Digitalization of Education as a Prerequisite for the Implementation of Industry 4.0 Technologies in the Activities of Enterprises

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Abstract. The article is devoted to the problem of modernization of higher education in the digital economy. The place and role of education in the process of introducing Industry 4.0 technologies into the activities of enterprises have been determined. The directions of modernization of the educational process aiming students at fluency in knowledge and tools of the digital economy for smart production are determined. The modeling of the processes of implementation of technologies "Industry 4.0" based on the products of educational production. The main attention is paid to solving the problem of implementing the main stages of knowledge transfer and the integration of participants in this process.

1. Introduction
The idea of switching to fully automated digital manufacturing (Industrie 4.0) was first announced in 2011. within the framework of the state Hi-Tech Strategy of Germany, causing further great interest in its development in a number of countries. Currently, one of the main areas of work of state authorities is the implementation of a set of measures that provide for the further development of information technologies and the digital economy.

At the same time, one of the factors that form the priorities of strategic decisions of any state in the development of the information space is the digital transformation of education [1,2].

The importance of the development of the education system in the country as one of the key factors of economic growth should be emphasized. Countries that give priority to the knowledge economy show a steady pace of economic development, so the problem of digitalization of education is becoming more urgent every year.

Understanding when, where, and why machines, platforms, and crowds benefit is the key to success in today's economy [7].

In Russia, over the past twenty years, much attention has been paid to the digitalization of both the educational process itself and its management. However, the question remains as to how much digital education corresponds to the development of the real digital economy and how to improve the quality of the educational process by using the opportunities of the digital economy.

The study was conducted on the basis of collection and generalization (synthesis method), systematization (systemic method) and comparative analysis (complex and comparative analytical...
methods) of data obtained from official information resources, other sources of information, including regulatory legal acts, interpretation materials legal acts (formal legal method), analysis of practice, taking into account the systematization of the processes of introducing Industry 4.0 technologies based on the products of educational production (mental approach to modeling).

1.1. Analysis of the readiness of higher education in Russia for the development of the digital economy

Digitalization has made it possible to move to a new quality level of management in the sector of the real economy, providing the ability to use systems that allow tracking information necessary for the management process online, facilitating interaction between enterprises. The range of functions that are solved with the help of information systems is expanding. The result of using the Industry 4.0 concept is increased productivity, optimization of business processes, and reduced time to market. Transparency of the value creation process is achieved by controlling all stages of adding value to a product from the moment of its creation to the moment of delivery to the consumer.

Decree of the President of the Russian Federation No. 203 of May 9, 2017 approved The "Strategy for the development of the information society of the Russian Federation for 2017-2030", which defines the digital economy as follows: "The digital economy is an economic activity in which the key factor of production is data in digital form, processing large volumes and using the results of analysis of which, compared to traditional forms of management, can significantly increase the efficiency of various types of production, technologies, equipment, storage, sale, delivery of goods and services» [1].

In accordance with the decree of the Government of the Russian Federation of March 2, 2019 No. 234 "Management system for the implementation of the National Program" Digital Economy of the Russian Federation ", the costs of performing work on the development of digitalization by organizations' own resources, regardless of the source of funding for the GDP deflator by 2024. should be 5.1%, against the base value - 1.7% (Fig. 1).

![Figure 1](image_url)

**Figure 1.** The costs of performing work on the development of digitalization by organizations' own forces regardless of the source of funding for the GDP deflator, % [4].

The decree also stipulates that by the end of 2023, all state universities are required to implement elements of the "Digital University" model, and by the end of 2024, 120 thousand people can be accepted to higher education programs in the field of information technology and 10 million people can be trained in online programs for the development of digital literacy [3]. Thus, according to a systematic study of the Russian online education market conducted by Netologiya-group, with the participation of the Higher School of Economics, FRII, FOM, comScore and East-West Digital News, the volume of the online education market in Russia will grow to 53.3 billion rubles by 2021, which shows more than a twofold increase compared to 2016 [10].
Researchers believe that digitalization should be understood not only as the translation of information into digital form, but as a complex solution of infrastructure, management, behavioral, and cultural nature.

Then, within the framework of this approach, digital education appears as a process of organizing interaction between teachers and students when moving from goal to result in a digital educational environment, the main means of which are digital technologies, digital tools and digital traces as the results of educational and professional activities in a digital format [11, p.30].

Digital tools can be represented by software products for managing the educational process, organizing the educational process, presenting educational material, recording professional actions, and recording achievements in a digital format.

Digital traces – all actions of students in the Internet space, left as print, including presentations, blogs, discussions in various formats in the distance learning system (DLS), video facts, etc.

Thus, we can conclude that the main system-forming components of digital education are: digital educational environment, digital processes of educational process organization, digital processes of knowledge verification, digital technologies of training organization, digital content, digital technologies of interaction, digital resources [11, 12, 13,14].

In addition, it should be borne in mind that an important component of the organization of the educational process in digital education is the digital educational environment as part of the electronic information and educational environment, the content and conditions of operation of which are also determined by the regulatory framework of state and industry significance.

The main problems of digitalization of education include the desire to imitate full-time education, poor quality control of educational products, low interactivity, simplification of competencies, problems of socialization and transfer of implicit knowledge [12, p. 3].

As for the prospects for the digitalization of education, they allow solving the problems of education accessibility, expanding the choice of the form of education, and increasing the variety of tools for transferring knowledge. In addition, digitalization will inevitably lead to the transformation of the educational services market. The main players will be leading universities (generation of new knowledge, development of fundamentally new educational products, training of scientific personnel); companies - manufacturers of electronic educational products and global educational platforms (broadcasting of finished educational products to the consumer).

Thus, the practice of reforming the modern system of national education indicates the need to improve the quality of strategic planning of the educational process at all levels.

It is necessary to solve two tasks: building a socially-oriented market economy in the Russian Federation and the transition to a post-industrial innovative development path [5, p.287].

Indeed, the experience of previous years has shown that it was precisely the lack of the necessary state support that was a constraining factor in the development of the system.

For example, the data in Table 1 show that in the period from 2014. to 2018 the dynamics of spending on research and development in priority areas of development of science, technology and technology, carried out by organizations' own efforts, regardless of the source of funding, has a downward trend, although there are some minor fluctuations in the nanotechnology and life sciences industries. It is obvious the solution to the alignment problem involves a wide range of issues, including those determining the investment attractiveness of the direction.
Table 1. Expenditures on research and development projects, carried out on their own by organizations, regardless of the source of funding (% to the previous year) [5].

|                                                                                           | 2014  | 2015  | 2016  | 2017  | 2018  |
|-------------------------------------------------------------------------------------------|-------|-------|-------|-------|-------|
| Total expenditure, including:                                                             | 117,16| 109,00| 106,79| 107,27| 99,84 |
| technological systems of the information and telecommunication network                   | 117,66| 105,56| 104,53| 104,44| 93,52 |
| nanotechnologies                                                                          | 130,22| 104,35| 101,98|  86,30|113,61 |
| life science                                                                              | 122,40| 120,87| 111,28| 106,18|119,70 |
| nature management and resource conservation                                               | 122,58| 113,70| 111,48| 107,66| 94,01 |
| energy and resource conservation, nuclear energy                                          | 110,01| 102,60| 114,31| 105,19| 96,33 |
| transport and space technologies                                                          | 111,36| 106,17|  98,51|112,61| 93,66 |

In the coming decades, the most important link between innovations and opportunities, education, will also be transformed [8].

First of all, this applies to economic education. In a rapidly changing external environment, organizations survive and lead, staying ahead of their competitors in the field of product, technological and organizational innovation.

In the foreign practice of economic education, initially formed in market conditions, traditionally the main attention was paid to the activation of the educational process and its approximation to the conditions of the future professional activity of graduates, which was expressed in the competence-based approach, which is also used in Russian federal educational standards [2].

The educational process should be aimed at the model of the future and, in view of this postulate, should initially be considered a prerequisite for the introduction of Industry 4.0 technologies into the practice of enterprises and organizations. Analysis shows that there is already some experience of interaction. So, for example, for the period from 2014 to 2018 there is a tendency of an increase in the number of educational organizations that have carried out research and development under the Industry 4.0 program by 30.63% (Fig. 2).
Figure 2. Participants of the industry 4.0 program, by type of organizations (units) [5].

The level of training of a specialist in the field of economics and enterprise management is assessed by his ability to quickly analyze economic situations and make management decisions, which requires mastering the skills of orientation in the digital space, working with large amounts of information, and developing situational thinking skills in students.

At this stage of development, it is already possible to speak about the formation of an information environment for the habitation and life of people and the creation of an information society [6, p.11]. The digital economy has become the basis for the transition to a qualitatively new level of information and analytical support of the management process, significantly increasing the efficiency and efficiency of this process [10, 14]. Integration of digital technologies into business processes allows you to differ from competitors, bring products to foreign markets, optimize processes, and reduce costs. A wide range of opportunities provided by the digital economy made it possible to move from the point use of specialized software products to the creation and distribution of multipurpose BI-platforms (Business Intelligence), integrated with the Internet [5, p. 24].

The digitalization of the Russian economy can become an important source of long-term economic growth. According to the Digital McKinsey expert group, contained in the report “Digital Russia: New Reality” for July 2017, the digitalization of the Russian economy will lead to a GDP growth of 4.1 - 8.9 trillion rubles. by 2025, which will amount to 19 - 34% of the total increase in GDP [1, 8].

In the framework of the national program "Digital economy" created projects aimed at the digital development, the use of digital technologies to improve the quality of life and conditions of doing business [3]. The relevance of digital transformation increases interest in the problems arising in the course of this process, the most important of which is the need for investment in staff development and training. Digitalization leads to a change in the quantity and quality of labor, requires workers to develop new thinking, adapted to digital reality.

1.2. Modeling the processes of introducing Industry 4.0 technologies based on educational products
In the course of the study, an analysis of approaches to the systematization of the processes of introducing Industry 4.0 technologies based on educational production products was carried out, which made it possible to outline a modeling scheme based on a mental approach (Fig. 3).
The main trend in the development of the digital age is to increase the efficiency of the production sector through consistent digital integration and intensification of processes.

This integration takes place in three directions: on the horizontal axis for participants in the entire value chain [2, 18], both end-to-end integration of production processes across the entire structure of the business model, and on the vertical axis for all organizational levels of the internal production chain [3].

The introduction of Industry 4.0 technologies into the activities of enterprises is a complex problem that requires a strategically sound decision, large investments, culture change, new skills and competencies. However, modern enterprises are changing their traditional business model and are rebuilding their processes to meet current requirements and trends [17, 19, 21, 22]. In the spring of 2017,
the Industrie 4.0 Maturity Center, part of the German Academy of Sciences and engineering acatech, presented the results of the "industry 4.0 Maturity Index" study.

The maturity index characterizes the readiness of enterprises to move to the level of industrial development that corresponds to the ideas of "Industry 4.0".

To assess the compliance of enterprises with the requirements of Industrie 4.0, acatech, together with partner companies, developed a methodology and an indicator called the maturity index (Maturity Index). Both are described in detail in the document «Industrie 4.0 Maturity Index. Managing the Digital Transformation of Companies» [20].

The index allows you to judge at what stage the company is currently moving towards the desired state that meets the requirements of Industrie 4.0. Namely, the state of a fast-growing, dynamic and adaptable company.

Each company has a path to Industrie 4.0 it may be different, but in general they must go through a number of steps [20].

1. Computerisation.
   The goal of the computerisation stage is to provide digital control tools for all major production components and upgrade outdated equipment.

2. Connectivity.
   Networking involves combining isolated technologies into a common environment that meets the company's business requirements. Usually a Protocol connection is used for this purpose Internet Protocol (IP), forming at the same time Internet of Things. Network interaction allows you to combine CAD/CAM automatic design and production procedures with Manufacturing Execution System (MES) process control tools, organize remote maintenance, and so on. If you improve not new, but workable equipment, it can also be included in the interaction.

3. Visibility.
   Visibility creates a digital representation or virtual counterpart of the enterprise. Falling prices for sensors and other digital equipment make this possible. The more sensors, the more accurate the display. The presence of a display associated with PLM, ERP, and MES systems allows managers to see the real-time picture of the enterprise and make the necessary decisions. The problems at this stage are not so much technical, but rather the complexity of ensuring that reliable data is collected, namely, in some cases there is no single source of truth or it is not possible to collect data without human intervention.

4. Transparency.
   Transparency in this context refers to the connection of digital display with analytical systems, more commonly known as big data systems. Here we have to solve the classic problem of extracting knowledge from data.

5. Predictive capacity.
   Predictive analytics technologies adapted to production can be used for forecasting.

6. Adaptability.
   Adaptability, as the ability to predict, opens up the possibility of automating functions related to business adaptation to changing external conditions.

As you progress through all six stages of digital transformation and increase digital maturity, training for smart manufacturing is as important as technology and production organization.

It is necessary to create a professional atmosphere that will enable the benefits of Industrie 4.0 to be realized. It consists mainly of readiness for changes based on knowledge, openness to innovations, constant professional growth [13, 16, 18, 19, 24, 23].

Thus, at the present stage of the implementation of Industry 4.0 technologies in the activities of enterprises, special attention should be paid to the field of education, which prepares personnel for the practical application of the principles and concepts of intellectual production management [6, 7].

In favor of this argument, it should be emphasized that over the past decade, special attention has been paid to training programs based on the topic of lean manufacturing [5]. It should be noted that current and future scenarios of production development in the context of the fourth industrial
revolution also require the formation of other competencies that will allow managers and employees of organizations to cope with the problems of the growing digital production system. Therefore, the curricula and programs of educational institutions should include disciplines that form an innovative educational space and influence the formation of relevant competencies, and involve students in research work [15]. As a result, trends and trends in the development of industry 4.0 suggest the development of conceptually new directions in the development of education, which directly affects the effectiveness of organizations. The key characteristics of education are the knowledge, experience, and skills that organizations need to achieve their goals in a competitive environment.

Thus, in modern conditions, we can speak of a high level of the educational process only if it aims students to be fluent in the knowledge and tools of the digital economy for smart production. In the context of solving this problem, a number of areas can be identified.

First, the transformation into a new digital space involves the implementation of the concept of lifelong learning, which will allow each person to realize their competencies to work in modifying digital processes.

The second direction of improving the level of the educational process in the conditions of digitalization of the economy is to strengthen the block of disciplines based on the use of information technologies in the economy. It is obvious that a graduate of an economic university must have the latest software products in the field of their future profession, for example, such as CRM Bitrix 24 and others[15].

The third direction of free acquisition of knowledge and tools of the digital economy can be the widespread use of distance and online educational programs. However, in some cases, there are still reasons that hinder the transfer of knowledge.

2. Conclusions
Transfer can take various forms, for example, from the transfer of knowledge through individual private projects to individual national programs implemented at different levels of government.

In the process of implementing the main stages of knowledge transfer (initiation, movement, integration), difficulties may arise in transferring knowledge from the individual to the collective level, due to distortion or possible loss of some of the knowledge.

In such conditions, it is necessary to maintain the stability of partnership relations. In this case, it is advisable to:
• providing information to all interested persons about national programs and opportunities to complete training in General education and additional General education programs in the framework of the target orientation;
• support for knowledge transfer by public-private partnerships;
• organization of external knowledge transfer;
• increased attention to vocational training and orientation programmes for young people;
• provide flexibility in making employment decisions at the local level;
• strengthening civil society control over the targeted spending of budget funds allocated for the implementation of national programs, etc.

In conclusion, the core of integration should be a structured process of the knowledge economy, the purpose of which is to develop in detail the strategy of educational systems of different levels and profiles and determine the areas of responsibility and functions in the course of practical implementation of this strategy.

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