

# EVALUATION AND SUGGESTIONS FOR IMPROVING THE SYSTEM OF TRAINING AND EDUCATION OF INDUSTRIAL PERSONNEL ON THE BASIS OF FOREIGN EXPERIENCE

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**Abstract.** *The paper deals with the concept and essence of the concept "Industry 4.0", characterized by the digitalization of all economic activities, and its significance and components are shown. The aim of the research study is to assess the existing system of education of engineering personnel and develop proposals for its improvement in the conditions of the fourth industrial revolution. Methods of empirical and theoretical research, including SWOT analysis, are used. With a SWOT-analysis the positive and negative aspects, as well as the opportunities and threats of implementing this concept in the economic life of Russia are estimated. The priority directions of formation information infrastructure of the digital economy are given. The components of the quality of educational services are identified. The experience of foreign countries shows that digital technologies will lead to transformations in the labour market, a new model of labour and employment "Work 4.0" will be distributed, within which a new type of labour activity will be developed, called an on-demand economy etc. New requirements of employers for training of personnel for industrial enterprises are particularly considered.*

**Keywords:** *competences, digital technologies, "Industry 4.0" concept, system of education.*

## Introduction

The modern world is undergoing a profound digital transformation. The Internet of Things, that is, the connection of all kinds of devices, objects and sensors online turns into a giant, powerful and hypersensitive "superorganism" that can monitor, inform, manage operations and take measures in real time without active participation of individuals, in addition, creating unprecedented amount of data. Within the framework of the Industry 4.0 concept, various sensors, equipment, products in production and information systems will be

integrated within the production chain that extends beyond one enterprise. These interconnected complexes, the so-called cyber-physical systems, will interact with each other via the Internet on the basis of standard protocols, as well as independently collect and analyse data to predict failures, independently adjust and adapt to changes in the external environment. This in turn will increase productivity, give impetus to the development of the economy, promote industrial growth, and also change the requirements for the professional skills of the company's personnel, which, ultimately, will increase the competitiveness of companies and regions. The aim of the research study is to assess the existing system of education of engineering personnel and develop proposals for its improvement in the conditions of the fourth industrial revolution. Methods of empirical and theoretical research, including SWOT analysis, are used.

### **Methodology and literature review**

The object of the research is the relationship between universities and employers in the process of transition to a new system of training and retraining of personnel. The subject of the research is the improvement of the system of training and education of personnel of industrial enterprises in the conditions of digital transformation. This problem is investigated in the works of many authors Barkalov S., Burkov V., Burkova I. (Burkov, Burkova, & Barkalov, 2018), Davydova T. (Davydova & Barkalov, 2018), Negroponte N. (Negroponte, 2015), et al.

In the summer of 2017 in Russia, the programme "Digital Economy of the Russian Federation" was adopted. One of the sections of the programme deals specifically with human resources and education. It is obvious that the country's education system needs to be transformed and adapted to meet the needs of the new digital economy. By creating modern conditions for the development of human resources, the state seeks to minimize the risk of unemployment and to prevent the stratification of society in the medium and long term. Moreover, J.M. Keynes (Keynes, 2010) in 1930 said that labour and technology have long maintained close and mutually beneficial relations. Advances in machine learning, robotics and artificial intelligence will inevitably cause automation, changing demand for labour and the movement of labour. Statistics show that although technological changes have helped to increase labour productivity and gain economic growth and create jobs, at the same time, new technologies have replaced labour in many sectors and professions, leading to the displacement of jobs by sector, region or profession (Avdeeva, Averina, & Kochetova, 2018). According to the research of the Agency for Strategic Initiatives and the "Skolkovo", it is projected that by the year 2030, 57 traditional occupations will

disappear and 186 new ones will appear, 19% of all workers can be replaced by robots (Sheenko & Stasevich, 2017).

K. Schwab, President of the World Economic Forum in Davos, notes that in terms of scale, scope and complexity, the fourth industrial revolution has no analogues in the entire previous experience of mankind (Schwab, 2016). In the next 20 years, up to 50% of working operations in the world could be automated. In 2015 the volume of the digital economy of Russia was estimated at 3.2 trillion rubles, which corresponds to 3.9% of GDP, and by 2025, according to forecasts of the company McKinsey, it will grow to 9.6 trillion rubles and will be 8-10% of GDP (McKinsey & Company, 2017).

The index of adaptation of Russian industry, which reached a historical maximum (74 points) in 2016, indicates that its financial and economic position is evaluated in the best way, that is, 82% of them are in good or satisfactory condition. While the percentage of positive assessments of the financial and economic situation for the period 2008-2009 did not rise above the level of 56 points. It can be assumed that Russian industry today is stable and has the potential for development, increasing production capacity and carrying out production modernization. The latter is a priority task both at the level of an individual enterprise to ensure its own competitiveness and at the state level for the implementation of the policy of import substitution. It should be noted that today industrial enterprises do not experience an acute shortage of personnel, as it was during previous crises. Three quarters of Russian industry, according to surveys, have enough employees to maintain the current output. This is evidenced by the indicator of staffing, which decreased in 2016 by only 5 percentage points up to 75%. At the same time, its previous value of 80% is considered to be the absolute maximum for the whole period (1996-2016) of observations on the supply of Russian industry with personnel (Ministry of Economic Development of the Russian Federation, 2016). For comparison, for example, in 1996 this indicator fell to 51%, and in 2009 - to 59%. However, according to monitoring data, industrial enterprises rarely chose the answer "more than enough" in the process of research in terms of staffing (no more than 12% in the current crisis). This could mean that in the case of the beginning of sustainable growth of Russian industry, it will be difficult to attract the necessary additional labour. This assumption is confirmed by the fact that more often as anti-recessionary measures enterprises use wage reduction, transfer to part-time employment, the introduction of unpaid leave instead of dismissal of employees (Averina & Avdeeva, 2013). That is, the management of industrial enterprises tries to treat workers, which are becoming fewer and fewer, extremely carefully. The difficulty in attracting new workers to the industry can be recognized by several reasons: 1) an inefficient system of secondary specialized education; 2) the decline in the popularity of technical specialties

among the younger generation in higher education. Let us take a closer look at each of them.

The modern system of secondary vocational education is not able to provide the necessary number of qualified personnel for industrial enterprises. The reasons for this lie both in the unsatisfactory state of the material and technical base of secondary special educational institutions, the low salaries of teachers, the residual principle of financing, and in lowering the social status of graduates of institutions of secondary vocational education. According to the results of the research conducted at the Higher School of Economics, the overwhelming majority of graduates consider it necessary for them to obtain a higher education - only 4.8% are satisfied with their secondary vocational or secondary general education. Also indicative is the statistics of the intentions of students on vocational education programmes to continue their education (Gokhberg, Zabaturina, & Kovaleva, 2016).

The situation in the sphere of higher education is not encouraging either. Over the last ten years, the Russian labour market has experienced overproduction of humanitarian specialists.

The loss of a whole generation of skilled engineers in the 1990s disrupted the cycle of the reproduction of labour in industry. That is, the older generation of workers who are now over the age of fifty, could not pass on their experience and knowledge to the younger, resulting in a qualification gap. This situation was also affected by the general shortage of workers of middle and young age associated with the demographic pitfall that arose when a small generation of the early 1990s came to replace the generation of "explosive fertility" of the 1950s. As a result, many industrial enterprises are faced with the problem of aging personnel, when valuable specialists are about to retire, and the labour market in return offers very young and lacking experience and knowledge candidates who do not like the employer (Gokhberg et al., 2016).

### **Research results**

The newest digital technologies that are part of the digital infrastructure of the new economy are (Morozov & Morozova, 2018):

- Big data technologies and business analytics (Big Data) allow optimizing the quality of products, save energy and improve the efficiency of equipment;
- Blockchain technologies, in the form of a data bank, where information is stored in separate blocks, which is very convenient for fixing financial transactions;

- Internet of Things (ItoT), more and more devices will be equipped with computing power and standard network protocols, and the equipment will independently process data, interact with one another at the grassroots level and only if necessary provide access to a centralized control system;
- Neural networks (artificial intelligence), today robots increasingly become functionally independent, flexible and executive compared with their predecessors. Over time they will begin to interact with one another and not only to work quietly side by side with the person but also to learn. In the future, such robots will cost less, but have greater capabilities;
- Virtual and Augmented Reality technologies will be used to provide employees with up-to-date information, help in making decisions in real time and performing various tasks.

For example, it will be possible to obtain instructions how to replace a part in a faulty system directly at the time of its inspection with the aid of glasses of augmented reality;

- 3D modelling of objects, materials and production processes is widely used at the stage of new product development. In the future, this technology will be widely used in the production process, which will allow using real-time data in real time to represent the physical world in the form of a virtual model that includes equipment, products in production and personnel of the enterprise;
- Cloud technology, over time the quality of cloud storage technology will improve, and the response time will be reduced to milliseconds, and even the work of production control systems in the future will be based on cloud technologies;
- Intelligent sensors, the criteria for cyber security are secure access, reliable communication, as well as careful control of access of equipment and users to control networks (Gokhberg et al., 2016) etc.

Our analysis of the strengths and weaknesses of the Industry 4.0 concept is presented in Table 1.

*Table 1 SWOT analysis matrix of the Industry 4.0 concept (compiled by the authors)*

<b>Strengths</b>	<b>Weakness</b>
Political weight, determined by the number of industrial projects in the field of international cooperation and the pace of the industrial revolution Industrial growth, the highest level of business activity, economic development Innovation-information, technological, scientific and educational potential National and world scale of the markets of industrial goods and stock markets Formation of large financial structures Emergence of a large number of paid jobs for new areas and specialties Active information exchange Highly developed information and communication infrastructure High intellectual and cultural level in the field of science and technology, production of unique products in small series Reduction of the cost of works and stocks Improving the level and quality of life in the country	High concentration of capital at enterprises manufacturing high-tech products Limitation of highly skilled workers and capital Very high cost of technology and equipment, their accessibility for large enterprises and state High cost of monitoring and control of a fully integrated and optimized process flow
<b>Opportunities</b>	<b>Threats</b>
Use in the industrial production of digital modelling, autonomous robots, industrial Internet of things, additive production, cloud technologies, augmented reality systems, information security of major industrial systems, etc.	Imperfect system of training and education of the personnel of industrial enterprises Lack of the necessary number of specialists in the field of digital technologies Risks related to the quality, safety of processing and transmission of digital information High cost of transition of industrial enterprises to digital technologies

Our analysis shows the absolute expediency and necessity of the transition of the economy to the concept of Industry 4.0. The result will be industrial growth, economic development, production of competitive products, a transition to a higher standard of living, and an increase in its quality. Due to the limited labour and capital resources, industry has just started to explore the possibilities of new technologies, for example, the aerospace industry. Weaknesses and threats should be taken into account by the state and through the adoption of a number of programmes within the framework of Industry 4.0 concept to stimulate its implementation in certain industries and territories.

To search for possible solutions to the personnel problems of modern Russian industry, one should turn to foreign experience. Consider the specifics of the German vocational education system, thanks to which the country maintains the lowest (after Japan) unemployment rates among the entire population in general, and among young people in particular.

In Germany, the percentage of the population who received an average professional level of education is one of the highest in Europe. Among people aged 25 to 64, it reaches 86%, and 95% of graduates of major schools and gymnasiums plan to graduate from secondary vocational education institutions. More than 50% of the students in the group in question choose a dual training system. Thanks to this system, as many analysts note, Germany had low unemployment among young people even during the crisis of 2005-2009 (OECD, 2014).

A dual system or vocational programme has a strong emphasis on practical training in real working conditions. Training is characterized by an alternation of theoretical and practical blocks lasting one to two weeks, or by allocating a certain number of hours per week for a theoretical and practical course. In both cases, students spend more time working in the partner company in a position appropriate to the profession being studied. Young people get the opportunity to immediately apply the theoretical material studied in practice. In order to be trained under a dual system, a student must conclude an agreement with a partner company, under which the organization pays for his education, provides a place for internship during the whole period (2.5 to 3 years) and pays a scholarship. For his part, at the end of the training course, the graduate undertakes to work out the agreed term in this organization. Training is conducted both on the basis of medium-sized enterprises, and in large concerns. So, for example, you can get average professional training under a dual system from such giants as Volkswagen, REWE, SIEMENS, BMW, etc. Enterprises benefit from the dual system of professional education, as they get qualified young professionals with real knowledge and skills adapted to the firm's requirements, which means that the organization will not have to bear additional costs for the adaptation of new personnel. Most often the dual system is chosen for training in working professions, occupations from the spheres of industry, finance, IT and trade, as well as the social sphere. The dual system is implemented not only in secondary vocational education programmes but also in higher education programmes. About 15% of graduates of gymnasiums and institutions of secondary vocational education in Germany decide to get higher education, 46% of them choose programmes with a practical bias. Consequently, enterprises also have the opportunity to meet the demand for highly skilled personnel by concluding agreements under a dual system. The relative unpopularity of higher education in Germany is conditioned by the fact that

there is enough (and even more welcome) secondary vocational education for successful employment, so graduates do not see the point of spending time on obtaining a bachelor's degree, or the complexity of admission and training. According to statistical data, only 37% of the total number of students enrolled in institutions of higher education graduate (OECD, 2014).

The development of the digital service economy will radically change the labour market and affect all spheres of activity. First of all, the new model of work and employment "Work 4.0" will be distributed, within the framework of which a new type of labour activity, called an on-demand economy, crowdsourcing, etc. will develop. In addition, the level of staff mobility will increase, the technology of off-site work will expand, first of all it will concern the sphere of service and tourist services. The development of information and communication technologies will promote the spread of cross-border (remote) employment.

Due to the fact that the digital economy is based on the ideology of processing large amounts of information, the digital competence of personnel, security, reliability, long-term storage of large amounts of information will be of special importance (Averina & Lavrova, 2018). At enterprises in the sphere of information and communication technologies the share of employees with higher education reaches 74%, which confirms the need for the formation of information and communication skills of personnel for work in the digital economy (Sizova & Khusyainov, 2017). The high processability of all processes in the digital service economy will require the constant improvement of the skills of the personnel, so that the so-called lifelong learning will be in demand. Continuing education and self-development are necessary to maintain high skills of the staff, update knowledge in connection with the acceleration of scientific and technological progress, ensure the competitiveness of staff and advancement on the career ladder. All this acquires special significance and relevance in the conditions of a digital service economy.

In the conditions of a rapid change and in the concepts of scientific and technological progress, the role of masters, superintendents, production managers and other managers of the lower level will change. The results of interviewing superintendents and managers from multinational firms in the UK have shown that they need to replenish their knowledge in the field of electronics and the latest technological processes. Special difficulties arise for managers of the lower level when the equipment fails, when it is difficult for them to understand the causes of the breakdown or deviation of the operation modes of the equipment from the design parameters. Top managers expect from them not only the localization of technical problems and the search for solutions but also the prompt resolution of personnel management problems, first of all, the establishment of mutual understanding and high motivation of employees,



ensuring high labour productivity and high quality of products. All this significantly expands the scope of activity of the lower management personnel, which, in the face of growing competition, plays a key role in reducing the cost of production and increasing the output of high-quality products. There is an increase in the creative side of this staff, weakening control over the actions of qualified professionals, increasing the importance of informal working relationships, organizing mutual assistance and improving skills in diagnosing problems and solving them.

These and other problems of the development of modern management put forward the task of radically updating the concept of vocational training and continuous upgrading of managers at all levels. For example, the Western press reports the results of two studies conducted in the UK, aimed at studying the most important areas of training and skills development for managers of the future. It is noted that now universities, polytechnic universities and colleges of higher education with postgraduate courses give additional knowledge and skills to managers with some experience. In addition, there are private centres and commercial courses for managers and management consultants organizing various courses, seminars and conferences. To this, special courses of continuous management education are added at professional (technical, humanitarian) universities. Among the methods of teaching, modelling, role plays, seminars-conferences etc. are promising, while traditional lectures and discussions take up less and less place in the training courses (McKinsey & Company, 2017). In the future, managers will have to pay more attention to assessing external influences on the organization, integrating the main activity with side effects, employees to strengthen their leading role in all aspects and at all levels of functioning, to be able to inspire workers and mobilize their energy for common tasks.

### **Conclusions and proposals**

Based on the foregoing, it can be concluded that in order for the vocational education system in Russia to produce equivalent results, it is necessary to seriously reform it from the state, but, as it is known, in the near future, in addition to increasing the number of state-funded study places for technical specialties, no major changes are planned. Therefore, Russian industrial organizations should independently start solving problems with a shortage of qualified personnel.

The tasks of improving the system of training and education of personnel in the context of the spread of the concept Industry 4.0:

1. To develop and implement an adequate system of professional competencies as to which basic skills in computer and information

technology are necessary for all professions. It should be flexible: include elements that allow it to modernize and adapt itself; applied practical courses should be based on general digital literacy.

2. To develop and implement a system of constant retraining of teachers. The levels of professional and higher education need to be closely integrated with the leading market companies, which should tell the teachers what skills and competencies they need, as well as provide internship options and feedback on the quality of training. Universities in the regions should serve as a kind of conduit for the transmission of new trends in education in the digital age.
3. To develop and implement new programmes of professional development, as well as mechanisms for assessing their effectiveness. Development of new services that allow people to create their own professional development programmes. New opportunities for professional development and retraining, so that people can acquire new competencies that meet the requirements of the new digital economy. A special emphasis will be placed on overcoming digital illiteracy among the older generation.

Nowadays, a graduate of a competitive university is a specialist performing professional activities at the highest level, deliberately changing and developing him/herself in the labour process, adding a personal creative contribution to the profession that has found a personal purpose that perfectly concentrates the creative activity in the team in the criteria of extreme external action, stimulating in the community enthusiasm for the results of their own professional activities (Averina, Avdeeva, & Perevalova, 2018).

To train people with higher education in positions requiring a high level of qualifications, it is necessary to provide for more theoretical studies. Sufficient theoretical training can be provided both through the programmes of a partner educational institution and at a corporate university. The creation of a corporate university, which, of course, is only available to enterprises with a significant amount of financial resources, will help educate highly qualified specialists in areas relevant to the organization.

In the considered system of training, the experience of the German dual system is used. Namely, the alternation of theoretical and practical exercises is used, with an emphasis on the latter; mentors are involved; practical classes are conducted in real working conditions; a reward depends on the results of the student. In order to avoid a large staff turnover and professional staff stagnation in the future, the development programme for employees (higher education, advanced training and retraining) is added to the proposed system, which is especially important in cases where the employee has only a secondary education. For example, a bachelor's or master's degree programme can be

conducted in absentia for further promotion to a management position, or corporate training programmes are provided to change activities. In general, the stages of the unification of the Russian system of higher education can be represented as follows.

First, to increase the level of "humanitarization" of engineering professions by introducing changes in the curricula of both universities and retraining and advanced training systems for engineering workers. Specific knowledge quickly becomes obsolete. Students should receive skills of self-study and professional development in the course of their subsequent professional activities, and during their studies at the university, the main attention is paid to the study of general theoretical disciplines that develop and systematize independent thinking. The experience of higher schools in a number of countries shows that at least 20% of the time in the curricula of technical universities should be given to public disciplines, primarily Economics, Ecology, Sociology, Psychology, which is necessary for the preparation of fully developed engineers who can work with people and are ready to occupy leading positions in the business world.

Secondly, universities should teach students to work in a team, make joint decisions, be able to communicate with people, clearly state their thoughts. Training in the university should be carried out in groups, so that after graduating to work, graduates could work in integrated teams of engineers and researchers; requirements to engineers for mastering managerial knowledge are being strengthened.

Thirdly, each student needs management skills based on computer science and a foreign language. The development of the digital economy and industry 4.0 implies the expansion of international cooperation of engineering workers, their joint participation in the implementation of projects not only in European countries but also in other continents and intensification of international cooperation in the field of training engineers (exchange of students and teachers of technical universities, development of unified curricula). Selection of highly qualified teachers who could not only take into account the specifics of technical universities but also share the belief in the need for future engineers to study humanitarian subjects.

Fourth, paying attention to communication skills, i.e., teaching students the ability to effectively and correctly express their thoughts (both verbally and in writing) and listening skills (lecturer, interlocutor, etc.); conducting at least three times a year one-day seminars on various and often unexpected questions for students, the task of which is to stimulate creative opportunities and, more importantly, to awaken the students' desire for creativity and non-trivial thinking (in particular, to hold seminars on topics such as "Humanitarian Aspects of Business Activities", "Engineers and Artists", "Adoption of Optimal Solutions",

"Environmental Technology", "Engineering Ethics", "Engineering as a Culture Mirror", "Assessment of Risk Related Situations ", etc.).

Fifth, participation in contests and Olympiads reflecting the awareness of professional choice and the awareness of personal and public significance of professional activity, civic maturity, the potential of intellectual and creative abilities and readiness for its application, psychological preparedness for meeting with professional problems and creativity in extreme conditions .

When comparing foreign higher education systems, it is necessary to take into account the length of the previous period of study, for example, 13-14 years in Italy, the FRG, the Netherlands, the UK; an average of 12 years in Spain, France, Ireland, Portugal, etc. And the duration of the training course during the academic year: it varies from 900-1100 hours in higher engineering schools in France and Spain to 500-700 hours in other EU countries (Shchekin, 2002). A higher education system can be rigid, structured, or more liberal, allowing the student to change the minimum duration of training through intensive training.

### **Summary**

Our SWOT analysis shows the unconditional expediency and necessity of transition of the economy to the concept Industry 4.0. The result will be industrial growth, economic development, the production of competitive products and the transition to a higher standard of living, improving its quality. Due to the limited labour and capital resources, the industry has just started to master the possibilities of new technologies, for example, enterprises of the aerospace industry. Weaknesses and threats should be taken into account by the state and through the adoption of a number of programmes within the framework of the concept Industry 4.0, to stimulate its implementation in certain industries and territories. Obviously, the education system of country needs to be transformed and adapted to meet the needs of the new digital economy. The system of institutions of secondary vocational education is an inefficient source of renewal of personnel of industrial enterprises because, due to the loss of popularity among young people, problems with funding and the material and technical base, it produces fewer and fewer specialists, and their competencies often do not meet the requirements of the labour market. The experience of Germany has shown that among industrial organizations, there is an effective source of personnel attraction provided by the state education system. Due to the popularity of secondary vocational education, which develops from the opportunities that a student receives after graduation (guaranteed employment immediately after graduation, familiar working team and working conditions, decent wages), firms have the opportunity to replenish their staff with young employees with minimal inconvenience and as a result, they do not experience such problems with the reproduction of personnel that exist among Russian industrial enterprises. The stages of reforming the Russian educational system are proposed, which consist in the development and implementation of an adequate and flexible system of professional competences, a

system of continuous retraining of personnel, new programmes for the professional development of teachers and workers. Naturally, the priority should be given to the training of young engineering personnel.

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