The Human Factor in Industry 4.0 and Some of Its Intergenerational Implications

MONIKA ŠESTÁKOVÁ
Vysoká škola manažmentu v Trenčíne / City University of Seattle programs
Bratislava, Slovakia

Abstract: The rapidly growing literature on Industry 4.0 is devoted mainly to technological and IT aspects of the Fourth Industrial Revolution. Human factor's role has been underestimated to some degree. The basic objective of the paper is to outline the role of the human factor in the coming era, changes in the required labor skills, motivation, desirable organization culture and management system. The key role of the education system to prepare a workforce for the industry 4.0 is generally accepted, and new requirements and methods of education are going to be formulated. Life-long, continuous education and training is regarded as an imperative to prepare the workforce for Industry 4. However, this training is to be performed also by companies (employers), reskilling and retraining their existing workforce to meet the new requirements and integrating higher institutions' graduates into the exsting workforce communities. In these communities, the cooperation and knowledge sharing between different age groups is inevitable. What is almost ignored in the literature is the fact that the human factor means not only workers (the knowledge worker of a new type is to be formed) but also human beings as end customers. Knowledge is important also for them to enable them to practically use new sophisticated products and services. Insufficient IT and new technology knowledge is typical of the older generation, and even developed countries have to take measures to eliminate the intergenerational digital divide.

Keywords: Industry 4.0, human factor in industry 4.0, changes in labor skills, final customers in Industry 4.0., intergenerational aspects of digitalization.

1 Introduction

The Fourth Industrial Revolution (Industry 4.0) represents a fundamental change in the way we live, work and relate to one another. It is a new chapter in human development, enabled by extraordinary technology advances commensurate with those of the first, second and third industrial revolutions. These advances are merging the physical, digital and human worlds in ways that create both huge potential benefits and promises as well as potential peril and risks. The speed, breadth and depth of this revolution is forcing us to rethink how countries develop and increase their competitiveness, how organisations work and create value and even what it means to be human (World Economic Forum, 2019).

The bulk of literature on Industry 4.0 is devoted to technology and IT aspects of this revolution - basically from the point of view of the manufacturing industry. This is logical because the up-to-date technology is the material background of this revolution. The list of advanced technologies contributing to creating the Industry 4.0 is long, but probably the most important is the convergence of artificial intelligence, cloud computing, internet connectivity between people and physical objects, new interfaces between humans and machines and the capacity to collect, process and use massive data sets.

However, the Fourth Industrial Revolution is about more than just technology-driven change; it will impact everyone, including leaders, policy-makers and people from all income groups and nations. Human aspects of this transformation were first mentioned in connection

with the potential losing of jobs due to robotics applications. Discussions about the relation between robots and the human factor are still frequent in theory and policy, and practical implementation of robots in different companies, industries and countries will make it possible to test different hypotheses regarding the robotization's impact on employment.

Later on, other aspects of the role of the human factor in Industry 4.0 have come to the fore. Practical experience shows that human skills and motivation are the crucial factor for the efficiency of smart factories and all organizations in the digital era. The new business model requires rethinking of the whole HR functions, management style, organization culture, etc.

The present paper tries to outline the new role of the human factor more broadly. The second part deals with changes in labor skills and combination of skills in different professions, and shows that human labor is still important even in highly robotized enterprises. Life-long training and education are underlined as a prerequisite to forming and adjusting the workforce to the new and continuosly changing environment. The third part is devoted to some "more soft" aspects of the workforce development strategy – the new functions of HR policy, impact of the industry 4.0 on management style, organization culture and leadership role. In the fourth part, some intergenerational aspects of all the mentioned processes are outlined and in the 5th part, the necessity to improve IT literacy of older population is pointed out.

2. Changes in labor skills, workforce structure and the imperative of life-long reskilling and (re)training

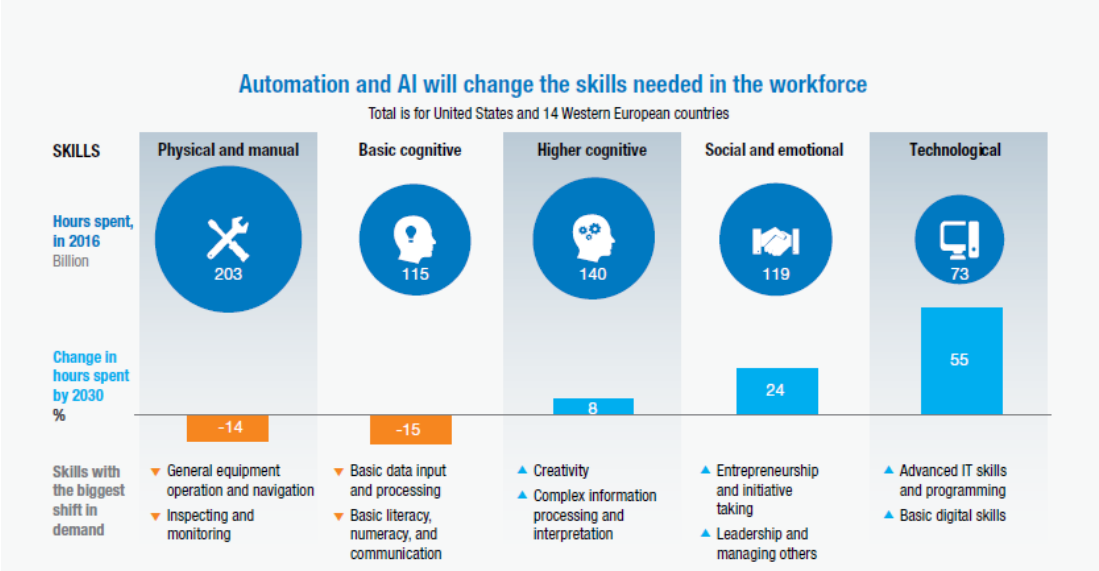
Digitization, automation and advances in artificial intelligence disrupt the world of work. Accoding to McKinsey Global Institute's report (McKinsey, 2018), by 2030 approximately 375 million workers (roughly 14 percent of the global workforce) may need to change occupational categories and be retrained to develop new skills to be able to work effectively in the new era.

The demand for basic digital skills, as well as advanced technological skills such as programming, will rise by 55 percent and by 2030 will represent 17 percent of hours worked, up from 11 percent in 2016. The demand for social and emotional skills such as leadership and managing others will rise by 24 percent, to 22 percent of hours worked. The demand for higher cognitive skills will grow moderately overall but will rise sharply for some of these skills, especially creativity.

Other skill categories will be less in demand. Basic cognitive skills, which include basic data input and processing, will decline by 15 percent. The demand for physical and manual skills, which include general equipment operation, will also drop, by 14 percent but will remain the largest category of workforce skills in 2030 in many countries. The competition for high-skill workers will increase while displacement will be concentrated mainly on low-skill workers, continuing a trend that has exacerbated income inequality and reduced middle-wage jobs. However, even some knowledge workers of today can be replaced (Sorko, S. R., Rabel B., Richter H. M., 2016; Bonecamp & Sure, 2018; Caldarolla et al., 2018). Figure 1 illustrates the changes in required work skills.

An increasing number of companies are aware of the required changes in labor skills and are taking measures to retrain their workforce and build the workorce of the future. This is the most important way to increase their competitiveness.

Fig.1 *Automation and AI*



Source: McKinsey, 2018, p. 5

In general, it is expected that repetitive activities and routine jobs with a low value added, which are easy to algoritmize, will be automated and more complex, and creative activities will be performed by humans (PWC, 2018; Deloitte, 2018). Humans' role will be to control work of robots and possibly detect technical problems in the working of machines or their not responding to changes in the environment.

As shown in the literature several years ago, robots do not have two abilities:
- Pattern recognition
- Complex communication (Levy-Murnane, 2004)

Performing these roles still belongs to the human factor. Although recent development of artificial intelligence has questioned the inability of robots in the two mentioned skills, there still prevails the view that there are tasks that have proven to be very difficult to automate, in particular those involving flexibility, judgement and common sense. Even companies that practically implement the smart factory model confess that human workers are necessary in Industry 4.0. "Human workers are still more flexible than robots and they can adjust to workflow changes much quicker" (Tesla, 2018). In inter-personal roles – leading and motivating people – the human factor is indispensable.

The crucial role of *education and training* to prepare the worforce of the future is generally accepted. Not only radically new skills and knowledge will be important, but also the demand for different skills and their combination will change dynamically. **"The future of work will be a race between education and technology,"** says Mauricio Maceri, the president of Argentina at the 2018 G20 summit. The new role of education cannot be just reduced to educating more engineers, creative designers or data analysts (Accenture, 2018). It is also important to ask how roles will be redefined and in what ways tasks will be affected by intelligent technologies.

The fourth industrial revolution will influence actually all workers (although with different intensity and sometimes indirectly). The same technologies responsible for increasing

complexity of work (which are, for the time being, mainly visible in manufacturing) make also possible using of new methods of training. New technologies let employees self-guide their way through new processes and enable collecting of data on trainee process in real time, allowing for continuous improvement. Real-time data empower supervisors to provide feedback flexibly, and the entire learning and training process becomes more efficient. Artificial Intelligence (AI) enables the personalization of learning, improving relevance and heightening the impact for each individual.

For companies, the first step to solve the skills mismatch (or skills crisis) can be training in the form of experiential learning (learning by doing). Learners are active participants, not passive recipients of knowledge (Accenture, 2018). This method should be the basic form of retraining of the existing workforce within life-long education schemes but also of training of new employees. The very skills that are growing in demand according to several analyses (complex reasoning, critical thinking, creativity and socioemotional intelligence) are the ones best acquired through experiential learning techniques (Accenture, 2018, p. 16).

A traditional form of learning that is „close to reality" is apprenticeship. The nature of apprenticeship ensures that participants practice the full range of skills that a job demands. The chance to build these skills and gain familiarity with the world of work while continuing studies can be attractive. However, in some countries (in Slovakia as well) young people and their families regard this form of education as less valuable than, e.g. universtity studies. However, both forms of education need not be mutually exclusive. In educating future engineers, a theoretical approach in the classroom should be enriched by real-life projects, such as the „learning factory" or „teaching factory" paradigm (Stavropolusa et al., 2018).

Education and training (or retraining connected with a change of job) cannot be just a once-for-all task. It is a continuous and life-long process. Its necessity must be – especially under conditions of Industry 4.0 – deeply rooted in the human mind. Lifelong learning starts early. School systems should be designed to ignite passion for lifelong learning. Children should be encouraged to develop a growth mindset.

3. Human resource management for Industry 4.0

With the changing role of the human factor in Industry 4.0 and increasing requirements on continuous innovation and learning, a new role of the HR management comes to the fore. Companies should have a long-term vision and strategy of their development and a strategy of HR development should be a part of it. Future jobs and skills required should be forecasted (of course, forecasting them is not so easy). Due to the continuous automation of simple manufacturing processes, the number of workspaces with a high level of complexity will increase, which results in the need of high level of education of the staff. The challenge is to qualify employees to shift their capacities to workspaces with more complex processes and ensure the retention of jobs in changing working environments.

Developing the workforce to meet present and future market needs postulates the identification of required competences. Competences are defined as "the set of skills, abilities, knowledge, attitudes and motivations an individual needs to cope with job-related tasks and challenges effectively" (Hecklau et al., 2016). For Industry 4.0, most authors mention four main categories of competences:

a. technical, job related knowledge and skills;

b. methodological skills (skills and abilities for general problem solving and decision making);
c. social competences (ability to cooperate and communicate with others);
d. personal competences (individual values, motivation, attitudes).

Qualification is understood as the process of developing the required set of competences through training and education (Hecklau et al., 2016, p. 2).

On the basis of global economic challenges, social challenges, technical challenges, environmental and political challenges, companies should define their strategy, and required competences for the workforce should be derived (estimated). The derived competences can be structured (clustered) into the four mentioned categories of competences. Then the role of the HR management is to prepare, hire or retrain the workforce according to the required competences.

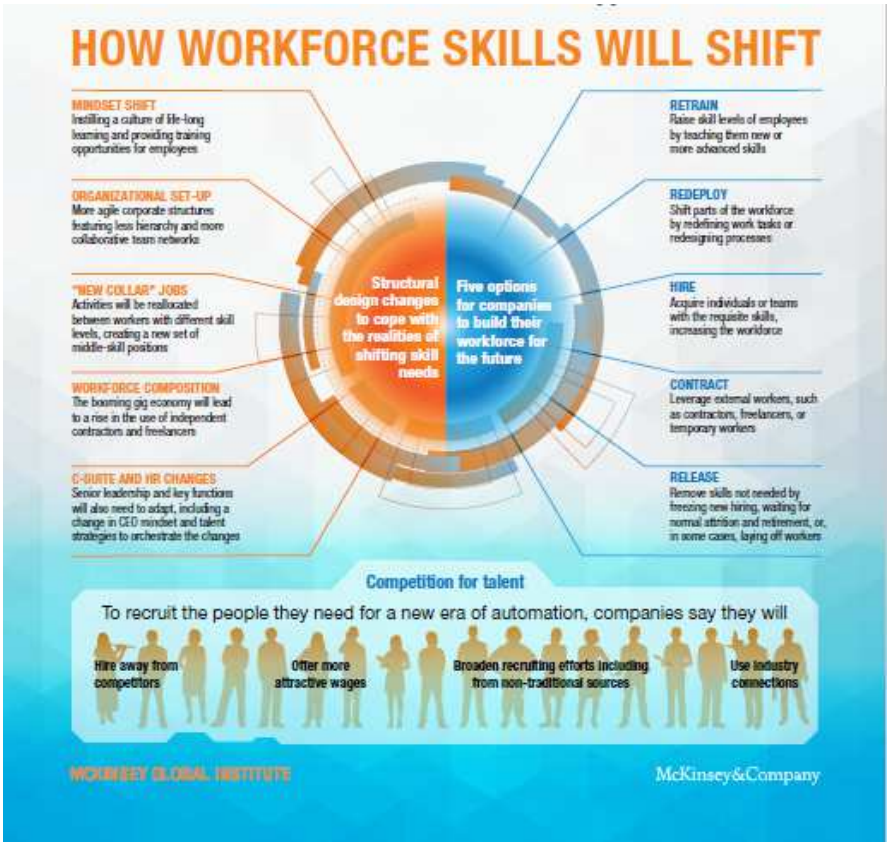
Forming the workforce structure corresponding to Industry 4.0 requirements cannot be just mechanical calculation of necessary skill shifts and their administration. It is extremely important to influence the workers‘ mindset and their willingness to learn and adjust, to form an innovation and learning supporting culture in companies, to create and keep clear communication channels (within the company and also with cooperating partners), etc.
In preparing the workforce for the new era, companies apply the „three R strategy“:

- retention
- retraining
- recruiting.

The method of contracts with skilled workers from outside (contracted freelance skilled workers or consultants) can be added to these three basic methods. Retention of the existing workforce can be applied in the form of redeployment of parts of the workforce by redefining work tasks or redesigning processes. The interacion between the mentioned methods and strategies is illustrated in Figure 2.

According to many authors, transition to Industry 4.0 requires a *new business model* and changes in the management style (Roblek et al., 2016). Although we cannot find a complex and generally accepted definition of this new business model, some features are often mentioned: self-organization and decentralization, flattening of organizational hierarchies, smart products, a new system of distribution and procurement, manufacturing processes closely connected across corporate boundaries, digital sustainability, etc. Sometimes, six factors are mentioned as benefits of the Industry 4.0 implementation: smart economy, smart mobility, smart environment, smart people, smart living and smart governance. However, some empirical research suggests that actual behavior of companies is far from this ideal (Deloitte, 2019; PWC, 2018).

Fig.2 *Workforce skills*



Source: McKinsey, 2018, p. 5

Digital technologies have influence not only on the area of information technology but also on how businesses are managed and what kind of leadership styles are applied.

„Today´s organizations are not a collective of bosses and followers... Leaders emerge from across the board and collaborate with each other to bring forth innovation“ (Rana & Sharma, 2018).

Essential elements determining *digital leaders* are the ability to move from fixed cycles for assessing employee performance up to the ability to understand that situations determine the need for assessing employees and teams equally, the ability to distribute tasks based on the situation and team competence, high level willingness and ability for change, encouraging high level agility between the market, customer, partners, and employees, the ability to create an open atmosphere with the learning effect in errors and a collaborative atmosphere for handling conflict situations, the ability to create a transparent framework for information distribution, and counting on employees' and teams' self-responsibility (Oberer & Erkollar, 2015, p. 6).

4. Inter-generational aspects of forming the human factor of the future

All the mentioned changes (actual and expected) in the role of the human factor have significant inter-generational implications. Radical changes in required labor skills have different impact on different age groups, and perspectives of the Industry 4.0 are differently perceived by different generations. A widespread opinion is that the youngest generation,

„children of the internet", especially wellcome the advent of this era and will support the required changes.

Companies are aware of the fact that the existing composition of the workforce is multi-generational. Employees in the middle age („generation X") and even older workers are valuable for the transfer of knowledge, based on previous experience, contacts, etc., and they are an important part of the company's human capital. Moreover, they are loyal to the company, and their role as representatives of the „organization memory" (especially baby-boomers and seniors) can be important for the organization culture. Retention of the valuable human capital and its required retraining is important for companies´competitiveness.

Of course, digital capabilities of different generations are different. However, practical use and effectiveness of these capabilities is significantly influenced by the knowledge acquired through the companies´practical experience and „learning by doing" (which is, to a high degree, the tacit knowledge of the existing employees). Intelligent technologies can't be just transferred to a company from outside. A particular type of a digitized system and a human-automation symbiosis in a company should be developed and further adjusted **with** the employees of the company, not imposed upon them. The workforce should be not only informed about new approaches but also committed to the changes. And this workforce is multi-generational. That means inter-generational cooperation is important in developing the new digitized systems and their continuous improvement. In the process of this cooperation, digital capabilities of workers with lower digital skills should be improved (applying the learning-by-doing approach).

Let's start our excursion into generational aspects of the problem „How ready the workforce is for Industry 4.0" by analyzing strengths and weaknesses of the youngest generation (millenials and Generation Z), which is usually regarded as the basic supporter and human driver of Industry 4.0. Our basic source of data will be *The Deloitte Global Millenial Survey 2019* (Deloitte, 2019 b). The 2019 report is based on the views of 13,416 millennials questioned across 42 countries and territories. Millennials included in the study were born between January 1983 and December 1994. The report also includes responses from 3,009 Gen Z respondents in 10 countries. Gen Z respondents were born between January 1995 and December 2002. The Survey was oriented on millennials' (millennials are sometimes called GenerationY) perception of the current economic development, business motivation and their relationship to technology, especially the advent of Industry 4.0. All the respondents from the millennial cohort were working. Most of the respondents from Generation Z were still studying; some of them were simultaneously employed.

The views of respondents are rather pessimistic, and the Survey called them "a disrupted generation". According to the Survey, young participants are increasingly pessimistic and mistrustful of both their careers and the world around them. Respondents expressed a strong lack of faith in traditional societal institutions, business motivation and macroeconomic perspectives. Among 20 challenges facing the society that most concerned respondents on a personal level were (in a given order) climate /environment, income inequality, unemployment, crime, corruption, terrorism and - on the 7th place - education and skills training.

The top priorities of the respondents were: travel and seeing the world (57 %), high salary (52%), buying a home of their own (49%), making a positive impact on the community/society (46%), and - on the 5th place – having children/starting families (39%).

Millenials' opinions about business are pessimistic. Only 37 percent of millennials believe business leaders make a positive impact on the world, and more than a quarter (26 percent) say they don't trust business leaders as sources of reliable and accurate information.

For our paper, the most important is the attitude of millennials to the advent of Industry 4.0 and its impact. Forty-nine percent of millennials believe new technologies will augment their jobs; 25 percent expect Industry 4.0 to have no impact, and only 15 percent fear it will replace all or a part of their job responsibilities.

Only about one in five respondents believe they have all the skills and knowledge they'll need for a world being shaped by Industry 4.0, and 70 percent say they may only have some or few of the skills required and will need to evolve their own capabilities to increase their value. There are various views of how to acquire new skills. Millennials say business (30 percent) has the greatest responsibility for preparing workers, followed by educational institutions (24 percent). Generation Zs put the onus on colleges, universities, and secondary and vocational schools (36 percent). Both cohorts agree that individuals— through self-education and ongoing professional development—should improve their skills. However, millenials´ view that businesses should play the leading role in preparing workforce for Industry 4.0 is in contradiction with the view of business leaders formulated in one of the previous Deloitte Surveys (Deloitte, 2019a). Business leaders think that the responsibility to prepare for Industry 4.0 falls on individuals, governments and schools rather than business.

A serious problem for companies can be a high fluctuation rate of young people. 49 percent of respondents would, if they had a choice, quit their current jobs in the next two years. If companies invest in the training of this youngest part of their human capital, this will lead to a loss. Although labor mobility is regarded as one of the requirements of the new era, there must be some limits to the drain of talent. The basic reason of this fluctuation is dissatifaction with the pay. However, 28 per cent of millenials do not see an opportunity for training and development in their company.

On the other hand, 28 percent of millenials plan to stay in the company longer than five years. There were strong correlations between those who plan to stay in their current jobs and those who said their companies delivered best on financial performance, community impact, talent development, diversity and inclusion. That could be why many companies that traditionally focused primarily on profitability are working hard to adopt new mindsets that coincide with what younger generations seek.

An appealing option for young people is to enter the gig economy, to do freelance or contract jobs. However, only 6 percent of millennials said they had chosen to be part of the gig economy instead of working full time. Most of them regard a freelance job as a supplement to full-time employment.

According to the Deloitte Survey, millenials and Generation Z make up more than half of the world's population and, together, account for most of the global workforce.They can be – and should be – the crucial part of the workforce for Industry 4.0. The young respondents are aware of the new demands for labor skills that are connected with the advent of Industry 4.0. They were educated for a digital society and wish to use and improve their digital capabilities to achieve their personal satisfaction but also some broader social objectives.

However, these generations, for the time being, are not a very stable part of the workforce of individual companies. Their training and preparing for the new demands should happen in multigenerational teams. In these teams, they should get acquainted with the practical side of the (current and future) business, and inter-generational transfer of knowledge can happen.

What are the other generations participating in the workforce today? Another generation (passing from the youngest workers to higher age groups) is the *Generation X*. This cohort includes people born between late 1960s and the first half of 1980s. Due to a lower birth-rate at that time, this demographic group is not large (in comparison with millenials or baby-boomers). As an opposition to their mothers' workholism, they prefer balance between work and personal (family) life; work should be interesting and creative for them and independence is among their most important values. Members of this generation have some common features with millenials: independence, need of creativity, being skeptical of authority. The basic difference is their longer work (and practical) experience, which has somewhat mitigated their original ambitions and values. Nevertheless, the generation X is perceived as a cohort that has disrupted some traditional societal values.

Over 60 percent of the Generation X in developed countries have university education. They are technologically adept. They are comfortable with smartphones, email, laptops, tablets, and other technology used in the current workplace. Technology is inextricably woven into their lives. They are flexible, adapt to change, friendly and tolerant of alternative lifestyles. After some retraining in the up-to-date technology, they can be valuable members of the Industry 4.0 workforce. However, some problems can arise if their workload (due to required cognitive capabilities and management responsibilities) are too high to satisfy their preference for balance between work and personal life.

Another generation is the *baby boomers* – people born after the war, between 1946 and mid-1960s. It was the largest generational cohort in the USA up to 2015, and it still is an economically and politically influential generation. Many of them are at the top management positions. Most of them entered the workforce in the period when computers were in their rudimentary stage. Those baby boomers that were using IT in their professional careers have basic IT capabilities. However, today most baby boomers are approaching the retirement age or are already retired and represent (in the USA and some other developed countries) a relatively wealthy group of the „silver generation" – they form an important component of a demand for new products and services. This demand can be of a long-term character because baby boomers (in the USA) are the longest living generation in the history.

Today, baby boomers hold a large amount of the wealth in North America, making them a prime market segment. As they have aged, baby boomers (that were at the top management positions) have shaped the focus of companies to satisfy older people's needs more.

Baby boomers that are at the top positions in organizations (or in the government) today can significantly influence the way and degree to which countries will be prepared for the Industry 4.0. Their strategic thinking, ability to create a supportive environment in companies, emphasis on continuous innovation and learning can be very important.

The influence of this generation on the economy and markets is sometimes called a „baby boomer effect". This term was originally used in the realm of technology and referred to the importance of simplifying the interfaces of consumer electronics to encourage the wealthy baby boomer generation to upgrade. Although today the term is used in a broader sense, the

problem of simplifying the consumer-new products interaction can be topical for the new, Industry 4.0 era.

Younger workers see baby boomers at the top positions as a barrier to professional growth of younger specialists. On the other hand, several studies have shown a drop in productivity when boomers retire due to the loss of organizational intelligence. For the work ethics, it is still important to keep some basic principles that the baby boomer generation introduced into practice.

The generation of "veterans" (people born before the war or during the war) is usually not mentioned in connection with the digital society although with the aging population, the share of people in 55+ in the total population, and even in employment, is growing. However, according to demographic classification, these people represent actually the oldest group of baby boomers. In V-4 countries in 2016, the share of people in the age group 55-64 years that were working was 41.6 percent, with the highest number in the Czech Republic (almost 90 percent). In Slovakia, this share was a little lower than 50%, but most of these workers were employed full time. Older seniors, in the age 65+ have a much lower employment rate. The average for V-4 countries is 3.4 percent, for Slovakia less than 3 percent (Kostrova, 2018: EUROSTAT Database, 2017).

Veterans that are still working are usually in jobs where digital capabilities are not required. Many of them have access to the internet but they do not use it in their work. However, in this age group, we can also find specialists that are actually knowledge workers (mainly researchers and university teachers) and that have been forced to acquire digital capability. Due to their tacit knowledge and experience, this part of the older generation can be valuable in educating the future workforce.

5. Improving (or forming) digital skills of the older population

The human factor not only includes workers, but it also represents all the citizens, including children, retired persons and other individuals that are not working for various reasons. All of them are tax payers (at least of indirect taxes); they have to communicate with government authorities; they will be included in the e-health system, and, mainly, all of them will be final consumers in an ever more digitalized society. In the era of Industry 4.0, some digital literacy will be necessary for all the people.

Statistical data show that digital literacy is unevenly distributed between different age groups. The digital divide, which exists not only between countries but also between different groups within the same country, is usually treated as the differing amount of information between those who have access to the Internet (specially broadband access) and those who do not have the access (OECD, 2018).

Let´s look at some data from a survey on access to the internet and use of it in Slovakia, during recent years (Kokles, M. et al., 2017). Respondents of the survey were 2906 Slovak citizens older than 18 years. 60% of them were women, and 40% were men. The respondents were from various regions and age groups. 68% of the respondents had high school education, and 31% had university education. Digital capabilities were self-assessed by the respondents, at the scale ranged from one (I am able to do very well) to five (I am not able at all).

There were three basic groups of indicators: hardware (work with computers, mobiles, computer peripherals, access to the internet), software (work with various operating systems) and the way of using the internet (search for information, e-mail, chat, social networks, calling by internet, e-commerce, internet banking, communication with government institutions, etc.). In the 1st group of indicators (hardware), assessment of men is higher than that of women. About 10% of the whole sample are „not able at all" to work with computers, and a similar share has no access to the internet. As can be expected, digital capabilities are increasing with the level of education and declining with the increasing age. In the age group 65+ there was the lowest value for almost all the indicators of digital capabilities. The lowest level of an individual indicator has been achieved for „the work with databases", which is very important for the work skills in Industry 4.0. Just 10% of respondents said they were able to do it very well.

The survey has shown that a digital divide in Slovakia exists – between persons with different educational levels, between generations, regions, etc. An interesting conclusion from the survey is that 72 percent of the respondents indicate that they have acquired digital capabilities by self-study, not during formal education. The educational system in Slovakia is clearly not successful enough in educating the labor force with the required level of digital capabilities.

From the point of view of our paper, a more detailed analysis of digital capabilities of the older generation is required. The generation of seniors cannot be regarded just as an undifferentiated group of low-skilled persons, digitally almost illiterate, and refusing to learn and acquire digital capabilities. Today´s generation of seniors includes also some workers (sometimes even knowledge workers of the past) that have digital capabilities corresponding to the years of their active participation in the workforce. They are interested in improving (updating) their digital knowledge - not only because they would like to be regarded as a potential part of the skilled labor supply or plan to use this knowledge in a freelance job, but also because they need it as customers of sophisticated products and services and as citizens in a more digitalized society.

That´s why improving digital skills of the older generation is important. It shouldn't be based just on individual initiative and self-learning activities. Help from outside is necessary. It can take the form of courses organized by public authorities (also local ones), mass-media activities, or even some forms of companies´ communication with final customers, explaining them the benefits and working of new products and services. All these activities can help to overcome the inter-generational digital divide.

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Contact data:

Assoc.prof. Monika Šestáková, DrSc.
Vysoká škola manažmentu v Trenčíne / City University of Seattle programs
Panónska cesta 17, Bratislava, Slovakia
msestakova@vsm.sk