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Technical education in the context of the Fourth Industrial Revolution

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Abstract

The onset of Industry 4.0 assumes a change in the nature and structure of the labour market. An unintended consequence of macro-structural social changes is the production of actors for whom it is difficult to adapt to the new conditions and who can thus join the socially redundant category. The development of Industry 4.0 threatens particularly low-skilled individuals (according to the Czech and Moravian Confederation of Trade Unions, 2017, Industry 4.0 represents a threat to 40% of jobs). The lack of social positions associated with usefulness and recognition, along with the attributes of the contemporary society (social atomization, individualization, and the decline of solidarity within society) and the tendency to psychologization of phenomena caused by structural causation (the individual as the only "party at fault" in his/her life situation) can contribute to social conflicts and the emergence of social-pathological phenomena. The simultaneous activity of representatives of generation X, Y and Z with a different character of knowledge and skills, expectations and demands for work-life balance will also be specificity and challenge for the labour market.
The aim of the paper is to draw attention to the transformation of labour market requirements not only for graduates of technical universities within the transformation of the structure of job positions. Through data description and analysis, the contribution reflects the change in current theories and trends in education, and focuses on effective methods of interconnecting social sciences and engineering to reduce the risk of social deconversion.

Keywords:
Society 4.0
Technical education
Labour market
Soft skills
Deconversion

1 Introduction

Every developmental change in production and economy has had significant economic, social and demographic consequences in history. The individual stages of the industrial revolution accompanied not only the changes in habitual practice in the production, distribution and consumption of goods and services, changes in the structure and nature of the labour market, but also the fundamental changes in the way of life of individuals and social strata. The transformation of the organization of production, work, lifestyle, and the way of thinking that started the new millennium was identified in the second decade of the 21st century as the fourth industrial revolution, and the professional and lay public works with it as Industry 4.0.
The essence of the Fourth Industrial Revolution was laconically depicted by Z. Bauman: "This seems to come close to the once-popular ironic vision of future factories, expected to employ only two live creatures: one man and one dog – the man will be there to feed the dog, and the dog to prevent the man from touching anything" (Bauman, 2016, p. 112)
The Fourth Industrial Revolution is linked to the process of digitization and cybernetization of the production and distribution of goods and services. Linking the production process will increase the efficiency not only of

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the production, but also of product development and service. Intelligent systems will effectively replace human manual work: in particular, this raises serious concerns about the fate of the secondary labour market, which is characterized by low-qualification jobs, low wages, worse working conditions, and, as a result, greater staff turnover. Representatives of the Czech-Moravian Confederation of Trade Unions (2017) assume the decrease of up to 40 per cent of employment opportunities in this sphere over the period of ten to fifteen years. This development will be accompanied by the creation of new jobs, requiring professional qualifications, most often in IT and other technical fields, and an individual approach to education as a lifelong process. At the same time, the number of jobs in the helping professions will be increased, where people and human access have an irreplaceable place.
It is a question of the extent to which labour market participants will be able/will want to adapt to the new conditions.

2 Deconversion as a consequence of industrial revolutions

The adaptability of participants raised similar questions during the so-called First, Second and Third Industrial Revolutions. From a historical perspective, the individual stages were always marked by a wave of *deconversion*. The French sociologist Robert Castel described a situation where, as a result of major macro-structural changes, a group of participants is formed who become "socially redundant". They cannot adapt to new socio-economic conditions, and their social status is based on social uselessness and absence of social appreciation, recognition. (Castel, 2002)

Castel dates back the first wave of deconversion to the time before industry began to engage in human existence, and he brings it into line with the changes of feudalism in the fourteenth century. He connects the next wave - from today's perspective - with the First and Second Industrial Revolutions (18th century to early 20th century). So far, he has identified the last one with the onset of the Third Industrial Revolution. It seems that its consequences are now becoming more significant - and they will become more important in the future.

The progress of the individual stages of the deconversion depended on the current political and socio-economic, or legislative framework. The physical liquidation of those who were redundant, which was characteristic of the fourteenth century, was prevented by the existence of supportive social networks in the next wave of deconversion. On the part of the participant himself/herself, it was primarily a functional system of social ties within an extended family, or a community. Individuals with no access to full-fledged work were provided with the framework of decent living conditions by social welfare state mechanisms. With the emerging industry, emerging public sector organizations and private companies, there was also an increase in the opportunity to employ these individuals on the labour market, and hence the possibility of ensuring living standards. The participants affected by the third wave of deconversion have at the same time been threatened by the instability of these institutions - the family, the welfare state, and the labour market. (Keller, 2014)

The third wave of deconversion can be combined with the Third Industrial Revolution - even with the beginning of the process of globalization - and we can put on the timeline at the turn of the 1960s and 1970s. In this period, the unintended consequences of the process of modernization and industrialization began to be fully manifested both at the macro-structural level (uneven distribution of economic and hence political power, time-space compression, interdependence, and hence the fragility and instability of the world's regions, the devastation of the environment; threat of abuse of advanced technologies, e.g. in the development of weapons of mass destruction, etc.), and from the perspective of the participant who is expected to adapt to unstable, unpredictable and dynamically changing conditions, namely also in the context of a change in the socio-historical context, which unprecedentedly released him/her from traditional ties (family, community, church), left him with unlimited possibilities of choosing individual identity and way of life, but without any stable frameworks for behaviour, without traditional institutions and systems of social control. At the same time, it has made him/her individually responsible for this change in structurally caused phenomena.

The established trend of social atomization has deepened with the expansion of the Internet across the social strata. Isolation in the private sphere of individual interests, needs and opinions, often carried out through social networks, discussion forums and virtual communication partners, has a negative impact on public life,

collective activities decline, social passivity and apathy appear in a significant part of the society (Sennett, 1977).
The principles of the Fourth Industrial Revolution, it seems, do not contribute to the restoration of social cohesion, the necessity of personal contact, communication and argumentation of various social groups in the public space. Deepening of social differences and the diversification of society according to the degree of possibilities, abilities and willingness to adapt to changing conditions is more likely than benefiting from the advantages brought by Industry 4.0. The environment on which the increase/decrease of the participant's social status directly depends is the labour market (and the related social subsystems, e.g. educational - see below).

3 The labour market and the Fourth Industrial Revolution

The growing volatility of the positions of participants on the labour market has been evident from the end of the twentieth century and is accompanied by processes of flexibilization, or precarization of work. Limiting full-time work contracts in favour of the growth of temporary and part-time jobs has shifted the uncertainty of a globalized and unstable market from companies to employees. In response to dynamic changes in the economy, a steady life and career path loses its importance; stability, solidarity and loyalty to one employer is not a value. The immobile career, the unwillingness to move on within the labour market - and thus throughout the whole stratification system - is vertically or horizontally considered to be a failure. Competitive advantage is gained by participants who are characterized by the highest degree of flexibility, willingness to take risks and the ability to cooperate with anyone. (Sennett, 1998)

If labour market flexibility is not linked to protective legislative, political, economic and social measures, uncertainty is growing. One of the concepts that emerges during the above-mentioned period and that can be used in the light of the expected development is flexicurity. In a general sense, it is "... a policy strategy to increase labour market flexibility, organization of work and labour relations on the one hand, and to increase social protection for vulnerable groups in the labour market on the other." (Wilthagen and Rogowsky, 2002)

The aim of the strategy is, among other things, to strengthen the position on the labour market for low-skilled participants, to contribute to their participation both on the labour market and in the wider social context, and to prevent their social exclusion.

However, the basic prerequisite for industry, society and work 4.0 is a participant motivated to expand and/or enhance his/her skills through lifelong learning. The condition, however, is to reform the education system itself in such a way that its profile is not only in line with the personal interests and preferences of pupils and students, but also with the requirements of practice and the labour market.

Current data from the Czech Statistical Office reflect the limited possibilities of applying the acquired education in the professional practice of young employees aged 20-34. Obviously, with higher education and specialization, their employability increases (see Table 1).

Achieved level of education CZ-ISCED 2011					
	In total	Basic education	Secondary education without secondary school leaving examination (including apprentice schools)	Secondary education with secondary school leaving examination	Higher
In thousands					
In total	**1405.5**	**64.6**	**383.2**	**553.1**	**404.6**
yes	639.6	5.3	150.0	202.0	282.2
yes, partly	278.9	9.5	56.8	144.0	68.5
rather not	182.1	11.8	51.9	88.0	30.3

no	304.9	38.0	124.5	119.0	23.5
In %					
In total	100.0	100.0	100.0	100.0	100.0
yes	45.5	8.2	39.1	36.5	69.8
yes, partly	19.8	14.8	14.8	26.0	16.9
rather not	13.0	18.3	13.6	15.9	7.5
no	21.7	58.7	32.5	21.5	5.8

Table 1: Applying education of 20-34-year old employees in their employment. Source: ČSÚ (Czech Statistical Office), Selection Labor Force Survey -AHM2016 (https://www.czso.cz/csu/czso/cri/ctvrtletni-analyza-vsps-na-aktualni-tema-1-ctvrtleti-2017)

More specific data can be gained by comparisons of the applicability of the achieved education on the labour market across the study fields (Table 2). A comparative survey among university students shows that they are least likely to use the knowledge and skills acquired in the field of art and humanities (24%) and "services" (32.2%) in practice.

Achieved level of education CZ-ISCED 2011						
A broadly defined field	Secondary education without secondary school leaving examination (including apprentice schools	Secondary education with secondary school leaving examination	Higher	Secondary education without secondary school leaving examination (including apprentice schools)	Secondary education with secondary school leaving examination	Higher
	In thousands			In %		
general education	-	33.6	-	-	49.4	-
art and humanities	4.2	7.9	8.2	62.6	50.3	24.0
social sciences, journalism and information science	-	-	8.9	-	-	13.4
trade, administration and law	10.3	50.6	7.3	48.6	36.6	13.0
technology, manufacturing and construction	91.7	48.2	3.9	37.8	27.2	6.2
agriculture, forestry, fisheries and veterinary medicine	8.7	12.2	-	63.5	58.7	-
health and social care, care for favourable living conditions	-	12.4	4.0	-	37.2	7.6
services	59.4	33.0	8.7	62.3	47.9	32.2

Table 2: The number of people aged 20-34 who said that their qualifications are not entirely or rather not used by their level of education and education. Source: ČSÚ (Czech Statistical Office), Selection Labor Force Survey-AHM2016 (https://www.czso.cz/csu/czso/cri/ctvrtletni-analyza-vsps-na-aktualni-tema-1-ctvrtleti-2017)

4 From Education 1.0 to Education 4.0

While the industry has undergone four revolutions since the 18th century, from simple mechanization through automation and the introduction of IT to the use of complex cybernetic-mechanical systems (Schwab, 2016), the area of education is mostly more conservative, which is understandable as technological advances also bring, in addition to innovation, many new risks. The principles of learning are stable, technologies transforming the world primarily influence the methods and environment in which the education takes place. A detailed description of each type of education in the context of four industrial revolutions was provided by A. M. Harkins as early as 2008 (see Table 3). He connects Education 4.0 with the production of innovations, expanding the supply of learning environments (the school is only one of many educational options available), wiping out the differences between the role of the teacher and the student, daily updating of educational resources that are not just present and available to everyone like in the previous type education, but they are constantly being changed and supplemented.

	"Download" Education 1.0	**"Open Access" Education 2.0**	**Knowledge Producing Education 3.0**	**Innovation Producing Education 4.0**
Meaning is…	Dictated	Socially constructed, with aid of (usually limited) Internet access	Socially constructed and contextually reinvented knowledge	Built through selective individual and team-driven embodiments in practice, i.e., through focused innovations
Technology is…	Confiscated a the classroom door (digital refugees)	Cautiously adopted open access (digital immigrants)	Everywhere (digital natives in a digital universe) for ubiquitous knowledge, construction and transmission	Always changing with the direct input of learners acting as a major source of techevolution in the service of innovation production
Teaching is done…	Teacher to student	Teacher to student and student to student (progressivism); Internet resources are a normal part of learning activities	Teacher to student, student to student, student to teacher, people technology people (coconstruction of knowledge)	Amplified by positive innovation feedback loops; ubiquitously and creatively in all phases of living, learning, and working;
School are located…	In a building (brick)	In a building or online (brick and click), but increasingly on the Web through hybrid and full internet courses	Everywhere in the "creative society" (thoroughly infused into society: cafes, bowling alleys, bars, workplaces etc.	In the globally networked human body, a continuously evolving instrument innovatively supplementing and replacing the classroom
Parents view school as…	Day care	Day care with a laboratory edge, provided by open access and gradual movement toward project based learning	Places for students to create knowledge, and for which parents may provide domestic, volunteer, civic, and fiscal forms of support	Schools are viewed as one of many innovation venues for continuous innovation by students, teachers, parents, etc.
Teachers are…	Licensed Professionals	Licensed Professionals who	Everybody, Everywhere, backed	Everybody, everywhere, is an

		team with students, parents and others to (gradually) create more interesting class experiences	up by wireless devices designed to provide information raw material for knowledge production	innovation production source backed up by intuitive software "partners" and human collaborators
Hardware and software in schools…	Are purchased at great cost and ignored	Are open source and available at lower cost, permitting open access "on the cheap" and beyond school premises and timeframes	Are available at low cost and are used purposively, for the selective production of knowledge	Are innovated daily, since virtually all software is person specific as an unqualified expressions of familiarity and partnership
Industry views graduates as…	Line workers from whom little create is expected	A workers marginally prepared for the knowledge producing economy	As knowledge producing co-workers and entrepreneurs who can support the development of focused knowledge construction	As innovation producing co-workers and entrepreneurs who can sustain focused on innovation construction

Table 3: The Leapfrogging context: moving from Education 1.0 to Education 4.0 Source: Harkins, A. M. (2008), p. 2-3.

The introduction and expansion of new technologies in the context of the Fourth Industrial Revolution has led to the emergence of new professions and new ways of working, which has also been reflected in the formulation of new requirements regarding preferred knowledge and skills of staff associated with different modes of preparation and behaviour patterns than in traditional professions. Greater emphasis is put on lifelong learning, self-management, and the development of human potential. The reason for these changes can be found in the fact that, in the digital age, specialized knowledge and activities quickly become obsolete, so their constant updating is needed. According to Levy and Murnane (2013), people with high information literacy and ability to deal with unexpected unstructured problems will be most likely to assert themselves in the future. The least successful will be job seekers who only offer solid knowledge and routine repetitive thought processes and activities.

4.1 Extending the portfolio of required competencies

In addition to professional IT competencies (work with databases and expert systems, data analysis, etc.) and other technical disciplines, the vision of Education 4.0 is associated with the requirements of creativity, independence, cooperation, development of social competences, such as communication and presentation skills, team work ability, management skills, etc. Education 4.0 is used in the sense of training people for the needs of Industry 4.0. However, it is problematic to predict how innovations will continue to evolve and what the graduates of schools will actually need in the future. Thus, reforms of the education system should lead to the creation of a group of graduates who are able to be knowledgeable in rapidly changing conditions, are flexible enough and adaptable. Therefore, in the context of education, there is an increasing debate about the need to withdraw from the profile of a specialized school educating narrow specialists. In addition to expertise and specialization, emphasis is placed on readiness for change, adaptability, ability to communicate effectively, and so on. The sociologist Zygmunt Bauman observes: "It may be necessary to try to produce self-propelled cruise missiles that control themselves instead of ballistic missiles with once and for all encoded direction and speed" (Bauman, 2006, p. 135) And he adds: "Instead of specialization, it may be necessary to create the flexibility and ductility of the spirit and the ability to rapidly change the professional orientation, depending on the changing requirements." (Bauman, 2006, p. 136) But there is also a critique of the education of universal workers for industry and the labour market. In the case of the formation of universal employees of the new industry, it is a question to what extent the goals connected with the individual development of human potential and improving the quality of life will be met.

The concept of work begins to dominate the entire society, a mass worker of the past period is replaced by a socialized worker. Free time becomes space for further work. Garrett uses the concept of a social factory in which the whole company is available for work and profit generation. (Garrett, 2014) At the same time, work is increasingly connected with transience and uncertainty. Emphasis on the flexibility and individuality of staff (school leavers) is linked to the goal of removing them from social ties and commitments that could significantly reduce the adaptability capability, and it appears even before the expansion of the concept of Industry 4.0 and the Fourth Industrial Revolution. For over ten years, employers have stressed the importance of such competencies that make it easier to change the profession without unnecessary complications.

The necessity of lifelong learning for employability on the labour market is also recognized by graduates and employees. After 2000, graduates became more aware of the need to respond to the changing demands of the labour market and the accelerating trend of developing new technologies and knowledge. According to Papřoková (2009), students in this context started to prefer long-term courses organized by the university where they studied three times more often, compared to the short ones, and once as much, they preferred doctoral studies and other forms of education. In 2008, employers in the Czech Republic most often demanded from university graduates: flexibility, willingness to learn, language skills, responsibility, communication skills, PC skills, language competence and creativity. In the case of secondary school students, they expected practical knowledge of the field, independence, working and moral habits, education, willingness to work and develop, flexibility, dedication, the art of dealing with people, etc. Other studies (Tvrdý, 2007, Kalousková, 2007) focused on identifying employers' demands in the context of changing labour market conditions highlighted the following competencies: proficiency in handling information, ability to take responsibility, make decisions, willingness to learn, responsibility, adaptability, and flexibility.

Matochová, Račáková (2016) analysed the responses of 491 students of two technical universities - VŠB-TU in Ostrava and the Technical University in Košice. Students assessed their level in twenty types of communication skills. The skills that students have a very good command of are those connected with relationships, listening skills, empathy (e.g. providing information, giving positive feedback, being patient while listening, etc.). The reported skills they need to improve include verbal skills, cognitive functions in relation to memory, attention, concentration, art of leadership, productive polemics, discussion and argumentation, the ability to assert themselves, the ability to impress others (e.g., to manage the negotiations, to express themselves clearly in a conflict situation, to lead a dialogue with an unknown person, etc.).

While in humanities, the development of these skills is often part of a field of study curriculum, within the framework of science, or technical fields, these psychosocial skills are still considered second-rate and non-essential. That is why various courses, training modules and projects for students of technical universities are focused on their development. The project "Corporate Culture as an Integrative Element of the Curriculum of Social Sciences at VŠB-TUO" has been implemented since 2010 at the VŠB-TUO[3]; it aims to respond to the demand of the labour market and provides students with learning modules focused on mastering soft skills. The project monitors the link between the competitiveness and professional development of graduates and their ability to adapt to the working environment, or corporate culture, to contribute to its formation, and to use it for career growth and increasing the prosperity of the organization. Students acquire knowledge about identification and internalization of basic rules, values and standards of the company, principles of negotiation and communication in the organization. After passing the modules, students are able to recognize the core elements of organizational culture (values, standards, artefacts), adapt to the culture of the organization (effectively participate in team activities, lead a team), act and communicate within a given type of corporate culture.

4.2 Changing the qualification structure

In Czech conditions, facing the challenge of Industry 4.0 and meeting employers' requirements is linked to the increase in the number of students in apprenticeships, which is against the planned vision for the reduction of

[3] The contribution was created within the framework of the sustainability of the project "Corporate Culture as an Integrative Element of the Curriculum of Social Sciences at VŠB-TUO", reg. no. CZ.1.07/2.2.00/15.0128

the number of blue-collar jobs (even qualified) due to the introduction of Industry 4.0. As it turns out, under the conditions of the new industry, a "technological scientist" rather than a "technological worker" is needed. The change in the structure of the employees' qualification competencies is inevitable according to the results of the latest OECD studies (2016). "Increased globalisation and rapid technological change, but also demographic, migration and labour market developments, have drastically altered the structure of employment and the skill requirements of occupations in most countries in recent decades - and these trends are expected to continue in the foreseeable future. (…) In fact, in the European Union, more than 40% of workers feel that their skill level is not matched to requirements of the job and in many countries this figure is increasing." (OECD, 2016, s. 26)

Within the framework of Education 4.0, the emphasis is on the technical and scientific nature of education emphasizing critical and digital thinking, the use of advanced information technologies and expert systems, data analysis, mathematics, physics, robotics, cybernetics. The director of the National Education Fund, Miroslava Kopicová, is of the opinion that in the following years, the importance of humanities will also increase; they will supplement and develop the technical and natural science base of the students' education. (Education 4.0, Digital Czechia, 2016)

The humanization of technical education at technical universities is based on the idea of a graduate who is not only a qualified expert but also participates in project management, is a part of a team that s/he possibly manages himself/herself, and in this context, s/he is forced to solve social science issues such as psychology, sociology, law, etc. The possible linking of technical disciplines and humanities is, among other things, the introduction of teaching soft skills into the portfolio of subjects at technical universities in order to respond to the new demands of the labour market and to increase the employability of their graduates. Within the soft skills development, students define their strengths and weaknesses, improve their presentation and communication skills, learn to plan their careers, and learn about time-management techniques. As has been said above, in addition to professional competencies, social competencies are required to ensure better co-operation with other people and self-reliance, such as team work ability, communication and presentation skills, self-management, creativity, etc. These social competences include broadly portable knowledge and skills that increase the employability and flexibility of workers across disciplines.

Within the framework of the Fourth Industrial Revolution and the effort to transform the education system into Education 4.0, it is desirable to extend the professional training of students (not only those with technical focus) to a suitable concept of the development of educational social skills and to try to strengthen their readiness to practice with respect to the profile of the study fields. The need to develop social skills responds to the demands of the labour market and is based on the demands of employers.

5 Summary

Education is one of the most effective tools of vertical social mobility. In the field of technical education, the demand for qualified graduates and workers has prevailed over the supply on a long-term basis. Support for and development of technical disciplines is also the basis of Education 4.0 concept, which focuses on changes in the education system responding to rapid technological developments and changing the demands of practice in relation to digitization and robotization of production and distribution of goods and services. In addition to IT, mathematics, robotics, cybernetics and other technical expertise, social skills of employees are also desirable, while emphasizing the flexibility and adaptability of labour market participants. The key role in their employability is played by the readiness for dynamic market changes and the ability of lifelong learning. Strengthening these competencies can help to better adapt the participants to changes in socio-economic conditions and help them integrate into the social fabric, stabilize their social status, and avoid joining the socially redundant group.

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