Journal of Human Resource Management
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HR Advances and Developments
ISSN 2453 – 7683 www.jhrm.eu

Human Capital Management in the Industrial Revolution 4.0

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ABSTRACT

Purpose - The technological breakthrough known as the 4th Industrial Revolution is characterised by the mass spread of the Internet and its penetration into most human activities. Devices are being connected to this network, giving rise to new sociotechnical systems. For such systems to work reliably, experts with digital skills are needed.
Aim - The aim of this paper is to explore the possibilities of appropriate curriculum adaptation in light of human capital development trends in the context of digitalisation.
Design/methodology/approach - A detailed survey of publications in the Web of Science database was used to investigate the issue under study. In order to have a complete picture, the results were examined in VOSviewer.
Findings - The results show a growing trend of interest in this subject. Professionals are making efforts to incorporate digital courses into the curriculum since they recognise the value of continuous learning.
Limitations of the study - Much deeper and more detailed research, based on primary data sources is needed on this issue to obtain more relevant and detailed results.
Practical Implications - This paper has provided insight into the trend of the issue under study, revealing the necessity of implementing digital courses in the content of education. The paper's contribution is its suggestions for curriculum modifications that would help students become more digitally literate and hence more equipped for the workplace of the future – Work 4.0.
Originality/value – Research, based on secondary data sources, confirms the growing importance of a digital nature in context of Industry 4.0 with practical implications to educational process.

KEY WORDS

human capital, digitalization, education 4.0, industry 4.0, work 4.0

JEL Code O31, I21, J24
DOI: 10.46287/KVJI8339

1 INTRODUCTION

The digitalisation of the economy and the fourth industrial revolution are accompanied by a blurring of the boundaries between physical and digital technologies. This process leads to the creation of new jobs and the development of human capital as a key competitive advantage. The introduction of new technology into established operations means that employees have to face increasing demands on their skills and competencies. In the area of human resources, trends associated with the digitalisation and robotisation of production can be observed. On the one hand, there are job cuts, wage stagnation, and the growth of certain wage inequality; on the other hand, there is the emergence of new, interesting, and well-paid professions (Kolmyková & Merzlyaková, 2019). Digitalisation is seen as a fundamental transformation of both industry and services. This is also linked to a radical shift in the conditions of work. The core of so-called Industry 4.0 combines machines, products, materials, and humans with software to enable partial or full automation through systems of intercommunicating sensors (Haipeter, 2020). The structure of an Industry 4.0 system is defined as a set of technological components and related organisational units that serve a given purpose or function. For Industry 4.0 to be successful, its parts must be viewed as a complex sociotechnical system (Xu, 2020).

Instead of being a product of management theory, human capital has its roots in the economic sphere. The concept of human capital was originally formulated by Nobel Prize-winning economist Theodor Schultz (1961), who pointed out the benefits of investing in education on a national scale. Over the following years, other economists have taken Schultz's definition of human capital and expanded it in various ways. Nowadays, there are a number of definitions and ideas associated with the concept of human capital in different fields. The management literature also describes human capital as the sum of the skills, attitudes, and interactions between managers and employees (Flöthmann et al, 2018). Employees who have strong interpersonal relationships with co-workers and external partners are much more willing to share their knowledge and skills, which makes human capital management a key resource needed to support the effective use of digitalisation (Kosmol & Lutz, 2019). Since people and digital technology are intertwined, it can be argued that a company's performance is closely correlated with the abilities of its employees. Therefore, if a company is to catch up in the digital transformation race, it must appropriately overcome and compensate for the skills and competency gaps of its employees. The Fourth Industrial Revolution could only be perceived as a great opportunity by a given sector if it is endowed with a competent workforce capable of handling the introduction of new business models and technological developments. Thanks to real-time data generated by intelligent and automated production systems, employees will be able to make more informed decisions and deal with complex situations. Automation can also lead to improved safety, for example, by allowing workers to stay at a safe distance from machines. The main condition for the creation of this highly skilled workforce is the retraining and upskilling of existing and potential workers. Human capital is a fundamental factor that accelerates or slows down the innovation transformation. The development of human capital is closely related to the acquisition of new knowledge, new methods of work, and new technologies (Krasnostanova et al., 2021).

Today, human capital is increasingly becoming a critical factor for the development, competitiveness, and performance of organisations and society as a whole. The concept of human capital is still being explored by economists and managers. In connection with it, there is also a need to address investment in its development. This article aims to explore the possibilities of appropriate curriculum adaptation in light of trends in human capital development in the context of digitalisation.

2 THEORETICAL INSIGHTS

Digitalisation is defined as the process of transforming an organisation from traditional to new ways of working and thinking using digital, social, mobile, and emerging technologies (Burnson, 2018). There are studies that have confirmed the positive role of digitalisation as a competitive and process advantage.

Arcelay (2021) highlights the importance of this process in the renewable energy sector, where digitalisation enables an efficient network that can be used to manage large amounts of data, optimise operations, improve performance, and more easily control processes in real time. According to Popkova & Giyazov (2021), the quality of services provided by the healthcare system depends on the level of digitalisation of the economic system of a country. The latter directly determines its ability to cope with viral threats, such as the Covid-19 pandemic. Using correlation analysis, it has been proven that countries with high levels of digitalisation have a more progressive healthcare system, which provides a great advantage in the fight against viral contagion. Through a thorough theoretical analysis of academic publications and professional viewpoints, Akyazi et al. (2020) discovered that core abilities, such as fundamental digital skills combined with advanced technological skills, are also becoming more important in domains dealing with machinery and manufacturing.

Key factors for the successful implementation of digital technologies were identified by Mhlungu et al. (2019) using a questionnaire survey. Their research demonstrates that the driving forces behind corporate activities are: (1) client orientation; (2) governance; (3) innovation; and (4) resource outreach. Radzi et al. (2021) also highlight the importance of government governance of corporate digitalisation processes. For example, they discovered through a case study that very few Malaysian businesses are adequately pursuing digital transformation, resulting in a low return on investment for the digitalisation process.

A study conducted in Ukraine has shown that the state's policy in the field of human capital development does not meet the modern challenges associated with the rapid development and spread of digital

technologies. As a consequence, inequalities in the labour market arise, and there is a shortage of highly qualified professionals with digital competencies at the appropriate level (Irtyshcheva et al., 2020). The lack of a skilled workforce capable of filling emerging digital jobs goes hand in hand with technological barriers.

Knowledge gaps in the current demand for digital experts were explored in a study by Georgiou et al. (2021). By analysing nearly 2000 jobs in the oil and gas industry, they found that the most in-demand competencies directly related to the digitalisation process are the skills of (1) extracting from web content, (2) storing, (3) retrieving data from databases, (4) analysing data, and (5) visualising data for web applications. Further emerging requirements are knowledge of programming languages such as Typescript, C++, or Python. In the field of education, digital competencies for instructors include (1) analysing course content, (2) conducting videoconferences, (3) managing online courses, (4) managing online learning resources, (5) managing online learning activities, (6) developing tests, (7) developing instructional media, (8) developing instructional videos, (9) organising active learning activities, and (10) online assessments (Wannapiroon et al., 2022). In their study, Blumberg & Kauffeld (2021) proposed a competency model based on professional, methodological, social, digital, and personal competencies.

According to the study by Popkova & Sergi (2020) by 2030, businesses will leverage Industry 4.0 skills to optimise their processes and activities, but they will reject full automation. The phenomena of Industry 4.0 and Work 4.0 are naturally complemented by the phenomenon of Education 4.0. Godin & Therekh (2021) focused on the transformation of education itself as a system and the process of knowledge transfer in four main areas - pedagogy, technology, management, and economics. They proposed a model for linking these four areas and explored the possible impacts of ICT on educational institutions. Being digitally literate means knowing when and why digital technologies are appropriate and useful for a given task and when they are not (Hague & Payton, 2011). Based on a review of existing competency frameworks, both mathematical and digital, Geraniou and Jankvist (2019) consider a combined "mathematical digital competence," and in their study, they propose a way to understand this theoretical model. Digital competence can also be compensated to some extent by software (Nyikes, 2018).

Newland & Handley (2017) focused on academic staff at the University of Brighton. They proposed The Digital Literacies Framework (DLF) which, once implemented, enables academics and its administrators to deliver effective forms of learning and e-learning to students. Pedro & Chacon (2017) have provided evidence of the significance of the educational institution's participation in students' development of digital competencies. Their comparative study between gifted and average students attending primary school, with the aim of identifying different trends in information retrieval skills, did not show the impact of precociousness on this competence. However, it did point out the importance of an active approach to this issue by the educational establishment.

Numerous studies have directly addressed the inclusion of technology as an educational tool. Implementations of electronic gaming technologies enable students to master digital devices, communication applications, and information networks (Ivanova & Korostelev, 2019). The digital competencies that are created when implementing gaming technologies contribute to the formation of more competent and competitive specialists in the modern labour market demand (Pinkovetskaia et al., 2020). In addition to gaming technologies, vocational training centres can also be used. Roll & Ifenthaler (2021) proposed in their study the implementation of interconnected so-called Learning Factories 4.0 in technical vocational schools. These can support the development of subject-specific technical skills as well as multidisciplinary digital competencies. Prieto et al. (2020) recommend the creation of a so-called I4Tech Laboratory in which human intelligence and the cognitive capabilities of AI-based systems interact.

The modern economy places higher demands on the quality of human capital, namely on individual characteristics, knowledge, and professional skills and competencies. By analysing the values of human development indices, Janshanlo et al. (2020) demonstrate in their study that for the development of individuals, attention must be paid to indicators such as the level of education or access to education for all segments of the population. Every person who has the ability to lead and manage others in a school setting should also be involved in human capital management and participate in various human capital management activities (Šikýř & Šafránková, 2018).

3 METHODOLOGY

The aim of this article is to explore the possibilities of appropriate curriculum adaptation in light of trends in human capital development in the context of digitalisation. According to the previous theoretical insights, the following research questions were formulated:

1. What elements can be included in Education 4.0?
2. How has Work 4.0 changed the requirements placed on individuals?

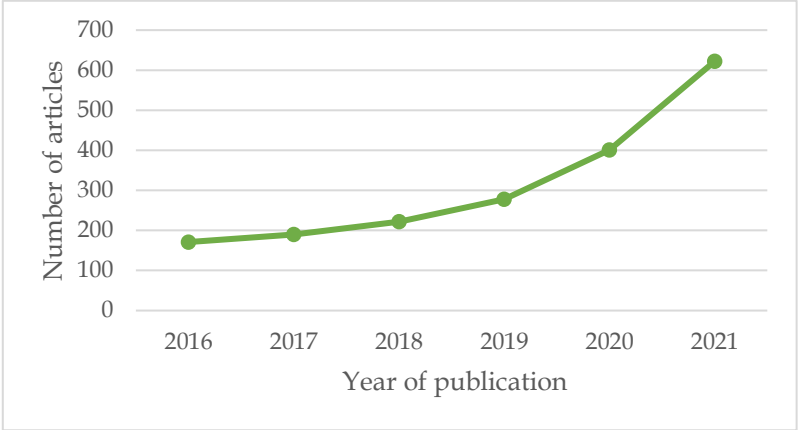
In order to achieve the goal of the paper, a survey of the Web of Science database will be conducted. The search will be conducted by entering basic parameters for results related to the topics "industry 4.0", "education 4.0" and "digital skills". The first step will be to enter the word "education 4.0." in the search box and filter the relevant results. Secondly, the country with the highest number of published articles will be selected. As a third step, the searched articles will be categorised by subject area. The fourth step will narrow down the scope of articles by redefining the search boundaries by adding the keywords "industry 4.0" and "digital skills", and the industry categorisation will be performed again.

The results of the Web of Science searches will be further analysed for keywords using the freely available VOSviewer (van Eck & Waltman, 2010). The keywords will be exported from the Web of Science as a plain text file and then loaded by VOSviewer to create a map of their occurrence and interrelationship. After opening VOSviewer, clicking on the "create" button will select to create a map based on the biblioFigureic data from the Web of Science database (the file to be examined will be uploaded from the computer in .txt format). "Co-occurrence" will be selected as the type of analysis, "full counting," and "all keywords" as the method. The minimum keyword binding threshold will be specified. An analysis will also be performed in the context of time, with an occurrence threshold from 2016 until now. The programme will create colour-coded clusters. Based on all the findings, a discussion will be conducted.

4 RESULTS

Firstly, the subjects covered in this article looked for in Web of Science articles. We started with the word "education 4.0" was entered into the search box together with the parameter "topic". Initially, 5.575 results were generated for all years (1991-2022). However, these results had to be modified by narrowing the time frame to fit the objectives of this article. Therefore, the incomplete year 2022 and everything from 1991 up to and including 2015 were filtered out. In addition, a "document types" filter was applied to restrict the results to articles only. Those categorised as open access were selected. This yielded 1.884 results.

Fig 1. Web of Science search results by year of publication



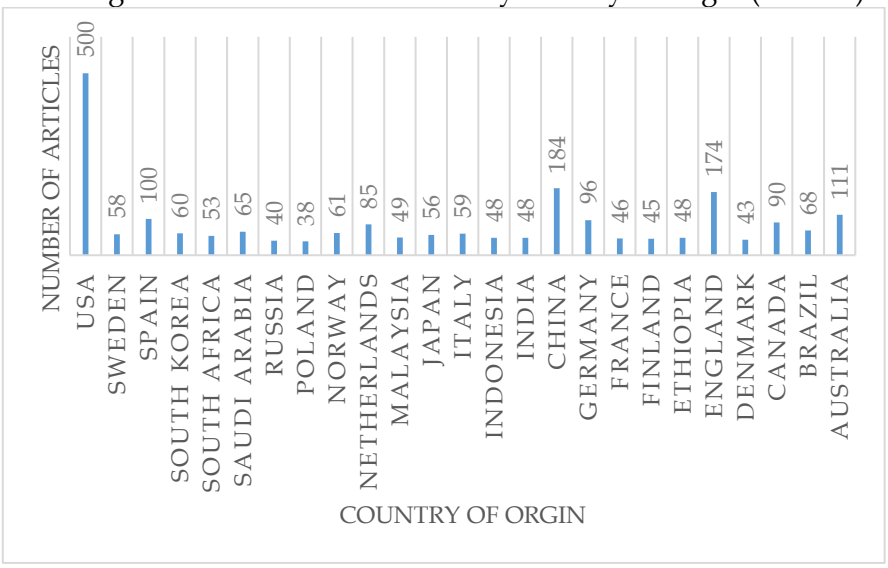
Source: Web of science, adapted by authors

Figure 1 shows the expected trend of growing interest in Education 4.0 and related topics. While only 161 articles were written on the topic by 2016, the number of articles almost tripled by 2020. By 2021, 622 papers have already been written on the topic and included in the Web of Science database. Digital

education is becoming increasingly significant and is making its mark in the professional and scientific spheres.

Another phenomenon observed was the countries that deal with the subject the most. A total of 138 countries were generated. The USA accounted for the largest number of results, with a total of 500 articles. Compared to the size of the United States and the whole of Europe, Europe is slightly better off in terms of researching this issue, with 586 articles in the top 25 (see Figure 2). The Czech Republic was ranked 51st with 14 articles, which suggests that the country is more likely to be inspired by other countries in this respect.

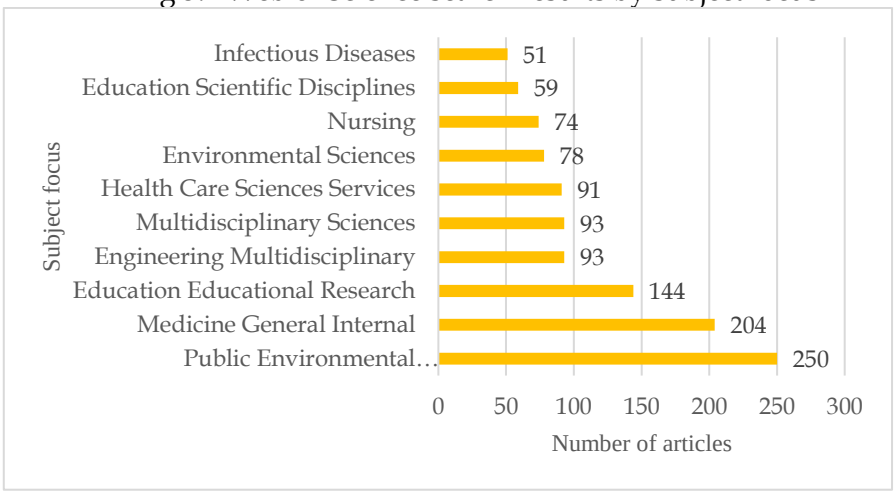
Fig 2. Web of Science records by country of origin (TOP 25)



Source: Web of science, adapted by authors

A final analysis of the search results was their distribution into subject categories (see Figure 3). With the most results, the medically focused categories, namely "*Public, Environmental, and Occupational Health*" and "*General Internal Medicine*", appeared in the first two places, followed by "*Educational and Pedagogical Research*" in third place.

Fig 3. Web of Science search results by subject focus



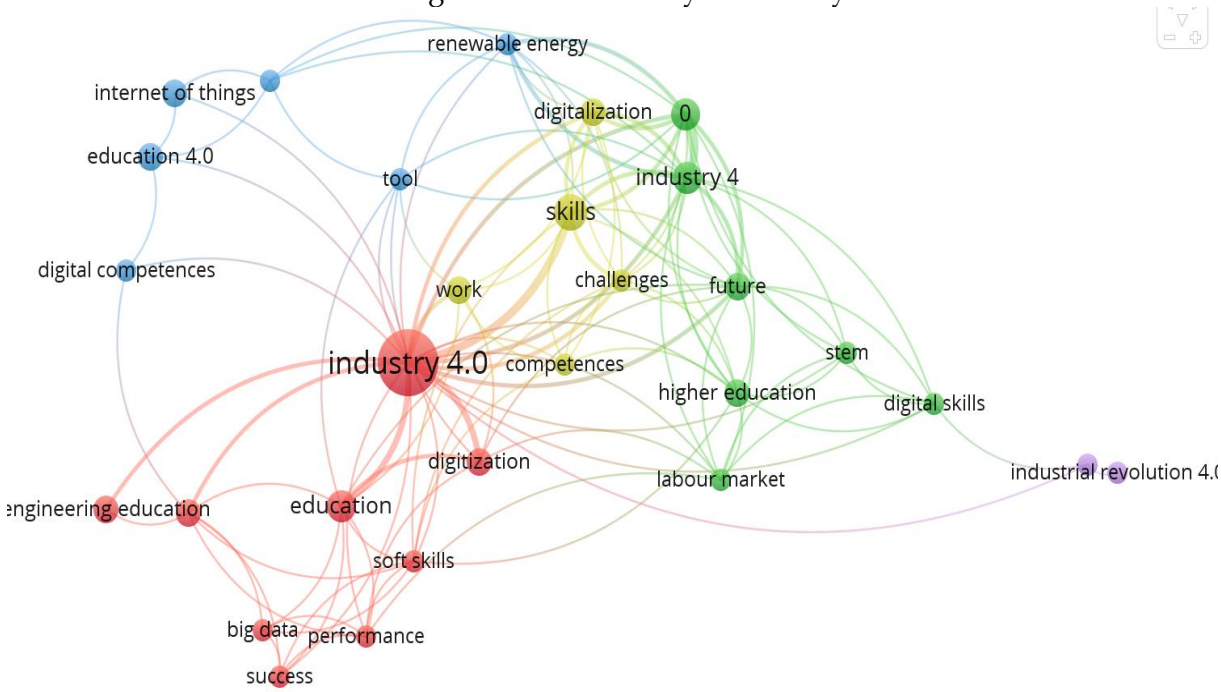
Source: Web of science, adapted by authors

The three most commonly used languages in which the articles were published were English, Spanish, and Russian. 96% of the articles (n = 1.815) were published in English, 1.85% (n = 35) in Spanish, and 0.64% (n = 12) in Russian.

Additionally, the search was expanded to include the terms "*industry 4.0*" and "*digital skills*" with the criterion "topic". 31 results were generated. After this type of narrowing of the search scope, the articles were more closely aligned with the purpose of this paper. 32% (n = 10) of the articles fell into the category "*Educational and pedagogical research*". 9.6% (n = 3) of the articles fell into the category "*Environmental Studies*" and 6.4% (n = 2) into "*Business*". This generated file was exported as a text file and subjected to analysis in VOSviewer.

The results of the Web of Science search were further processed, and keyword analysis was performed to create a map of their occurrence and interrelationship. The analysed file was exported from the Web of Science as a text file (.txt) and contained the above-mentioned 31 articles. It was uploaded to VOSviewer, and the connections were searched for. The minimum keyword linkage threshold was set to two. From the sample, 29 keywords matched such filtering. The programme produced a total of five colour-coded clusters, which can be seen in Figure 4.

Fig 4. VOSviewer keyword analysis



Source: WOSviewer

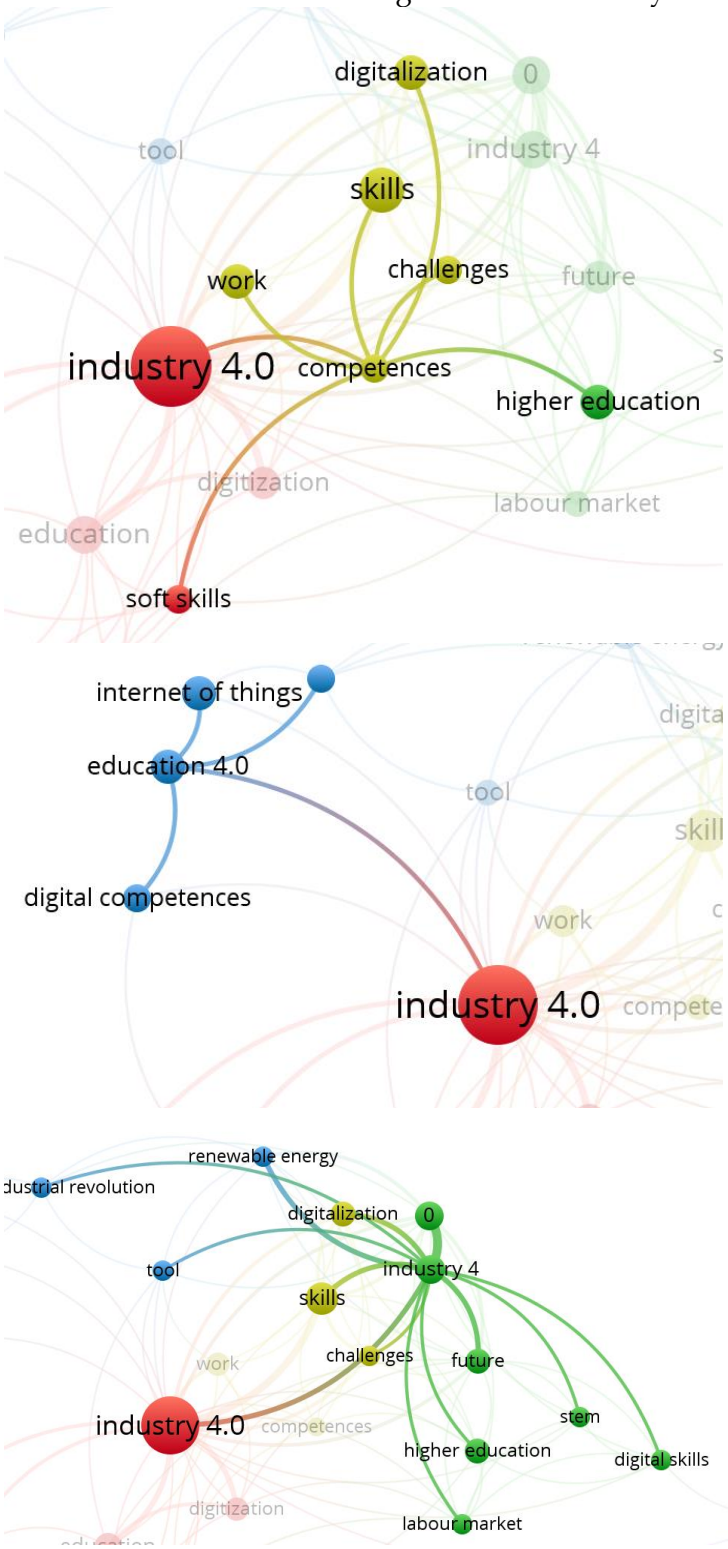
The red cluster, with "*industry 4.0*" as its primary keyword, was the most striking from an aesthetic standpoint. This cluster consisted of nine words and formed the core of the subject under investigation. The second most substantive group was the green cluster, whose central keyword was "*industry 4*", which was equivalent to "*industry 4.0*". The green cluster was made up of seven words. The blue six-word cluster also contained the synonymous central keyword "*fourth industrial revolution*". The yellow cluster was made up of 5 words and its core keyword was "*skills*". The last purple cluster consisted of only two keywords, yet one of them was again equivalent to the central words of the other clusters, namely "*industrial revolution 4.0*".

The keyword "*industry 4.0*" was used the most in the articles, specifically 40 times with 16 links. The program placed it in a red nine-item cluster along with the words

1. Big data,
2. Digitalisation,
3. Education,
4. Engineering Education,
5. Performance,
6. Soft skills,
7. Success,
8. Technology.

Furthermore, "*industry 4.0*" was directly linked to words from other clusters, namely "*(digital) competencies*", "*education 4.0*", "*internet of things*" and the synonym "*industry 4*", which merged the words "*digital skills*", "*future*", "*higher education*", "*labour market*" and "*stem*".

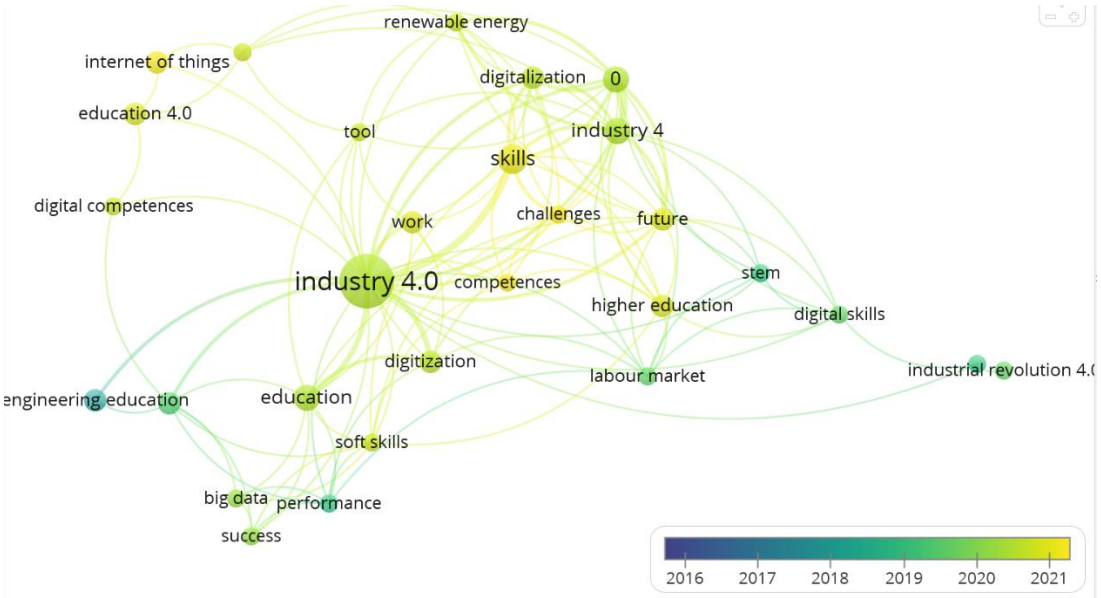
Fig 5. VOSviewer keyword analysis (direct links)



Source: WOSviewer

Next, an analysis of keyword searches in the context of time was conducted. The scheme is shown in Figure 6.

Fig 6. VOSviewer Keyword search analysis in the context of time



Source: WOSviewer

5 DISCUSSION

Thanks to the Web of Science database, an overview of the general trend and an overview of the issue under study were obtained. Since 2016, there has been a significant increase in the number of studies that have addressed the topic of Education 4.0. The research has shown that there is a strong interest in digitally literate professionals, mainly in the medical and healthcare sectors. The necessity of a direct correlation between digitalisation and the quality of a country's health services was also pointed out in the study by Popkova and Giyazov (2021), mentioned in the literature review of this article. This fact is equally relevant in Europe and the US, proving that the fourth industrial revolution is equally affecting most of the modern world.

In order for the digital transformation process to be successfully anchored in any industry and subsequently maintained at a high level, employees with digital competencies are needed to manage this complex "cyber-physical" system.

According to research question "What elements can be included in Education 4.0?", we can conclude, that to attract professionals, investment in education and the adaptation of the curriculum to include digital subjects is needed. The first area is *information technology education*. To this end, the teaching of the basics of algorithms should be strengthened. Students should be introduced to the basic approaches of artificial intelligence and the fundamentals of computer security. The second major area of training is *data analysis using computers*. Learning in this area should include basic data mining techniques such as classification, clustering, association analysis, and prediction methods from data. In addition, students should be introduced to the various options for visualising the data collected, and the possibilities for storing the data, including the use of modern cloud technologies. Subsequently, they should also be introduced to data archiving, and deletion, including related issues of data security ethics and the legal implications of data leakage or misuse. An important part of this should be, preferably collaborative, large-scale project in which students practice the skills outlined above and attempt to analyse and predict from data either collected by themselves or provided by the teacher. The third major area should be *training in information and communication skills in the digital world*. Education in this area is also highlighted in documents related to the Education 4.0 phenomenon (e.g. World Economic Forum, 2020). Students should be made aware of the nature of the results that can be obtained by searching on the Internet thanks to commercial advertising (e.g. (1) awareness of the existence of paid advertisements in Google search results, (2) the differences in the results provided by this search engine for different users in different countries, etc.). They should also be provided with the possibility of using alternative search engines such as DuckDuckGo or Seznam, in order to compare the results provided by different Internet search engines, etc. Students should also be

familiar with sources such as Wikipedia, including its shortcomings. They should be able to find relevant information from different sources in a given field, compare them and present the results.

The use of modern digital tools should also be integrated into the teaching of traditional subjects. Such tools will allow students to prepare individually, progress at their own pace, practice repeatedly, etc. For teachers, these tools offer the possibility of assigning students different tasks to practise, recommending learning materials, as well as monitoring their progress on an ongoing and individual basis. For example, Khan Academy[1] already offers several pre-packaged courses in subjects such as mathematics, physics, economics and accounting. However, most of them are only available in English (or another language). It would therefore be beneficial to translate and adapt relevant courses such as accounting, which is not yet available in Czech, to the current Czech accounting standards and laws. Logic, statistics and probability should also be covered in more depth.

As for research question "How has Work 4.0 changed the demands placed on individuals?", it is possible to state, that according to the keyword analysis by VOSviewer, the third most popular word was "skills". This suggests that authors often associate the Fourth Industrial Revolution with new or existing skills. The words "*challenges*" and "*competencies*" were associated with the term "*skills*". In order to keep up with the rapid pace of development, individuals should acquire the ability to learn throughout their lives. Abilities such as leadership, problem-solving and communication complement digital skills and are essential for collaborative work that uses information and communication technologies. Flexible skills and competencies should be a particular focus. They enable workers to adapt continuously to changing conditions and technologies and to deal with complex activities that cannot be automated. The work environment is increasingly relying on digital and mobile tools or social media.

The results of the Programme for the International Assessment of Adult Competencies (Straková, Veselý, 2015) show that, on average, more than 50% of the adult population in the 28 OECD countries have only the most basic computer skills (writing an email, searching the web, etc.) or no computer skills at all. About a third of workers have more advanced skills. Therefore, specialists are needed to make full use of new technologies. Those who can code, create applications, manage networks and analyse large volumes of data are sought after. However, even a low-skilled workforce needs to have basic information and communication technology skills (e.g. blue-collar jobs in fully automated companies or waiters taking orders with iPads). Given the ever-changing skills needed, it is essential that workers have the opportunity to receive ongoing training. This requires better retraining and course offerings for businesses and workers. At the same time, each individual should be more responsible for developing his/her or their own skills and competencies.

6 CONCLUSION

The process of digital transformation will require the development of key abilities of each individual. The aim of this article was to explore the possibilities of appropriate curriculum adaptation in light of human capital development trends in the context of digitalisation. To the maximum extent possible, this objective has been accomplished. Education 4.0 is a combination of competency-based and digital education. It will be necessary to include elements of digital learning in as many curricula and courses as possible aimed at building key skills such as technical and digital skills, including softer skills such as problem-solving, creative and design thinking, communication, multicultural openness, management and interaction skills. This means that the digital economy will require all people to develop a range of new knowledge, abilities and different digital skills.

A key contribution of this paper is a brief insight into the areas in which students would be enabled to train these skills. It could be suggested that Czech and Slovak primary and secondary school curricula ought to already incorporate subjects of a digital nature. However, much deeper and more detailed research is needed on this issue to obtain more relevant and detailed results, from which a solid foundation of knowledge on a very complex phenomenon would emerge.

[1] https://www.khanacademy.org

Acknowledgment

This article was supported by the Cultural and Educational Grant Agency Ministry of Education (KEGA 012UCM-4/2022).

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