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## **PROBLEMS AND PROSPECTS OF HIGHER EDUCATION IN THE CONTEXT OF THE FOURTH INDUSTRIAL REVOLUTION**

**Abstract.** *The article is devoted to clarifying and systematizing higher education prospects and problems conditioned by the fourth industrial revolution. An analysis of its essential technologies' influence on the higher education system is performed. The following scheme of the research is used: the essence of technologies; innovations created on their basis; the consequences of their introduction into the industry, both positive and negative; problems and prospects for the development of the system of higher education. Based on the analysis results, problems and prospects of universities' development in the conditions of the fourth industrial revolution are highlighted. Some practical aspects of Ukrainian universities' development opportunities in conditions and on the basis of technologies of the fourth industrial revolution are considered.*

**Keywords:** *system of higher education, the fourth industrial revolution, university management, opportunities and threats of development, innovations in scientific and educational activities.*

### **Introduction**

The fourth industrial revolution (IR4.0), which is gaining momentum, initiates fundamental changes in all areas of human activity: industry, services, public administration, everyday life, etc. IR4.0 integrates computer information technologies, automated production,

and human intelligence into a single self-governing system [Schwab 2016]. On this basis, new technologies are emerging that are used in various sectors of national economies and in local, regional, and state administration. This leads to the rapid aging of existing knowledge and skills since most of them are unclaimed in rapidly changing conditions. IR4.0 technologies require new professions, reduced training time for relevant specialists, and constantly updated knowledge and skills. Under the new conditions, the need for creatively thinking specialists in creative jobs is increasing, and the need for specialists in occupations that involve monotonous standard work, both physical and intellectual, is sharply reduced. Thus, changes are initiated in the areas of training specialists, especially in the field of higher education. IR4.0 technologies also open up new opportunities in the organization and content of the educational process, help improve its quality and allow you to train specialists in the necessary professions quickly. They also expand the possibilities of access to training and make it convenient for the teacher and the learner, in particular, from the standpoint of:

- a variety of learning technologies: teaching in classrooms of universities, at future workplaces (real or virtual); online distance courses; exams; online or off-line consultations, and much more;
- time and place of training (geographical region, location of the subjects of the learning process: at home, on vacation, in transport, etc.);
- information saturation (availability of electronic libraries and information bases, open courses of disciplines, etc.);
- visibility of the presentation and consideration of the studied patterns, objects, phenomena, technologies (computer simulation, virtual technologies), etc.

The outlined factors have a direct impact on the activities of universities and the higher education system as a whole. An analysis of their influence (both positive and negative) makes it possible to reasonably choose promising strategic directions for the development of universities (the education system), to increase their competitiveness in domestic and international markets for scientific and educational services in the conditions of IR4.0. Under these conditions, the problem of analyzing the problems and prospects of higher education caused by IR4.0 is actualized. Using the analysis results will provide an opportunity to develop strategies for the development of higher education in general and individual universities in particular, which will use the possibilities that open up and counteract emerging threats.

The analysis of the impact of IR4.0 on the labor market and training, in particular – in the system of higher education, is devoted to the work of scientists from different countries.

[Rotatori 2021] note the impact of IR4.0 on all sectors of the country's economy and social system. They focus on the effects of IR4.0 on the workforce and the need for it to retrain about new conditions. With the help of experts (business leaders, university employees, government officials, etc.), they identified the main problems of national staffing economies in the conditions of IR4.0 and outlined areas for training specialists in new professions. [Eberhard 2017] explores the issues of labor market transformation under IR4.0, predicts the emergence of new occupations, and the extinction of some existing ones. They note an increase in demand for specialists with new professional skills in the context of digitalization and outline the competencies necessary for specialists in new professions. The results of this study can be used to adjust the directions and technologies for training specialists with the conditions of IR4.0. [Quyet 2020] outlined the areas of influence of IR4.0 on higher education in Vietnam, which relate to the educational process; curricula and teaching methods; admission to study; learning environment, etc. He proposed recommendations for developing the higher education system in Vietnam under IR4.0 in the context of universities, teams of managers and teachers, and students. [Kayembe 2019] analyze opportunities and threats for higher education in South Africa in the context of IR4.0. They identify the main problems of its adaptation to new conditions: insufficient funding, underdeveloped infrastructure, and poor readiness of teachers.

Propose state support measures for the development of the education system concerning IR4.0. [Gueye 2020] proposes a new university concept (university 4.0) that builds on the IR4.0 concept for higher education. It involves unifying people (teachers and trainees), digital technologies, and the learning process into a single system. It is proposed to introduce automation of the learning process by analogy with production processes based on IR4.0 technologies. This will allow, according to the authors, to teach of modern digital and pedagogical innovations, improve the quality of the educational process, and adapt it to the conditions of IR4.0. [Krishnannair 2021] consider the theoretical aspects of using IR4.0 technologies to realize the ideals of positive social change in the post-colonial South African higher education system. [Levchenko 2021] analyze the development of the higher education system in countries with transitive economies in Ukraine and Algeria. In particular, they consider the imbalances of mass education, which are reduced to a low level of graduate training, orientation to outdated development concepts, and non-compliance with the requirements of IR4.0. The authors offer a scientifically based approach to the optimal strategy for eliminating imbalances in higher education in countries with economies in transition in the context of their development in line with IR4.0. [Zavera 2019] highlights the

main challenges of the educational environment regarding IR4.0. In particular, she examined the impact of transformations caused by the symbiosis of man and machine on the formation of a new paradigm of the educational environment. The main modifications in the education system aimed at implementing human capital in the conditions of IR4.0 are considered: the formation of new skills, the development of creativity, adaptive capabilities to environmental changes, etc. [Sekiyama 2020] considers the problem of student mobility under IR4.0 from the utility structure of their spending on studying abroad. The impact of IR4.0 on mobility is analyzed using the proposed theoretical and economic model.

It is shown that the increase in the global volume of knowledge increases the demand for training abroad. At the same time, the rapid aging of expertise and the relatively high cost of studying abroad reduce the need. To solve the problem, it is proposed to develop students' skills necessary for work that machines cannot perform. [Komara 2020] considers information management to increase Indonesian universities' competitiveness in the context of IR4.0. The problems of universities related to IR4.0 are analyzed. To solve them, it is proposed to use computer information technologies IR4.0, which are used in industry. [Брусенцова, 2016] examines the essence of paradigm shifts in higher education under the influence of IR4.0. She identified the main trends in the development of modern higher education in the conditions of the network economy and IR4.0. [Гулей, 2018] explores the impact of digitalization on the functioning of the ore market, reducing the risk of an imbalance in professions and adapting the personnel of organizations in various industries to innovative vectors of economic development. In [Четверта, 2018, p. 435-444] reveals the role of higher education in the system of formation of universal competencies necessary for employees in the conditions of IR4.0. The material and virtual environment's influence on university and university education is considered.

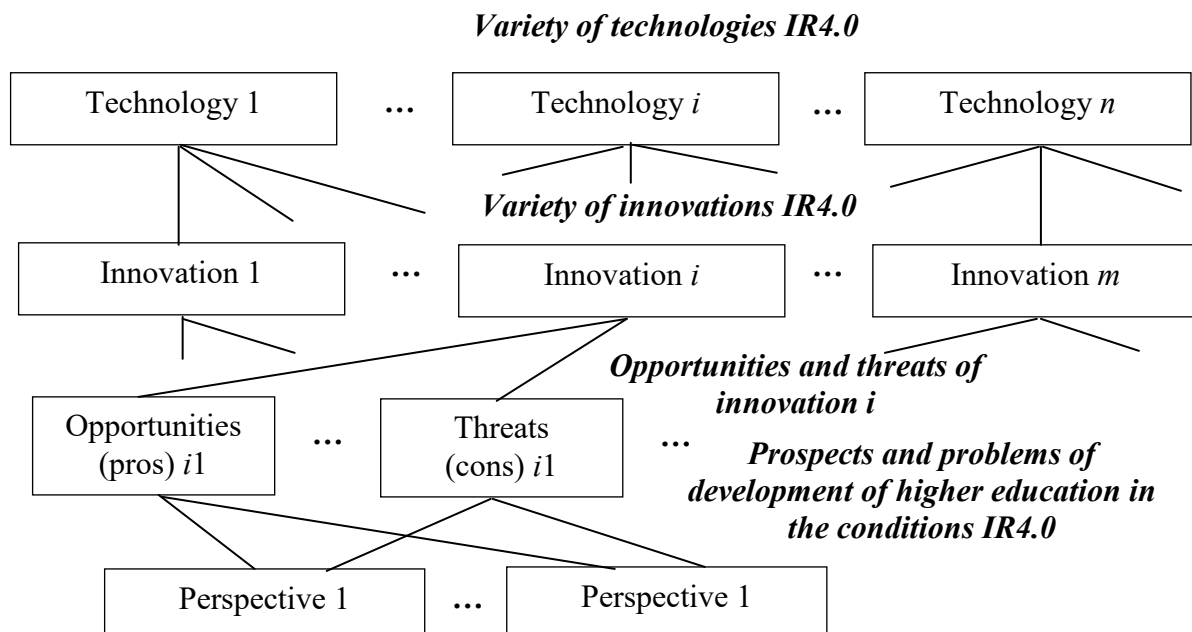
The analysis of literary sources shows that they have studied several essential aspects of the impact of IR4.0 on the higher education system in various countries. There were considered positive moments forming development opportunities and difficult moments carrying threats. Some proposals have been developed for using IR4.0 technologies and approaches in the educational process of universities. Several measures have been proposed to improve the system of higher education at the state level to adapt it to the requirements of IR4.0. However, there is practically no systematization of the prospects and problems of the development of higher education in the conditions of IR4.0, considered from the standpoint of the influence of individual technologies and innovations created on their basis. And this

complicates the development of strategies for the development of higher education, especially at the university level, which allows them to compete in the conditions of IR4.0 successfully.

**The purpose of the article** is to clarify and systematize the prospects and problems of the development of higher education, which takes into account the opportunities and threats of IR4.0 technologies for the activities of universities in the market of scientific and educational services.

### **IR4.0 technologies and their impact on the higher education system**

An analysis of the essence of the main IR4.0 technologies, as well as the innovations created on their basis and the practice of their implementation in various areas of human activity, made it possible to determine the nature and directions of their influence on these areas. Considering the problems of the study, special attention was paid to the trends in the development of the labor market in the conditions of IR4.0 since they directly affect the field of higher education. The results of the analysis are presented in the form of the following structures: IR4.0 technologies (individual or their combinations), see [Schwab 2016]; innovations created on their basis; the consequences of their implementation – positive and negative impact; emerging challenges and opportunities for higher education (Figure 1).



**Figure 1 – The structure of the analysis of the impact of IR4.0 on the formation of problems and prospects for the development of higher education**

The presented results of the analysis relate to the assessment of the consequences of the introduction of IR4.0 in industry and the assessment of the results of their impact on the higher education system. Fragments of the analysis for other areas of human activity are given in [Ілляшенко 2016]. Let us consider each of the structures obtained according to the proposed scheme.

1) The combination of technologies "Internet of things", "predictive analytics (big data)", "cloud computing," and "machine learning" allow you to manage production processes in real-time, which, in turn, makes it possible to create innovative automatic factories, which are connected via the Internet with economic counterparties. The positive result is cost reduction, productivity increase, adaptive production and logistics, product customization, etc. The negative effect is the deepening of technological and economic inequality in countries, the disappearance of traditional professions, and the focus mainly on highly qualified personnel. From the standpoint of the higher education system, a negative point is a need to quickly change the areas of student training, the formation of the appropriate human resources potential of universities, their material and information base, the transformation of the management system, etc. A positive aspect is an opportunity to strengthen the position in the market and even take a leading role in training specialists in certain professions.

2) The technology of "additive manufacturing (3D printing)" allows you to change the technology of manufacturing parts, assemblies and mechanisms: in mechanical engineering, construction, and the military sphere ("printing" components in the field). The positive is the reduction in manufacturing costs, adaptability, and increased production productivity. In small-scale and single-piece production, this dramatically reduces the time and cost of manufacturing parts and assemblies. The negative point is the possibility of a radical transformation of industries, industries, and markets to which it will be necessary to adapt, as well as the disappearance of traditional professions and the emergence of new ones. Positive and negative impacts on higher education are similar to those described in 1<sup>st</sup> point).

3) "Augmented reality" and "digital product cloning" technologies make it possible to create holographic images and digital copies of objects that can be studied, tested, and improved based on the test results. Among the positive aspects is an increase in the efficiency, quality, and productivity of work on creating and testing objects. Negative moments: functional and technological unemployment, the disappearance of traditional professions, and the emergence of new ones. Positive and negative impacts on higher education are similar to those described in paragraph 1). The following should also be added to the positive: an increase in demand for retraining and retraining of specialists; the possibility of creating

virtual simulators, building virtual analogs of objects studied and/or designed by students, conducting their virtual tests, etc.

4) Aggregate use specified in paragraphs. 1-3 technologies allows you to create a number of innovations: technological, organizational, managerial, etc. In particular: modeling business processes simultaneously in virtual and physical reality, which allows you to optimize them quickly; horizontal and vertical integration of business processes that will enable you to coordinate the interaction of their participants; the use of artificial intelligence in management, which helps to increase the speed of response, the quality, and objectivity of management decisions. The overall positive result of introducing these innovations will be a sharp acceleration of technological changes, which will ensure economic growth, an increase in the quality of life, and an increase in demand for creative specialists. Negative moments: change in organizational structures of management and forms of a labor organization; spread of new forms of labor relations; functional and technological unemployment; the disappearance of traditional professions and the emergence of new ones; the growth of contradictions between the owners of capital (physical or intellectual) and employees, talent and mediocrity; permanent adaptation of business, the transformation of its forms; the need for constant retraining and retraining of employees. Positive and negative impacts on higher education are similar to those described in paragraph 3). In addition to them, it becomes possible to combine at the level of individual universities (based on IR4.0 technologies) into a united system:

- human resources: management, teachers;
- consumer resources: students, trainees, persons undergoing retraining and/or advanced training, etc.;
- information, analytical and software resources of scientific and educational materials on electronic media (library, repository, electronic training courses of disciplines, software used in research on the academic work of teachers and staff, etc.);
- information-analytical and software resources on electronic resources used in managing the activities of the university (regulatory framework, documents characterizing the conduct of the educational process by teachers and students' progress, documents indicating the scientific activities of the university, papers describing the staffing of the scientific and educational process, etc. );
- equipment used in scientific research and educational process, both physical and digital representation of virtual forms (objects, technologies, processes, etc.);
- base of financial resources of the university;

- processes: implementation of scientific research; conducting classes; interaction with external economic counterparties and contact audiences, etc.

A generalization of the results of the analysis (see paragraphs 1-4 above), considered from the standpoint of the problems and prospects for the development of universities in the conditions of IR4.0, is presented in Table. 1.

It should be noted that the universities of Ukraine, responding to the challenges of IR4.0, use the opportunities opening up. In particular, at the National University "Lviv Polytechnic" (Lviv) at the Institute of Computer Technologies, Automation, and Metrology, within the specialty "Computer Science," bachelors are being trained under the program "System Engineering (Internet of Things)" [Офіційний 2021].

Elements indicated in the Table. 1 self-governing system is currently actively used in several universities in Ukraine. In particular, teachers and students of the National Technical University "Kharkiv Polytechnic Institute" [Офіційний 2021] using smartphones or personal computers have access to individual electronic cabinets, in which they get access to the class schedule, the database of assessment sheets for subjects, lists of student groups, etc. They also have access to electronic educational, methodological, and scientific materials, courses of disciplines, information, and analytical materials, the current regulatory framework, software that is used to plan and process the results of scientific research, complete assignments, communicate between teachers and students, and much more. Some universities have developed software models of objects, processes, phenomena, etc., used in scientific research and education. The mentioned resources, information, and analytical materials are available from any personal gadgets of teachers and students at any time (in the open access mode or subject to obtaining such rights).



**Table 1. Problems and prospects for the development of universities in the conditions of IR4.0**

Problems	Perspectives
The disappearance of existing and the emergence of new professions require changes in the areas and specialties of training specialists	The opportunity to offer new areas and specialties of training adapted to IR4.0, which will allow you to take a leading position in the market of scientific and educational services
Rapid changes in the labor market require high efficiency of work to change the content and organization of the educational process	The possibility of expanding the forms and methods of training specialists, expanding the range of advanced training courses and accelerated retraining
Loss of relevance of professions that involve the performance of routine monotonous operations (physical and intellectual) since they are easily automated	The relevance of the development of students' creative abilities, motivating teachers and students to create and use innovative technologies IR4.0
The need to form the human resources potential of universities, strengthen their material and information base, and radically transform the management system, including the formation of an innovative culture for the survival and development of universities in the context of the growing spread of IR4.0 technologies in almost all spheres of human activity	Technical and technological possibilities of transforming universities into self-governing systems, which, based on IR4.0 technologies, provide mutually agreed interaction: students; management, teaching and teaching support staff; processes (management, training, research, interaction with external audiences, financing, etc.); equipment used in the scientific and educational process; information and analytical base, etc.
	Creating software and hardware systems interacting with a person for designing, developing, studying, and testing objects, technologies, processes, etc.

Innovative organizational structures of university departments have been created and tested, showing their high efficiency in the context of technological transformations [Illiashenko 2018]. Systems have already been designed to include almost all of the listed subsystems and their elements combined using IR4.0 technologies. However, their widespread use is a somewhat distant prospect. The main reason that hinders their spread is insufficient staffing (managers and specialized specialists), software, hardware, and financial support, outdated organizational and managerial structures, low innovative culture of management and teaching staff (especially in terms of perception and use of IR4.0 technologies [Ilyashenko 2014]).

### **Findings and conclusions**

It is shown that the growing strength of IR4.0 affects all areas of human activity, including the higher education system. From these positions, an analysis was made of the nature of the impact of the leading technologies IR4.0 on the higher education system.

An analysis scheme has been proposed and tested, which, unlike the existing ones, makes it possible to determine the impact of individual technologies (their combinations) and innovations created on their basis. The proposed scheme made it possible to analyze the chains: technology (technologies) IR4.0; innovations created on their basis; positive and negative consequences of their introduction in the industry; problems and prospects for the development of the higher education system in the current conditions. As a result, the opportunities and issues of the development of higher education in the needs of the fourth industrial revolution have been clarified and systematized. Based on the analysis results, the problems and prospects for the development of universities in the conditions of IR4.0 are highlighted. The practical aspects of using favorable development opportunities by the leading universities of Ukraine in the states and based on IR4.0 technologies are considered.

The results obtained develop the theoretical and methodological foundations of the innovation management of universities and the higher education system under the conditions of IR4.0. They can form the basis of the methodological base of the organizational and economic mechanism for managing higher education development strategies, especially at the university level, which allows them to successfully compete in the market of scientific and educational services in the conditions of IR4.0. Further research should be aimed at forming the foundations of such a mechanism.

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