AGRICULTURE 4.0 AND AGRICULTURAL VOCATIONAL EDUCATION AND TRAINING

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Abstract: Technological development plays an important role in the history of mankind, whether in development of economic production or society. Industrial revolutions are mentioned in connection with this development, with the one of the last stages called Industry 4.0. It is no different in the field of agriculture, where Agriculture 4.0 is taking shape. Vocational education and training, the role of which is to secure qualified workers for agricultural production, must also respond to these challenges. In this context, the article outlines the development of the agricultural sector in Czech Republic according to selected economic indicators, the development of agricultural vocational education and training, and finally, it provides examples of the enrichment of teaching with elements of Agriculture 4.0.

Keywords: agriculture 4.0, industry 4.0, vocational education and training, new technologies, virtual reality, constructivism, connectivism.

1 Introduction

Humanity develops, and with it also develops society and the knowledge of scientific and technological reasons and procedures, which are subsequently applied in the economic process. This leads to a constant expansion of knowledge and an increase in production possibilities.

Technological development is also related to these processes, which causes more significant changes in certain stages of human development. These changes are referred to as revolutions. If these changes concern industrial production, then we refer to them as industrial revolutions. However, these changes do not only concern the purely technical, industrial sector of the economy, but of course also have their progress in the field of agriculture.

The purpose of these industrial or agricultural revolutions is to increase the production capacity of individual sectors, individual producers and to increase the goods produced to satisfy unlimited human needs. Part of this process is also the tendency to free people, as workers involved in the production process, from heavy, strenuous, or monotonous work and thus provide people with the opportunity to develop their potential in other areas of production or human development.

In this sense, it is not necessary to view the issue of industrial and agricultural revolutions as a certain form of threat to people as workers, but rather as a means of achieving increasing production of necessary goods while using a smaller volume of human labor. This also saves hours of work spent during the day, i.e. shortening working hours, and potentially further shortening working hours in the future. The acquired time, as the most precious asset that people have, can be used for other activities, such as education, personal development, or regeneration of forces.

However, industrial and agricultural revolutions cannot proceed without adequately prepared workers, able to effectively use new knowledge applied in the production process. This creates constant pressure on the education system and the education of future graduates. Although the graduates should know classic, conservative production procedures, they should nevertheless be prepared for the use of new technologies in the production process of the real economic conditions of individual producers used at present and, if possible, in the future. It is questionable whether the education system can predict the future development of technology and preparing future graduates in this way. And if this approach is even suitable for the education of future graduates.

Either way, at least in the field of vocational education, it is necessary to think about the given issue and try to implement new approaches and technologies associated with the current version of the industrial (Industry 5.0) and agricultural (Agriculture 4.0) revolution.

Therefore, the aim of the article is to briefly characterize the course of industrial revolutions and related agricultural revolutions, with the subsequent identification of stimuli associated with the currently ongoing phase of the agricultural revolution and to connect these findings with the approach applied in agricultural vocational education and training. On this basis, provide an outlook on the possibilities of applying new technologies in agricultural vocational education and training in the future.

2 Methodology

The characteristics of the industrial and agricultural revolutions are made based on a survey of relevant sources describing the mentioned phenomena. Based on this desk research, the main driving forces in the currently ongoing phases of revolutions (Industry 5.0 & Agriculture 4.0) are identified.

The subsequent connection with vocational education and training is carried out first at the level of general tendencies of the inclusion of new technologies in teaching and subsequently the possibility of further implementation of new technologies in vocational education and training with a focus on the agricultural sector is outlined.

3 Industrial and agricultural revolutions

Revolutions in the way of securing livelihoods and producing goods to satisfy unlimited human needs can be identified deep in history. In a certain sense, both types of revolutions, the industrial and the agricultural revolution, are connected. This applies especially to the first early stages, which could be labeled as pre-revolutionary or proto-revolutionary. It concerns the issue of division of labor and specialization, which took place deep in human history. The division of people into hunters and gatherers brought the first increase in the efficiency of work and the income from such expended work. This can be considered the main idea of other upcoming industrial and agricultural revolutions as well.

3.1 Industrial revolutions and Industry 5.0

In the field of industrial revolutions, the first industrial revolution (*Industry 1.0*) is emerging, which is associated with the use of water and steam in industrial production, leading to a significant increase in labor productivity. The subsequent second industrial revolution (*Industry 2.0*) is then related to the introduction of new mass production technologies and the organization of the production process together with management based on scientific approaches. This creates large factories with assembly lines, and mass production enables a significant increase in manufactured goods and a decrease in production costs. The last of the backward-traced industrial revolutions (*Industry 3.0*) is then associated with the introduction of computer technology and information technology into the production process, when there is a further significant increase in the efficiency and productivity of work (Gashenko et al., 2020; Lazanyi & Lambovska, 2020).

These backward-traced industrial revolutions are then followed by another wave of industrial revolutions already organized and initiated by man, which has been labeled *Industry 4.0*. This phase of industrial revolutions is characterized by an even more intense use of new communication and information technologies, globalization, big data processing, robotics, augmented reality and virtual reality, and artificial intelligence. The Internet of Things and smart factories are used to be implemented (Beke et al.2020; Brahma et al., 2021; Flores et al., 2019; Grančíková et al., 2021). This wave has also spurred initiatives in a wide range of other areas, hence the emergence of initiatives such as

Education 4.0, Society 4.0, Agriculture 4.0 and many others occurs.

As Industry 4.0, although focused and highly effective in increasing the efficiency and productivity of the production of goods, has raised considerable concerns about the too rapid promotion of changes in economic life and the potential threat to jobs in many sectors leading to high unemployment, another phase of the industrial revolution has emerged in the European Union - *Industry 5.0*. This, currently the last phase of industrial revolutions, thus seemingly returns to the use of human potential. While not denying the benefits of previous industrial revolutions and not seeking some form of rollback, it advocates a higher involvement of human labor use, especially in the areas of creative and innovative industries. It thus puts the humans and human workforce in a cooperative position with the use of new technologies in the production process (Demir et al. 2019; European Commission, 2022; Nahavandi, 2019; Xu et al., 2021).

3.2 Agricultural revolutions and Agriculture 4.0

The field of agricultural revolutions was also subject to historical development, which mostly corresponds to the course of the industrial revolutions described above. If we were to reduce agricultural production only to its form of industrial processing of agricultural production, then we would certainly be satisfied with the above-mentioned description of industrial revolutions. This would particularly concern the introduction of mechanization and the industrial method of production into agriculture with the subsequent use of emerging information and communication technologies, which would lead to an increase in efficiency and productivity in agricultural production.

However, it is appropriate to mention the preceding phases of significant changes at least partially in agricultural production. These changes follow the already mentioned division of labor, associated with the division of humans into hunters and gatherers. In the agricultural production itself, connected with the cultivation of agricultural land, the functioning of the two-field and later three-field system of soil cultivation can be stated. These approaches to soil cultivation were based on the need to ensure sufficient renewal of substances needed for adequate soil yield, i.e. nutrients, and at the same time ensure the effective use of one of the important limited resources of economic activity, i.e. soil.

The increase in the production of agricultural crops, which would be able to provide sufficient nutritional value for the ever-growing number of the world's population, can also relate to the discovery of America, and with the spread of new crops, which thus gradually became available worldwide for agricultural production.

The problem of declining returns from agricultural activity in soil cultivation, caused by the excessive use of agricultural land and regulated by the above-mentioned approaches to soil cultivation, was subsequently solved by the introduction of industrially produced fertilizer. It was industrially produced fertilizers that led to a significant increase in agricultural production in the 20th century and thus enabled the rapid development of the world's population. At the same time, other products of industrial chemistry were promoted in agriculture, namely a wide range of preparations against various pests, pesticides, and diseases of agricultural crops. Here, in principle, significant connection between the industrial and agricultural revolutions can be seen.

The current initiative in agriculture can be seen as linked to Industry 4.0. That is also why it is referred to as Agriculture 4.0, where this designation rather refers to the interconnectedness of individual initiatives than to the order of the phases of the agricultural revolution. Agriculture 4.0 is also referred to as precision agriculture, digital agriculture, smart agriculture, or smart farming (Bushara et al., 2023).

In general, Agriculture 4.0 can be defined as agriculture using new technologies in a wide range of areas to achieve high efficiency and productivity while fulfilling a responsible approach to the use of agricultural land and sustainable management.

Agriculture 4.0 is therefore characterized by:

- the use of accurate data for agricultural activity in the field of soil cultivation,
- collection and processing of accurate data to increase the efficiency of managing the industrial method of agricultural production,
- the use of new technologies in agricultural production, including robotization, automation, digitization, and remote control,
- use of sensors and software data processing and others.

Drones or satellite mapping of the earth's surface are used to obtain accurate data, which is used, among other things, for activities to increase yields from cultivated land at optimal costs (Válek & Sládek, 2020). In connection with the collection and evaluation of accurate data, it is then possible to optimize, for example, the use of fertilizers and pesticides, according to the current state of agricultural production even at the time of its production in the fields. In this context, sensors on farm animals are also used to monitor their movements, possibly monitoring their health status (for example, “texting cows”). The use of new technologies in connection with the above-mentioned approaches enables concrete and precise dosing of fertilizers and pesticides, i.e. using “agribots” or autonomous vehicles, as well as other necessary substances for efficient and productive crop cultivation. This cultivation of crops takes place not only on agricultural land but also in hydroponics. To process big data, it is necessary to use specific technologies and software (Neves et al., 2023).

The following technologies are already available on the market in the Czech Republic today:

- livestock sensors,
- automatic milking technology,
- automatic feeding boxes,
- automatic feces handling systems,
- air conditioning units for pig and poultry farming,
- autonomous tractors and harvesting equipment,
- use of drones and satellite data,
- soil sensors and capacitive sensors.

3.2 Economic analysis of industrial revolutions

The above-described tendencies characteristic of individual phases of the industrial and agricultural revolution should also be reflected in economic data. To outline these impacts, previously published analyzes (Marinič & Pecina, 2021; Marinič, 2022), focused on the issue of Industry 4.0 and its evaluation through selected economic indicators available from the Eurostat database, will be used. Among the indicators used there were output, compensation on employees, consumption of fixed capital, gross fixed capital formation, hours worked by employees within total employment and number of employees within total employment as volume of persons.

These data point to the fact that in the Czech Republic there is an increase in investments in fixed capital, which can be interpreted, among other things, as investments in technologies, among which new technologies will logically represent a significant portion. The increasing level of investment in technology is manifested both by an increase in fixed capital, but also by an increase in the equipment of workers with capital. This subsequently ensures an increasing level of labor productivity. The increasing level of labor productivity then enables a tendency for workers' wages to rise. At the same time, there is also a tendency towards a decrease in the working hours of workers. All these identified manifestations can be considered positive, in terms of impact on the efficiency and productivity of producers in individual sectors and on employees themselves.

In connection with the focus of the article, it is necessary to emphasize the situation in the agricultural sector. It is precisely in this sector that the decrease in the number of employees and the increase in the volume of fixed capital with the effects described above are most pronounced. According to the data, the agricultural sector underwent the most significant change in the 1990s, when there was a significant replacement of human labor with the help of mechanization and automation. With the subsequent stabilization of the situation in the next period, which is associated with an increase in the company's capital equipment, which indicates the potential positive effects of both the Industry 4.0 initiative and, in particular, the effects of the Agriculture 4.0 initiative. In this context, it can be stated that the progress of introducing new technologies into economic life has been perhaps even more pronounced in agriculture since 2000 than in other sectors.

4 Vocational education and training focused on agriculture

Tendencies associated with the introduction of new technologies into the production process, whether associated in general with Industry 4.0 or specifically with Agriculture 4.0, inevitably require changes in the education of current workers as well as in the education of future workers. this creates significant pressure especially on vocational education and training, the primary task of which is to prepare future workers in accordance with the requirements of the labor market. At the same time, the education system, especially in the field of vocational education and training, also enables the retraining of existing employees.

Therefore, it is necessary for the preparation of future graduates of vocational education and training to receive adequate education and practical experience that will reflect current developments in the field of new technologies. From the point of view of the theoretical approach to the educational process, the use of new technologies can be included under two approaches, represented by constructivism and connectivism (Marinič & Pecina, 2023). For the constructivist concept of teaching, the use of problem-based and research-oriented teaching seems appropriate. These approaches make it possible to design teaching in such a way that pupils independently discover the required concepts contained in the educational content. This can be achieved by using real tools in real conditions, or by using simulated virtual reality conditions.

In many fields, virtual reality is already used for educational situations, and it can be assumed that its use will increase even more in the future. In addition, virtual reality provides the possibility of effective management of the learning process, its evaluation, and all this in a safe and economically relatively undemanding environment (Pecina & Andriusiunas, 2023). At the same time, students are being prepared to use new technologies in their future work, as virtual reality is also used in real economic conditions in the production process in variety of sectors.

The second mentioned approach is connectivism, which is based on the use of information and communication technologies to obtain, process, and use qualitatively preferable data from expert external electronic sources. Due to the current way of using information technology by the young generation, connectivism also appropriately uses the motivations of pupils in the learning process. In this sense, it has been possible to identify for a long time the possibilities of developing the selected competences of pupils precisely through new digital technologies. Pupils' access to these technologies, whether in terms of their material capabilities of obtaining the appropriate digital technology or mental attitude, enables their wide use both in the educational process and in future application in economic practice (Pecina & Sládek, 2018; Sládek & Válek, 2017; Válek & Sládek, 2017; Válek & Sládek, 2012).

On the one hand, professional education and training must ensure the transfer of knowledge, skills and attitudes based on the classical approach to individual fields, the transfer of customary production procedures, to ensure the applicability of graduates in their future professional application. In this sense, educational institutions in vocational training must also focus on simple and basic production processes using classic production processes and appropriate technological equipment. On the other hand, especially because of the increasing use of new technologies in production processes, it is also necessary to ensure the transfer of knowledge, skills and attitudes associated with new production procedures using new technologies.

Pupils therefore need to be introduced to digital technologies that are currently being used in practice and can be considered here as a certain form of a new standard. In this sense, such a transfer of adequate knowledge, skills and attitudes can be secured through appropriate conditions in the educational institution itself, or cooperation with producers with economic practice. In the form of excursions, internships or, ideally, a dual system of professional education and training.

As already mentioned, the agricultural sector appears to be more accelerating the use of new technologies than other sectors. In this sense, agricultural vocational education and training must set an example for other fields of education as well. And this is especially so if educational institutions in the educational system want to maintain their competitiveness and sufficient interest on the part of pupils. Adequate training of teachers and other educators in the framework of professional education and training is also needed to master this task. Also, their motivation to increase their professional qualifications and competences to transfer adequate competences in connection with new technologies is a must (Adamec, 2023).

5 Discussion of survey results

As the characteristics of the course of the industrial and agricultural revolutions and their current phase referred to as Industry 5.0 and Agriculture 4.0, together with the economic insight into the situation indicate, increasing efficiency and productivity is a desirable phenomenon in the development of humanity. How else would we be able to obtain more and more goods from limited resources to satisfy unlimited human needs?

Also, the above information indicates that agriculture is no longer an area dominated by a significant amount of inefficient human labor. Agriculture can even be characterized as a sector in which, more than in other sectors, the ideas of increasing efficiency and productivity through new technologies are manifested.

This is closely related to the reduction of the number of workers in the agricultural sector, but at the same time maintaining or even increasing the volume of production. It is related to the change in the structure of the economy when the importance of agriculture in terms of share in the total output of the economy is decreasing. However, the importance of agriculture lies in its ability to produce a sufficient volume of agricultural production to feed the population.

This phenomenon also manifests itself in connection with the increasing volume of agricultural production due to the limited possibilities of the extent of cultivated land. In addition, agricultural production represents a form of goods satisfying basic human needs. Needs of a daily nature, which also have an economic impact on household management. This influence was also identifiable in connection with inflation, which took place in the last years, when the higher rate of inflation was perceived by consumers mainly through the increase in the prices of agricultural production and energy costs.

All these indications indicate that agriculture is currently and will continue to be a very attractive sector in the future.

6 Conclusion

Human activity is associated with the effort to increase production possibilities while using limited resources, among which can also be counted the human activity necessary for the given production. In this sense, since the beginning of human

development, tendencies towards increasing efficiency and productivity have been manifested. Step changes can then be identified as revolutionary. And that is why drastic changes in the approach to industrial production are referred to as industrial revolutions. We are currently in a stage that is referred to as Industry 5.0. Similarly, initiatives in the field of agriculture are named after these industrial revolutions, namely Agriculture 4.0.

These are not just theoretical or philosophical concepts that should lead to more ideal production conditions and higher efficiency and productivity. these are processes that actually take place in economic practice. Even if their specific identification is not entirely obvious, and not hard economic data cannot identify significant leap changes in a short period, the impacts of both initiatives characterized here (Industry 5.0 & Agriculture 4.0) are showing. Even though agriculture may generally be associated with hard, strenuous work, reality and economic data suggest that revolutionary production change initiatives are proceeding slightly faster in it than in other industries.

This also puts pressure on the education system, which, through vocational education and training, must ensure adequate education for future graduates as participants in the labor market and future employees. Therefore, it is important that educational institutions follow current trends in the field of Agriculture 4.0 and thus prepare not only future graduates for the needs of the labor market, but also their own educators for an adequate form of education.

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