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Labour and Education Markets in Industry 4.0

Silvia Matúšová - Vojtech Kollár*

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Abstract:
Introduction: The current development of the world economy defined as the Fourth industrial revolution (Industry 4.0) is rather determined by a larger social change caused by the interconnection of the physical, virtual, and social worlds. It affects the market of products, production factors, sectors, services, education, research, social systems, the labour market, the education, and specialization, including the legal framework, and the use of digital technologies for production and education purposes.
Purpose: The aim of the literature review will be the description and analysis of Industry 4.0, which are digitization and the application of digital technologies, associated with new emerging jobs in the circular economy, artificial intelligence, cloud computing, development, sales of products and services and the focus on human resources, as Industry 4.0 requires new standards regarding Education 4.0.
Methods: The study, analysis, evaluation and comparison of selected scientific papers and research reviews of international organizations (European Union, OECD, etc.) related to Industry 4.0 and Education 4.0 resulted in the need for a significant transformation of education and labour markets, because of newly emerging professions demanding new profiles of graduates.
Conclusions: Calls for changes in the educational structure and new qualifications will be formulated regarding the Slovak economy by 2030. A successful transition to Industry 4.0 paradigm requires the linkage between industrial policy and educational, scientific, technical and innovation policies.

Key words: Economy 4.0, Education 4.0, labour market requirements, Teacher 4.0.

* Silvia Matúšová, Bratislava University of Economics and Management, Bratislava, Slovakia; silvia.matusova@vsemba.sk
Vojtech Kollár, Bratislava University of Economics and Management, Bratislava, Slovakia; vojtech.kollar@vsemba.sk

Introduction

The world is changing rapidly due to technological, social, economic, and societal changes. This process, referred to as the Fourth industrial revolution (Industry 4.0), optimizes procedures and applies new technologies to the production system. It is a transition to the industry based on digital technologies with an expected increase in productivity, production efficiency, reduction of energy and raw material intensity of production, optimization of logistics systems, building of intelligent infrastructure and reduction of production and final consumption in connection with the use of new technologies. Industry 4.0 represents a technology revolution, growing exponentially. It brings in a principal change in knowledge-based economy.

Humanity is facing the biggest challenge of its existence. The strategy "Industry 4.0" is where the physical world merges with the virtual. Information technology, telecommunications and manufacturing are united when the means of production are becoming more independent.

Industry 4.0 can be described as a cyber-physical-social revolution (Mařík, 2016) which concerns industrial production, science and research, education system, legal framework, social system, and labour market. Industry 4.0 is a program for the reindustrialisation of Europe. At the same time, it caused a new approach to education and labour market.

We live in the era of the digital economy and society, in which the adaption of people and the human workforce requires new approaches to education, training and retraining, acquiring new skills and knowledge. If the demand for digital and other skills continues to grow as fast as it currently does, employees and students will have to adapt their skills and abilities to market demands both at the start and throughout their working life.

Education will become a firm component of life, not just the studies at a young age. This will greatly affect the education and training systems, as well as the adaptability of students and the development of lifelong learning systems. The requirements of companies and enterprises on their employees are constantly growing, which is why lifelong learning - including on-the-job training (Barnová, Duda, Matulčíková, Gabrhelová, & Hrivíková, 2022) - is becoming a necessity. Therefore, it will not be possible to limit the age category of university students. Forms, methods and means of education at universities and lifelong learning institutions must also be subordinated to this. The transformation of economy due to Industry 4.0 paradigm is associated with the concept Education 4.0 which is mainly associated with the use of digital technologies in online education as a standard. Online education is considered as part of digitization of education at universities.

Leading positions are occupied by technological changes related to digitization, communication forms, analysis of large data sets, robotization, and artificial

intelligence. Man should be properly equipped through education to operate in above areas. Therefore, the most significant task of society at large is to develop human resources and increase the value of education.

Industry 4.0 requires the creation of a fast and accessible infrastructure for data transfer and the adaptation of the human workforce to the changes that the paradigm Industry 4.0 brings in. In this context, the educational system requires the comprehensive reflection of changes and challenges, starting with new educational policy objective, the application of innovative approaches to curricula and the ways of teaching and learning, to ensure the implementation of the new paradigm (Portál Industry4.0.sk).

1 Industry 4.0 and the labour market

Slovakia is situated at the beginning of Industry 4.0, which can transform the future requirements of industry related to the workforce. Thus, it is essential to focus on the main challenges and problems that could hold back Slovak businesses and slow down the use of the potential arising from Industry 4.0.

The lack of qualified labour force is a significant barrier to economic development and competitiveness of each country, including Slovakia, but can be considered a serious issue from the aspect of individual business entities competitiveness as well, since human capital represents a strategic tool for them (Rozvadský-Gugová & Barnová, 2020). This deficiency can deepen the success of the implementation of Industry 4.0 concept, especially in connection with the expected changes in the structure of industries, the methods of production, procurement, and sale of products.

The World Economic Forum (WEF, 2020) reports that while 71% of the world's work is currently still done by humans, this will change by 2025, and it is predicted that machines worldwide will do more work than humans. Around 70 million jobs will disappear, but on the other hand, new ones will be created, while the creation of 133 million new jobs is expected. New job positions will require new knowledge and skills that school graduates should have.

Jobs will be threatened due to Industry 4.0. The leading industry in Slovakia is the automotive industry, with a rapid growth of robotization and automation. Slovakia ranked 16th in the global ranking in terms of the number of industrial robots per 10,000 employees, achieving 165 industrial robots per 10,000 employees (European Commission, 2020).

The OECD study assumes that approximately 40% of traditional occupations will disappear in Slovakia because of greater automation (OECD, 2018). The replacement of the average employee by artificial intelligence reaches up to 62% in Slovakia, which is the worst perspective of the OECD countries, while the most threatened groups are young and unskilled workers (OECD, 2020).

The application of Industry 4.0 resulting in the changes in the labour market has become an object of several research studies and surveys in Slovakia and worldwide focused on future needs and demands for work force. The World Economic Forum (2020) predicts the growth of demand for jobs in the green economy, artificial intelligence, cloud computing, product development and sales, marketing and the areas related to mutual interaction by 2025.

As Hall et al. (2019) assume, the essential skills expected by Industry 4.0 from graduates at the international level by 2025 should include critical and analytical thinking; problem solving ability; self-management and active learning; learning strategies; creativity, originality, and innovative thinking; the ability to cooperate with each other; use, monitoring and control of technologies; communication skills; resilience, stress tolerance and flexibility.

The European Union points to potential benefits and risks resulting from Industry 4.0 by means of the SWOT analysis, identifying principal strengths and weaknesses, opportunities and threats associated with the implementation of Industry 4.0.

The main strengths of Industry 4.0 include:

a) increased productivity, more efficient use of resources, strengthening of companies' incomes and their competitiveness.
b) increasing the number of highly qualified and well-paid jobs.
c) increased customer satisfaction, access to new markets (increased possibility of product customization and greater variability of offered products).
d) higher flexibility of processes and control.

The main weaknesses were identified as follows:

a) high dependence on highly resilient technologies and networks, where small disruptions can have significant impacts,
b) high interdependence on numerous factors, including standards, single frameworks, supply of labour force with sufficient skills, reasonable scope of investments in economics, funding for research and development,
c) the cost of the development and implementation of digital technologies,
d) potential loss of control over the enterprise,
e) higher unemployment rate of semi-skilled workers.

According to the analysis of the European Union, digitization brings in the following opportunities:

a) strengthening the position of the European Union as a world leader in industrial production and other sectors,
b) development of new markets for products and services,
c) compensation of the negative demographic curve in the countries of the European Union,

d) reducing barriers to the entry of small and medium-sized enterprises into new markets and connecting to new supply chains.

The analysis of the European Union identifies the following threats and risks:

a) cyber security, protection of intellectual property and personal data,
b) employees, small and medium-sized enterprises, industries, and actors within the national economy often are not sufficiently aware of digitization and do possess the resources necessary to adapt to Industry 4.0, which could result into a comparative disadvantage of those companies and sector of economy,
c) a position of vulnerability to global supply chains, and a low degree of stability,
d) the rapid adaptation of foreign competitors to Industry 4.0 can neutralize the benefits of Industry 4.0 in the countries of the European Union.

Digitalization is defined as a technological trend that is reshaping all sectors of industry and society today. It is considered a major driving force of innovation and disruption that challenges private and public organizations equally. With all economic and societal sectors being affected, digital economy is very dynamic and increasingly competitive (Lang, 2021).

Based on estimates of the impacts of Industry 4.0, it can be assumed that the impact on the gross domestic product (GDP) will be smaller at the start of digitization and will reach its peak in the period 2025 to 2030. A shift in the employment structure can be expected in the horizon of the next 10 to 15 years. A decrease of jobs can be expected especially in manufacturing professions, while a more significant increase is expected in service-driven professions.

Digital technologies represent the most important aspects of life in the 21st century. They can create new value offers. The digital transformation will strongly impact labour markets. The companies will not pay human workforce if it can be replaced by robots and other digital solutions, thus gaining a competitive advantage over the competitors, while being able to produce the product better, faster, and cheaper. Competition is one of the driving forces of the market economy, and forces economic actors to innovate. Currently, innovation is mostly synonymous with the introduction of digital solutions, so economic and social stakeholders which do not benefit of digitization will fall behind and even lose their position on the market.

The European Commission applies the Digital Economy and Society Index (DESI) to rate the digital economy and society in EU countries. The DESI is a composite index published every year by the European Commission since 2014, measuring the progress of EU countries towards a digital economy and society. It brings a set of relevant indicators on Europe´s current digital policy mix, and virtual reality, robotics, and big date (Vidová, 2020, p. 498). Table 1 demonstrates the composition of the DESI index, applied from 2014 till 2020.

Table 1

The composition of DESI index of five principal policy areas

Policy areas	*Description*
1. Connectivity	Fixed broadband, mobile broadband, fast and ultrafast broadband, and prices
2. Human capital	Internet user skills and advanced skills
3. Use of internet	Citizens´ use of internet services and online transactions
4. Integration of digital technology	Business digitisation and e-commerce
5. Digital public services	e-Government and e-health

Source: European Commission (https://ec.europa.eu/commission/presscorner/detail/en/MEMO_19_2933)

In 2021, the Commission has adjusted DESI to align it with the four cardinal points set out in the Commission proposal for a decision 'Path to the Digital Decade Policy Programme'. The DESI Index in 2022 focused on human capital, connectivity, integration of digital technology in businesses and digital public services. The proposal sets targets at EU level to be reached by 2030 to deliver a comprehensive and sustainable digital transformation across all sectors of the economy.

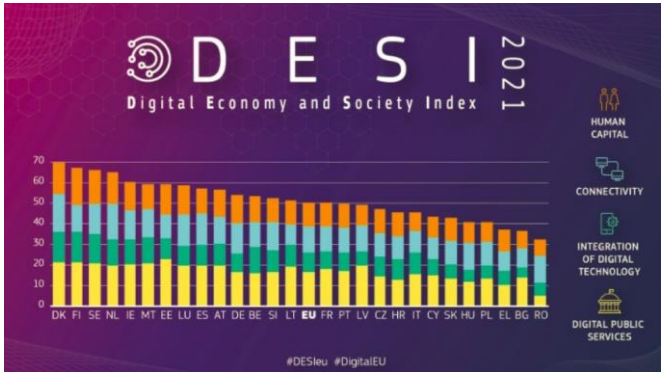


Figure 1. Digital Economy and Society Index (DESI) in EU countries in 2021 (https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021).

The EU DESI 2021 shows that, although Slovakia is making progress in Industry 4.0, compared to other EU countries, the country has been lagging for the last 3 years, and the lagging has even worsened.

In 2021, according to the DESI index, Slovakia ranked 22nd among the 27 EU member states. Slovakia has remained in the same position as in 2020. Regarding the human capital indicator, it ranked just below or around the EU average. Although as many as 54% of Slovaks have at least basic digital skills and 27% have above-average digital skills, this is less compared to the EU average of 56% and 31%, respectively.

In 2022, Slovakia ranked 23rd among the 27 EU member states. Figure 1 demonstrates that Slovakia fell by one position. Concerning the Visegrad 4 countries (Czech Republic, Poland, Hungary, and Slovakia) as indicated in the Figure 2, Slovakia was preceded by the Czech Republic and Hungary. It means that the two-thirds of the EU member states progress in DESI Index, however, Slovakia remains at the same position as in 2020, ranking among the seven least progressing EU member states.

Concerning the human capital, 55% of Slovaks have basic digital skills, which is slightly above the EU average of 54%. The proportion of ICT specialists in total employment is 4.2%, slightly below the EU average (4.3%). 16% of ICT specialists are women compared with the EU average of 19%. Slovakia's e-commerce scores have fallen: 13% of SMEs sell online compared with to 17% in 2020. 16% of Slovak enterprises used e-invoices in 2020 compared with 32% in the EU. Slovakia is below the EU average across the indicators for digital public services. The proportion of e-government users among internet users has decreased to 62% and is below the EU average of 64% (Digital Economy and Society Index (DESI) 2022 Slovakia, 2022, p. 3). Simply, Slovakia needs to improve and expand digital public services (Digital Economy and Society Index (DESI) 2022 Slovakia, 2022, p. 4).

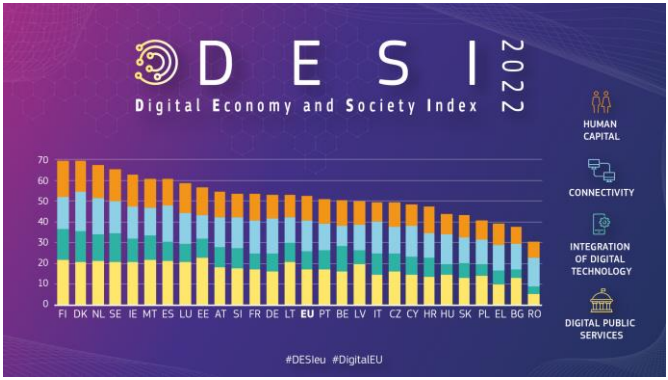


Figure 2. Digital Economy and Society Index (DESI) in EU countries in 2022 (https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2022).

The above results of DESI 2022 confirmed that Slovakia needs to focus on digital competence and skill development in pupils, students, and adults in the preparation of Industry 4.0. The insufficient digital transformation of society may affect the implementation of Industry 4.0 mainly from the aspect of digitally skilled workers and employees, practically in all sectors of national economy.

In Slovakia, the impact of Industry 4.0 within the next fifteen years will be dominant especially in the Industrial Production sector, where a decrease of over 95,000 jobs is expected by 2030. The main share of the decrease is expected by 2025. The positive effect should occur in the Construction Professions, where the impact of initial investments should persist.

On the other hand, there are sectors that should be relatively strengthened in coming years. The biggest job growth is still expected in IT, scientific research, legal and business consulting, media, and arts professions. An increase of 2,400 new jobs in IT and communication technology is expected. The sector of education is expected to prosper, thanks to the increasing investments of companies related to lifelong learning of employees. By 2030, the number of jobs in the sector of education should increase by at least 7,000.

Slovakia must therefore prepare for changes in the educational structure and new qualifications which must be applied in the Slovak economy by 2030. It will be inevitable to focus on the development of qualifications in sectors of education and information technology. This implies the necessity of supporting and reforming the educational system and ensuring high-quality physical and communication infrastructure.

Slovakia needs to focus primarily on the following areas:

a) support of educational policy,
b) support of physical and IT infrastructure,
c) protection of intellectual property,
d) change in labour law policy (working hours, working conditions, health, and safety protection at workplace, self-employed persons),
e) support of the legal system (data protection, legal liability, trade restrictions).

Firstly, Slovakia must improve is in the education system at all levels and should undergo its reform. The approach to education that persists in Slovakia is based on the experience of the 19th and 20th centuries and is not suitable for the development of talents in the new developing environ of the digital and circular economy. The ongoing education system is based on faulty assumptions. It creates an artificial barrier between the teaching of humanities and sciences, placing more emphasis on the social prestige resulting from acquisition of formal higher education and less emphasis on the actual content of education and knowledge acquired through practice.

Secondly, the support of the physical and IT structure in companies and educational institutions, the interconnection of theory and practice, especially by cooperation between universities and companies (e.g., through pilot schemes aimed at increasing the quality of graduates). Students would have the opportunity to confront theoretical knowledge with the requirements of practice and employers.
Thirdly, the concept of summer schools should be promoted, as they bring place for the development of additional knowledge beyond the curriculum, allow the creation of homogeneous groups of students linked by a common interest in industrial practice, the field of production and services.

2 Requirements of Industry 4.0 for Education 4.0

The Education 4.0 represents an inevitable trend in the new glance at education. Education is becoming a capital for an individual as well as for employers. The corner stone of professional success of individuals consists in flexibility and readiness for change (Krajňáková & Horváthová, 2020, p. 247). Competitiveness will increase in production and products, as well as in educational systems developing the talents in learners as educated employees will contribute to develop modern innovation systems.
Education 4.0 is defined as the use of technology in the context of teaching and learning (Dunwill, 2016, as cited by Krajňáková & Horváthová, 2020, p. 247; Pesti, Tamášová et al., 2021, p. 41). The concept Education 4.0 was designed to respond to the needs of Industry 4.0. New vision of education was aimed at the betterment of digital competences which could be applicable in all sectors of economy and production. Therefore, the traditional paradigm of education, teaching and learning must be re-assessed and transformed. Learners must be prepared for future radical changes in industries that will occur during their lives.
Digital coalition states that teachers should especially master the more advanced approach to education, reduce the curriculum to the essentials and avoid excessive memorization, support natural curiosity in children, not mortify children's creativity, critical thinking, interest in adventure, curiosity, desire after new knowledge (Združenie podnikateľov Slovenska, 2020).
The Association of Entrepreneurs of Slovakia also agrees with the above premise, adding that Slovakia wants to handle the challenges ahead, cooperation between companies and schools and school authorities is essential, and it should not be limited to dual education only. Policy makers also expect from companies the qualified answers related to the profile and qualities of graduates and the demands of employers, thus obtaining the comprehensive requirements related to the school education (Združenie podnikateľov Slovenska, 2020). Companies are quite good at defining which graduates they need today, however, it should be emphasized that the education cycle is much longer. If there is a talk about

today's freshmen, then with a high probability they will perform jobs that we even do not know, and still they need to be prepared for them. It is generally agreed upon, that the school should teach pupils knowledge of mathematics, sciences, and technology, develop soft skills and character in them. The ways of teaching and learning should promote a positive attitude towards education and learning among students and do not kill their curiosity and joy in learning new things.

Changes in the labour market are noticeable already at present. The increase in offers in the IT sector has been visible. In 2018, the IT sector and IT jobs were the fifth most demanded on the Profesia.sk, in 2019 it was the fourth most in demand, and in 2020 it was the third most in demand. The demand for IT workers increased by the corona pandemic crisis and the increasing automation that is gaining ground in the national economy (Profesia.sk, 2020).

The characteristics of Education 4.0 include education independent of time and space, personalized teaching, learning flexibility, project-based learning, the ability to analyse and interpret data, curricula development with the participation of students, guided learning, decentralization of work teams, and the setup of virtual and digital forms of collaboration and learning.

The key requirements of Industry 4.0 in relation to Education 4.0 can be formulated as follows:

1) Individualized education, focused more on the education of the individual, not on the education of the class as a whole group. Industry 4.0 will probably increase the number of employees contracted as freelancers, i.e., involved in specific projects. The expected transition of a large share of workers to other professions (e.g., via freelancing) requires an individualized approach to students on the part of educators.
2) The teacher training must be priority. Towards the future, it will not be sufficient for a teacher to study the teaching profession. It will be principally necessary for teachers to be continuously trained and able to work with the most up-to-date technologies. Teaching through new technologies should gradually cover the traditional subjects (e.g., biology, chemistry, and physics).
3) Increased flexibility in the teaching process is promoted. According to the traditional concept, the school seems to be outdated compared with the challenges of the future. Strict regulation of the educational process, e.g., the extent of the lesson, the exact schedule of lessons and breaks, can suppress a creative approach to teaching and learning.
4) Change should be carried out in the assessment of learners. The current assessment system is based on the same criteria for all learners. Considering the future professions, however, it can be expected that the assessment at workplace will be done in relation to the fulfilment of a

different task. The concept of Education 4.0 also operates with testing, while some online tests allow the learner to pass the test easier or "harder" according to learner´s abilities. The primary goal of testing is to provide feedback on knowledge and skills, not a grade.

5) The teacher is a mentor and coach. Education 4.0 assumes that the classic concept of the teacher as an "explainer of syllabi" or a "speaker dictating notes" will be shifted towards a mentor (especially concerning the development of soft skills). A Teacher 4.0 should be able to create video and audio content, visually engage content, use social networks in teaching, use blogs for participatory content, and create digital portfolios (Bolgarová, 2021).

Due to the requirements of the labour market for the future of jobs, education must be fundamentally changed.

Based on the future development and transformation of education resulting from Industry 4.0, several studies attempted to predict the new skills mostly valued in Industry 4.0.

According to a study by the American Society of Mechanical Engineers (ASME, 2022), companies should focus on three skill sets:

- those that companies MUST have (highest priority),
- those that companies SHOULD have (medium priority),
- those that companies COULD have (low priority).

The table 2 presents the breakdown of technical and personnel skills according to priorities.

Table 2

The breakdown of technical and personnel skills according to priorities

Technical skills	*Personal skills*
Highest priority: What companies must have?	Highest priority: What companies must have?
a) IT knowledge and skills	a) Time and personal management
b) Data and information processing and analysis	b) Adaptability to changes
c) Knowledge of statistics	c) Ability to collaborate in teams
d) Organizational and process knowledge	d) Social skills and communication skills
e) Ability to communicate with up-to-date interface (man-technology, man- robot)	
Medium priority: What companies should have?	Medium priority: What companies should have?
a) Knowledge management	a) Trust in new technologies
b) Interdisciplinary/general knowledge of technologies and organisations	b) Implementation of concept of continuing betterment and life-long

c)	Specific knowledge of production activities and processes	learning
d)	IT security awareness and personal data protection	
Low priority – What companies could have?		
a)	Ability of programming and coding	
b)	Specific knowledge on technologies	
c)	Knowledge of ergonomics	
d)	Knowledge of legal framework	

Source: own processing according to ASME

The era of digitization and changes at the global level require a different approach to teaching and learning and new relations within the educational system and external relationships.

The detection and identification of the required knowledge and skills in the Education 4.0 relates to the theoretical definition of skills, sometimes referred to as competences, and the identification of the most important skills from the aspect of Industry 4.0.

Competencies for the 21st century have been the subject of several studies and analyses. Several types of competences were defined - key or transferable, cross-disciplinary, global, competences for the 21st century and transversal competences. Currently, four basic types of broadly conceived transversal competences have been formulated, which go beyond the boundaries of the traditional teaching and learning system. They include digital information and media literacy, collaborative problem solving, awareness of sustainability and diversity, and the competence to know to learn and to learn in long-life learning (Hanesová & Theodoulides, 2022, p. 10).

Currently, it is emphasized that these competencies must clearly relate to critical thinking and reflection. Understanding this competence-thought framework is the basis for the formation of foundational knowledge and the formation of the potential of teachers.

Individuals, workforce, organizations, and businesses are currently exposed to unprecedented changes and challenges, such as rapid and radical developments and advances in technology, transformations and changes on a global scale, environmental sustainability, demographic change, and migration, as well as global political uncertainty. These changes can be characterized as a radical change in the paradigm of social and economic development, which confront humanity with positive and negative consequences in the world of work as well.

The report of the World Economic Forum (2016) stated that due to unprecedented changes in technological systems and intelligent systems, up to 65% of pupils entering school today will work in professions that do not yet exist and will use about a third of competencies that are not currently emphasized.

In 2016, the Future Jobs Report (The WEF, 2016, p. 3) stated that majority of current, most in-demand professions in many countries and industries did not even exist 10 or 5 years ago, and the rate of change will accelerate.

Professions that significantly affect people, will be expanding, including such newly emerging professions as specialists in human resource development, training and personnel development, organizational development, HR consultants and specialists, organizational culture personnel, service personnel and designers, problem solving consultants, e-commerce and social media specialists, experts in innovation development and innovation management. All newly emerging jobs are associated by the ability to present data, negotiate, and persuade, the ability to explain and lead others (Hanesová & Theodoulides, 2022, p. 14).

Even jobs described as stable (researchers, educators) will not remain untouched, but will undergo change and be based on the ability of cooperation between man and technology.

For this reason, it is necessary to look at competences and skills in a new way, from the aspect of the new needs and demands of life and practice.

The WEF report states that "the core of most jobs will be the transversal skills". Therefore, individuals, employers and educational institutions should focus attention on the formation and development of these competencies in ongoing, continuous education. If all actors adopt these new fundamental skills, it will be necessary to radically change the educational system and to resolve at universities what should be the content of formal academic knowledge, including transversal competences, which will be the educational outcomes, applicable in the personal, social, and professional life of the graduate.

A new vision concerning the content of education was brought by the WEF in 2016 (p. 32), when it introduced three new terms linked to education - competencies, foundational literacies, and character qualities, which are considered essential for education in the 21st century (Table 3).

Table 3

New vision for education

Foundational Literacies	*Competences*	*Character Qualities*
Literacy	Critical thinking/Problem Solving	Curiosity
Numeracy	Creativity	Initiative
Scientific Literacy	Communication	Persistence/Grit
ICT Literacy	Collaboration	Adaptability
Financial Literacy		Leadership
Cultural and		Social and
Civic Literacy		cultural awareness

Source: World Economic Forum, 2016.

3 Requirements of Industry 4.0 for higher education

Digitization also affects the field of education, although we are not at the end of this process, and therefore it is difficult to say exactly what role digital solutions will play in education in a horizon of few decades. In the education sector, it can already be observed currently, especially during the COVID-19 pandemic, that digitization replaces some elements of the traditional education and opens new possibilities that can educate students more effectively.

Progress in the digital economy can only be achieved by the quality improvement of education and the development of the skills of students and workers who can respond to new challenges of the labour market and accept technological innovations that will emerge at an ever-faster pace. Education is expected to prepare specialized human resources characterized by new knowledge, attitudes, work ethics, social and moral values, and skills to maintain and improve the development of society.

The management of universities and higher educational institutions must apply a new approach to the recruitment of future learners. The presentation of the universities must appeal to a wide range of potential learners, who most often decide on the quality of the offer, the new trends applied in education and the prestige of the university.

Universities should give students the confidence that they select the best offer by which their educational needs will be met. Through educational content and a wide range of study programs, the universities must be able to offer learners a powerful tool for learning and talent development.

Therefore, education must effectively adapt its "curriculum" to the needs of a changing society. It should be dynamic so that it can contribute to national development goals and bring about desirable social changes, preserve the positive aspects of the existing culture.

In accordance with the Strategy of the Digital Transformation of Slovakia 2030, "at all levels of the education system, there must be overall personality development, the development of a culture of relationships, and the development of the ability to learn, to be able to abstract problems and acquire knowledge in a targeted manner, as well as to orientate in the extensive data of the digital world" (Ministerstvo školstva, vedy, výskumu a športu SR, 2020, p. 29).

Higher education, research and innovation play a key role in supporting economic growth and global competitiveness, as they are part of economic, social, and cultural development. The mission of universities in the European education and research area is "to develop a harmonious personality, knowledge, wisdom, goodness and creativity in a person and to contribute to the development of education, science, culture and health for the well-being of the whole society. Fulfilment of this mission is the main activity of universities." (Ministerstvo školstva, vedy, výskumu a športu SR, 2020, p. 30)

In this context, higher education staff comes into focus, meaning all persons in institutions or programs of higher education who are engaged in teaching and/or scholarship and/or research and/or providing educational services to students or the community at large (UNESCO, 2020).

Development in higher education and research depends to a large extent on infrastructure and resources - both human and material, on the qualifications and expertise of teaching staff at universities, as well as on their human, pedagogical and technical qualities.

Digital transformation and information and communication technologies have taken over the world and are also present in education. During rapid growth, it is therefore necessary to provide education which increases the qualification of technological knowledge and skills of teaching staff of universities, educational and extracurricular facilities.

Acquisition of digital competence and skills is essential as every education and job in the future will require a certain level of digital competence and skills. Constant technological development and digitization require lifelong development of competences and skills from all learners, for Europe to remain economically competitive.

The European Union (European Commission, 2020) supports the development of a high-performing European digital education ecosystem and strives to improve the competences and skills of citizens for the digital transformation. It also supports equality during the digital transformation of education and society because it is essential. The European Commission also solves these problems through its main political initiative in this area - the Digital Education Action Plan (2021-2027).

Digital transformation is changing society and the economy with an ever-increasing impact on everyday life. During the coronavirus pandemic, the need for a higher level of digital capacity in education has been demonstrated, several challenges for education systems in the digital capacity of educational institutions and teacher training and the overall level of digital skills and abilities have been revealed.

Concerning this, the results of several studies are alarming. According to the OECD 2018 study, less than 40% of educators felt ready to use digital technologies in their teaching, with large differences between EU member states.

4 Digital transformation of education at universities

The term digital transformation refers to the transformation of the school, which also includes the appearance of digital devices, teaching procedures and methods, digital competences of teachers and students.

With the development of technologies, in addition to traditional competences (text understanding, logical, social, emotional skills), the development of digital

competence also became important. It denotes the knowledge that people possess how to use ICT tools, and that with the help of the digital tools they can interpret information and data, communicate, collaborate, take care of their personal safety and data protection, create digital content, and solve problems.

Digitization in education also brings fundamental changes in the areas of administration, monitoring and assessment. Digital tools and methods in assessment are not influenced by the environment, emotions and other factors that distort the result. Digital tools perform much better than humans in a crucial part of the assessment process: they can collect and analyse data at lightning speed. By connecting digital devices, immediate and highly accurate feedback is possible.

The use of information technologies at universities is one of the basic conditions for successful development. Colleges and universities have drawn up a strategic development plan, which also includes an IT development plan. Since the introduction, operation and the management of technologies and integrated information systems is very complex, the university management must provide them the constant support.

The digital technology equipment of universities includes:

1. High-speed infrastructure (telecommunications connection to the Internet and computer network).
2. University information system (basic, professional software as the basis of the university's integrated information system, licensed programs, database systems, presentation programs, video conference systems, communication programs - platforms for online communication (e.g., Cisco Webex, Microsoft Teams, educational platform Moodle, Slido), multimedia programs, electronic academic libraries).
3. Digital technologies (licenses, server, WIFI connection, LAN and WAN connection, notebook, SMART devices such as tablets, mobile phones, multifunction printers, projector, interactive whiteboard) staffed by experts (administrator, network administrator).
4. The management system of the educational institution as an open management system, quality education as the basic pillar of successful achievement of educational goals, the quality improvement of teaching and professional staff, etc.
5. The digital competences of the teaching and non-teaching staff must be upgraded through digital competence upgrade/upskilling courses, including the improvement of the command of software, hardware, work with information and services (information literacy) and the ability of electronic communication. The courses should be designed as lifelong learning and professional development training programs.

6. Digital technologies are an effective means of digital literacy improvement. Several countries, including Slovakia, have not approved a set of specific skills neither a digital skill development, assessment strategy referring to teachers as part of professional development.
7. Security in cyberspace - global security threats the Internet of Things - network protection, digital infrastructure safety against viruses and hacking - data leaks, personal data protection.
8. ICT development and management (regular maintenance, management, and development of digital technologies).

Technical infrastructure is a prerequisite for the success of online education, which takes place in a virtual environment. Online education "is the process of the teacher acting on students in the virtual space, while explaining the subject matter, giving instructions, discussions, providing feedback, while educational activities are carried out exclusively through the transmission of data via the Internet. Students participate in education in real time (synchronous learning) or from recorded materials in shifted time (asynchronous learning). It is a form of distance education." (Strenáčiková, 2020, p. 3)

However, online education brings specific challenges that students and teachers must cope with. Online teaching copes with such challenges that the classic face-to-face teaching does not have. The most important feature of education must remain the quality of teaching, regardless of the environment in which it takes place. L. Nelson (Nelson & Goodson, 2021) points out that quality and effective teaching is efficient teaching - and conversely, ineffective teaching is inefficient teaching - whether in a classroom, online or hybrid environment.

L. Nelson (2021) cites several sources and examples that confirm that:

- what matters most in learning of learners is good teaching, not technology,
- online learning improves when pedagogy drives technology, not the other way around,
- ineffective online teaching reduces students' chances of completing school or a given course, therefore improving online courses can support students' academic success,
- opportunities for cooperation among students, self-reflection and self-monitoring are among the most efficient educational practices in various environments.

When online learning follows best teaching practices, students may learn a bit more than in a comparable face-to-face class. Educators need more preparation time for online teaching. Online education also brings in challenges that full-time education does not present, e.g., social, and pedagogical challenges.

Learners in full-time education and learners in online education are challenged to persevere and succeed. They expect support and motivation from the teacher to persevere and succeed. Many students need more from online education than just

convenient online learning and a collection of reading materials, assignments, and assessments. The educator's social presence, personal contact, clear instructions and expectations, relevant documents, and absorbing tasks help learners learn and complete their studies.

Universities and educational institutions face several challenges in online education:

a) Quality assurance and overcoming doubts of educators about the quality of lecturing in the online environment and the content of presentations, endangering the academic success of students, while at the same time they perceive the increased external pressure on universities to develop new online courses as quickly as possible, educators do not have enough time to develop the best use of online technologies, which further feeds these doubts.
b) Technological tools are the matter of administrators, and not educators, but ultimately educators are supposed to have the command to apply them. Although technology administrators provide training to explain how to use technology tools, educators must learn how to use them in the context of teaching and research. As teaching professions currently face rapidly changing requirements, educators require a new and broader set of competencies, especially due to the ubiquity of digital devices and applications.
c) Incorporation of teaching procedures into online teaching is the task of the educator. When creating online materials and solving technical problems, educators tend to pay more attention to the correct use of technology than to correct teaching, even though they overlook the strategies they have acquired in their traditional teaching practice.
d) Technologies can fit well into teaching methods. The combination of technological elements, pedagogy and design of online teaching must be best recognized and applied by the educator.
e) Without interlinkage of pedagogy (pedagogical procedures) with the tools for quality improvement of university teachers in research and teaching, instructional design and online learning, it cannot be surprising that technology prevails over pedagogy and that many teachers have reservations about online teaching.

According to L. Nelson (2021), an effective transition to online education requires two key types of support: the value increase of online education through a better understanding of the pedagogical value of technology on the part of the educational institution, and competence upgrade in online education, including knowledge of specific technology-based skills (Nelson & Goodson, 2021).

The European Framework for Educators' Digital Competence (Punie, Y. et al, 2017) is a scientifically based framework that defines what digital competence

for educators. It provides a general reference framework to support the development of digital competences specific to educators in Europe. DigCompEdu's emphasis is not on technical skills, but rather on detailed information on how digital technologies can be used to improve and innovate education and training. Special attention should be paid to the role of a modern teacher who at the same time fulfils the role of a lecturer, tutor, digital advisor, content manager, digital learning practitioner, educational environment designer, blended learning designer, educational technology designer, mentor, and analyst (Teslenko & Khudyakova, 2020, p. 472). Modern teacher roles and competencies are presented in Table 4.

Table 4

Modern teacher roles and competencies

Modern teacher roles	*Modern teacher competencies*
Lecturer	Lecturing
Tutor	Development and maintenance of information educational technologies
Digital advisor	Training in the effective and safe use of the digital educational environment
Content manager	Use of digital technologies in the educational process
Digital learning practitioner, instructional designer of educational environment, blended learning designer	Construction of educational environment by disciplines based on the integration of educative tasks and the results of analysis of capabilities of services and platforms
Instructional designer of educational technologies	Student development research
Mentor	Mentoring
Analyst	The ability to create own development trajectory

The most significant competencies of teachers today include the following characteristics: readiness for continuous development and learning, information literacy and the ability to apply digital technologies in the educational process (Teslenko & Khudyakova, 2020, p. 472). The analyses of the teacher´s digital competencies allow to distinguish several levels of their development (Table 5).

Table 5

Levels of digital competencies development in teachers

Levels of digital competencies development	*Characteristics of the level*
Basic level	Knowledge and ability to apply a particular tool in e-learning and distance education
Practice level	Logical combination of full-time and distance (online) learning (allowing to use a mixed/hybrid approach in the educational process)
Advanced level	Ability to teach other teachers to make full use of digital technologies in the educational process

Source: Teslenko & Khudyakova, 2020, p. 473

Online education is a popular alternative to traditional, face-to-face education at universities. In 2019, Research and Markets predicted that the online education market would reach $230 billion value by 2025 – and with the major impact of COVID-19 on education, it is likely that online education programs will see even more growth.

In fact, the COVID-19 pandemic has shown what a practical and sustainable model online education is. It allows access to education even during a public health crisis, natural disaster, or other circumstances when students and teachers cannot travel and participate in full-time education. The pandemic has undoubtedly disrupted the entire education sector and forced academic staff and students to change their working, educational and even living conditions.

As many as 194 countries and regions temporarily closed their educational institutions in 2020 due to the pandemic, which affected more than 1.5 billion students worldwide. However, this process has not been easy due to a range of issues including IT, internet access and lack of knowledge about digital teaching and learning resources.

The OECD study (2022) highlighted how educators faced a steep learning curve in adapting to new teaching technologies at the start of the pandemic. Suddenly, they had to record lectures, create learning resources, organize online classes, online meetings, and consultations. It was easy for some, but not for others; they only learned to educate online because they were actively doing so due to circumstances.

New digital skills and technologies have played a key role in the transformation of traditional lessons into online education and hybrid learning. However, it

should be noted that such mixed teaching methods increased the working load and stress level of the teaching staff.

In the area of innovation and digitization, there is huge potential for using technology to deepen and support learning. The pandemic forced a definition of what teacher and student engagement really means in the classroom and showed that students could be more creative. Inside Higher Ed's annual report found that half of educators surveyed agree that online education is an "effective method of teaching", even though they also cited more stress and work pressure, more workload beyond working hours and too much engagement in front of a PC screen.

Regardless of where the education takes place – face-to-face, online, or through hybrid teaching and learning– effective engagement of students and acquisition of learning experiences from online learning should remain key priorities for higher education institutions.

According to the Online College Students 2022 report (Aslanian & Fischer, 2022) as many as 87% of college students and graduates agreed with the statement that online education is an appropriate way to educate and learn. In 2020, most likely due to COVID-19, up to 73% of students described themselves as studying online or partially online, compared to only 33% in 2017.

The pandemic affected the educational sphere at all types and levels of schools. It gave the opportunity to see the strengths and the shortcomings of educational systems. The adaptation to the online learning model can be a big challenge, however it brings in many advantages.

Today's workforce is gradually moving to the online environment. As many as 46% of foreign organizations surveyed by the Society for Human Resource Management (SHRM) said they use work from home and create virtual teams. As a result, the number of professionals who regularly work from home has increased by 159% over the past decade, with more than 4.7 million employees working at least half the time "online". Regarding the education, online education helps to prepare students for this change and shift towards online work (telework, home office).

The education informatization program until 2030 also defines solutions for the above-mentioned areas and proposes the following measures (Ministerstvo školstva, vedy, výskumu a športu SR, 2020, p. 29-30):

a) To put in place a system of education for university staff according to the specific training needs of individual categories (university teachers, researchers, artists, administrative staff and others).
b) Each study program should include the development of transferable and specific digital competencies in accordance with European standards and the needs of practice (the standard of digital skills will be part of the accreditation of the study program).

c) In teacher education and training, a precise distinction between the digital skills development (at all levels and in all subjects) and preparation for teaching informatics must be done, in primary education for all future teachers, at higher levels in the corresponding study programs. Every graduate of teacher education must meet the standard of digital skills associated with the study program (the standard of digital skills will be part of the accreditation of the study program). The development of future teachers' digital skills must be linked to the practical part of their studies (the same standard must also apply to Supplementary Pedagogical Study).

With reference to global trends in the digital transformation of education, in 2021 the Ministry of Education, Science, Research and Sport of the Slovak Republic approved the Program for Informatization of Education until 2030 which represents a long-term strategy for the development of education from the aspect of informatization, with the aim to achieve a significant shift in the use of digital technologies and get closer to a European standard. The program defines the requirements for the transformation of traditional education into digital education, the parameters, and the paths to it.

Conclusion

The world around is changing rapidly due to technological, economic, and societal changes. We live in the era of the digital economy and society, in which adapting people and the workforce to changes often requires adequate education, retraining and continuous acquisition of new knowledge and skills.

The requirements of companies on workers are constantly growing and lifelong learning is becoming a necessity. Therefore, it is not possible to limit the age category of university students. Today, an educational institution must be much more flexible than it used to be, and in addition to provision of basic educational functions, it must flexibly respond to the changing demands of the education market and those interested in education of different age categories, job positions and length of employment, who are united in their high demands for the quality education.

In terms of technology changes, all those related to digitization, communication, analysis of large sets of data, robotization and artificial intelligence lead. Advances in technology are primarily promoted through education. The best means of development in these areas are people and their educational level. Therefore, investments in the development of human resources and the increase of the education value in society become a necessary task for policy makers and decision-making authorities. Access to knowledge has changed. This fundamentally changed the relationship to knowledge, since in many cases not objective knowledge represents the value, but the acquisition of methods and ways (know-how) how to arrive at knowledge.

Slovakia needs to create conditions for the digital transformation of all sectors of the economy. This primarily includes the transformation of the current industry into Industry 4.0, by which we have access to technologies, as well as incentives and initiatives to solve specific problems, which will be used, for example, by digital innovation hubs. Innovative approaches and achievements of Industry 4.0 can significantly help Slovakia to function in a sustainable, ecological, and efficient way.

Since the COVID-19 pandemic, time has passed, full of challenges that have affected almost all areas of our lives. The world has changed, especially after the severe covid crisis and the shifting of geopolitical layers. New values were created, and old and proven over decades were blurred. People's thinking also changed. Our planet is facing challenges that have accumulated over the past decades and which we can only solve with united efforts. Science and the Art, the synergy between them, give us the eternal power to change our world and work for a sustainable future - the world of our generations. Humanity is facing the biggest challenge of its existence. The strategy "Industry 4.0" is where the physical world merges with the virtual. Information technology, telecommunications and manufacturing are united when the means of production are becoming more independent.

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