instead of a dot.

3. Evaluation of alternatives according to individual criteria

Alternatives are assessed in the same way as the criteria. The result is matrices of pairwise comparison of alternatives according to criteria. The final result of the application of the AHP method was the identification of the most important competencies for future job positions in the automotive industry (Figure 7).

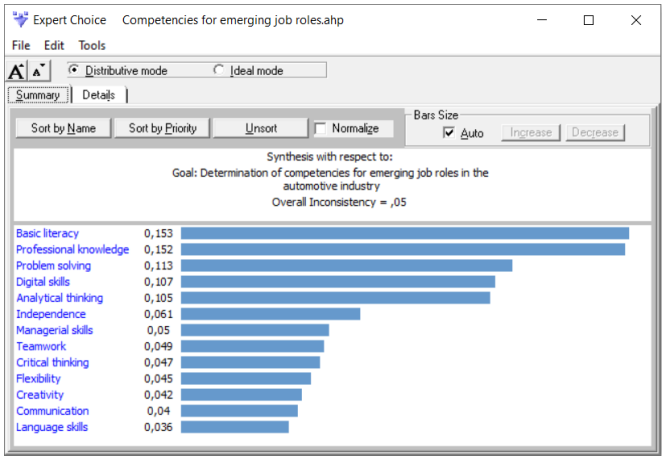

Fig. 7. Determining the order of alternatives (competencies needed for future professions) according to importance

The results shown in Figure 7 represent the ranked job competencies needed for future professions, according to the calculated significance from the most important to the least significant job competencies. Significance is determined by a synthetic indicator, which was calculated by the software on the basis of pairwise comparison by expert assessment of the required competencies for the performance of future professions. Overall inconsistency has a value of 0.05, so the condition of logical consistency is met and we can say that the pairwise comparison was performed correctly.

5. Conclusion

As demonstrated in the introduction, the Slovak Republic is at the forefront of per capita car production in Europe. Current research shows that the Slovak Republic is undergoing a transformation of production organizations in an effort to implement the Industry 4.0 concept. Mentioned concept will have a significant impact on labour market requirements. Requirements for employees' skills and competencies are currently changing with gradual industrialization. Based on forecasts, we can predict that the need for staff requirements in production organizations (job structures) will be completely different in a few years than it is at present.

Professions that are predicted to be in decline and becoming redundant are: Data Entry Clerks, Administrative and Executive Secretaries, Accounting, Bookkeeping and Payroll Clerks, Material-Recording and Stock-Keeping Clerks, Cashiers and Ticket Clerks, Assembly and Factory Workers, Accountants and Auditors, Sales Representatives, Wholesale and Manufacturing, Door-To-Door Sales Workers, News and Street Vendors and Agricultural Inspectors (WEF, 2020). Changes in the structure and nature of the required professions affect the requirements for knowledge and skills of employees. This fact will be challenging and possibly difficult for countries such as the Slovak Republic with a dominant production sector.

The main aim of the study was to expertly assess the importance of general competencies for transforming job positions in the automotive industry in Slovakia. For this purpose, the authors of the paper used the AHP method, using which it is possible to make effective decisions in complex issues, such as the transformation of professions within Industry 4.0. Based on a comprehensive assessment of professions and competencies, it was possible to apply the AHP method, which was used in the study.

An important starting point for the study was emerging professions in the automotive industry. The significance of the required competencies for future professions was assessed through expert assessment and using the AHP method. These jobs are currently key to the smooth implementation of Industry 4.0. The presented results showed that it will be necessary for employees of redundant professions to effectively transform into the required job positions. This transformation must be made possible not only by the automotive sector in the context of sustainable human resource management, but also by institutional education and higher education institutions. Regular reporting plays an important role, but also research and studies focused on the future of professions and expectations of the necessary competencies. The labour market has become more complex and demanding for employees, due to the exponential acceleration of technological innovation. Tasks are becoming more and more specialized and require a workforce that is able to retrain several times during their career. The most important thing for employees will be the ability to adapt and develop the necessary competencies as well as lifelong learning.

5.1. Research limits

One of the limitations of the presented research is the fact that the processed secondary data (the data on which the study was based) are currently available data, but this data reflect the past. Effective changes in the global environment may cause a shift in priority professions in the automotive industry as well, and these changes will be captured with a certain time lag. Another limitation is the functionality of used method, which depends on the quality of the outputs of the expert assessment by experts.

Through the use of AHP, it was possible to point out which competencies need to be paid attention to in the development of employees. The possibility to develop the identified competences is further limited, due to the fact that currently industrial enterprises face significant limits from the supply of materials and components as well as the energy crisis, and the Industry 4.0 transformation has begun to slow down.

A possible limitation of the study is also that we do not take cultural differences into account. In today's increasingly intercultural environment, differences in education, communica-

tion and working methods can have an impact on the importance of necessary professional and also general competencies.

The evaluation of individual competencies was carried out by experts from universities, and a potential limitation may be the distortion of the study results for the aforementioned reason. Thus, the assessment may not represent the full range of expertise required for a comprehensive assessment. A broader perspective and different views on competency assessment can be brought by experts from practice and the private sector, and governmental and non-governmental agencies.

Similarly, in the case of selection criteria that are based on research, consulting, or management involvement, they may prioritize individuals with specific expertise and suppress individuals with practical experience, regardless of education and academic qualifications. An example of a requirement may be experience and participation in research projects (both national and international), which may also limit the selection and exclude individuals who do not have such experience but have sufficient expertise. The result of direct personal assessment, discussion and consensus of experts can be to look at the problem from different angles and reach a collective assessment.

An important conclusion is that although expert-academic research may have limitations, efforts made to include diversity in other aspects may help mitigate and eliminate potential limitations in the study.

5.2. Future research

The authors of the paper plan to further investigate the possibilities of disadvantaged employees in the implementation of the Industry 4.0 concept and the possibilities of transforming retreating jobs and professions. The issue of human resource management in the implementation of Industry 4.0 has several bottlenecks such as effective training, retraining and requalification of employees for new jobs and lifelong learning. Another aim of the authors is to carry out quantitative research, focused the potential of employing disadvantaged groups of employees in the context of changing conditions for enterprises connected to Industry. 4.0, respecting the uniqueness of different generations of employees.

Industry 4.0 includes digitization, which is bringing change to today's industry. As part of the ongoing digital transformation of the economy and society, an industrial society is being transformed into an information society. This transformation brings the need for new skills. Based on data on the expected global average retraining need in the automotive industry from 2018 (WEF, 2018, ILO, 2020) and 2020 (Statista Research Department, 2022), the authors recalculated the expected need for retraining in the automotive industry for 2022 (Figure 3). In addition to labour shortages, organizations must address the need to adapt employees to the growing skill requirements of employees in the automotive industry. The need for development concerns professional, technical, digital but also non-technical skills. Necessary non-technical skills that need to be developed in the context of the Industry 4.0 concept include language skills, flexibility, reliability, cognitive skills, planning, leadership skills, teamwork, analytical and logical thinking, emotional intelligence, critical thinking, problem solving (Benešová and Tupa, 2017; Cimini, 2017; Prifti et al., 2017; Whysall et al., 2019; Shet and Pereira, 2021;).

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工业 4.0 实施对汽车行业员工所需一般能力的影响

關鍵詞
汽车 工业4.0
生产
社会环境
转型

摘要
为了降低运营成本并提高生产质量和效率，汽车行业的生产组织正在尝试实施工业 4.0 概念，这已成为过去二十年的一种现象。 这些举措对生产组织的员工产生了重大影响，尤其是汽车行业。 本研究的主要目的是专业评估一般能力对于斯洛伐克汽车行业工作职位转型的重要性。 本研究的出发点是针对汽车行业新兴职位以及斯洛伐克雇主所需能力的研究结果。 在专家评估的基础上，创建了所解决问题的层次结构，并应用层次分析法（AHP）评估了所分析职位的能力重要性。 结果表明非技术能力越来越重要。 分析表明，其实最重要的工作能力是：基础素养、专业知识、问题解决能力、数字技能和分析思维。 从雇主的角度来看，必要能力的发展对于从事衰退、濒临灭绝并需要转变为所需职业的职业的雇员来说也很重要。