The European Proceedings of
Social and Behavioural Sciences
EpSBS

www.europeanproceedings.com e-ISSN: 2357-1330

DOI: 10.15405/epsbs.2020.10.03.110

## ICEST 2020
### International Conference on Economic and Social Trends for Sustainability of Modern Society

# NETWORK FORM DEVELOPMENT TO IMPLEMENT LIFE-LONG EDUCATION

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## *Abstract*

In modern society, the tendency to an innovative economy transition, knowledge economy, is clearly manifested. This determines the demand for specialists who have a need and are ready to learn throughout their lives, and, accordingly, leads to the educational paradigm transformation. Currently, professional training is faced with the task of modernization in order to bring its substantive and procedural components into line with the observed trends in a changing economy and society. With regard to solving this problem, the authors used a systematic approach. Based on the identified contradictions in the training of personnel for high-tech areas of production, a system simulation of the network form for the continuing professional education (CPE) implementation has been carried out. The model is designed to identify the complex of organizational and pedagogical conditions necessary for the continuing professional education in the context of digitalization effective implementation. The study established and substantiated the integrative functions of the network form system of continuing professional education implementation, carried out in accordance with the developed model. Using concrete examples from the nano industry and mechanical engineering field, it is shown that the system functional qualities make it possible to put into practice the ideas of dual training, through which universities are given access to modern production technologies, software and hardware systems and commercial software, and enterprises are able to purposefully influence the educational programs content implemented by universities, use the personnel potential of universities for the modernization of production and innovative developments evaluation.



**Keywords:** Professional education, continuing education, continuing professional education implementation.

https://doi.org/10.15405/epsbs.2020.10.03.110
Corresponding Author: A. I. Nazarov
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

## 1. Introduction

The education sector has been and remains one of the most important effective factors in social development. However, the components of the educational process have not changed significantly over time. As before, training includes three main components - the transfer and receipt of educational information, educational and cognitive activities based on the knowledge gained and the monitoring of the achieved level of education (certification). Means and methods of training are traditionally associated with one or any combination of these components.

At present, there are mutually complementary education systems (Sokolova, 2017) and education models (Choi & Kim, 2018) that rely on various forms of knowledge representation and technical possibilities of their transmission: a book, online and offline e-learning courses, digital information educational environment, the Internet, social networks, etc. The emergence of such a variety of forms of representation and transfer of knowledge was associated with the most significant information revolutions in history, namely, the evolution of a language, writing, books printing, and in recent years - digital technology and the Internet. The qualitative changes that have taken place in the conditions of the society existence have led to a change in the typologies of people's consciousness and approaches to organizing the educational process both in terms of technologies developed specifically for teaching (Koretsky & Magana, 2019), and in terms of its methodology (Andreev et al., 2020). Distance learning has become increasingly common (Sharshov & Belova, 2018), and online learning is widely used as well (Volungeviciene et al., 2020).

Innovations in education are caused not only by information revolutions. In a modern dynamically developing society, cardinal changes occur in all spheres of human activity, in particular, in the economy (Golaydo, 2017). Production is becoming high-tech and knowledge intensive. New tools and technologies are rapidly emerging, developing and being introduced in mechanical engineering, robotics, nano industry, etc. The volume of new knowledge and the speed of their dissemination in society are constantly growing. Knowledge is increasingly moving into innovation. A new economy based on knowledge production is emerging (Davydova & Kudryavceva, 2017).

A significant role in the new economy is played by engineering education, which, by virtue of its essence, is focused on the innovative development of the manufacturing sector (Arkannikova & Kondin, 2019). To increase competitiveness, knowledge-based enterprises need employees who are able to conduct inventive activities based on the achievements of fundamental science, the results of applied research and the possibilities of breakthrough technologies.

In society, the ideas of open (Baygusheva et al., 2018) and continuing education (Romanova et al., 2019) have become more and more in demand. The knowledge economy needs professionals who are ready for lifelong learning, capable of self-education, able to constantly and successfully adapt to rapidly changing conditions and tasks.

Almost all the achievements in the manufacturing sector are based on the results of joint activities of scientists and practitioners from different corporations and countries. In this regard, the integration of educational and production activities in high-tech sectors of the economy becomes extremely necessary, and a variety of educational programs is designed to provide training for specialists, combining the interests of the individual, society, and the innovative economy (Hodgson et al., 2019; Nurutdinova, 2012). Thus,

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while preserving its essence, education is being transformed both with the aim of solving fundamentally new problems facing it, and with the aim of finding effective teaching methods and technologies.

## 2. Problem Statement

The state and society have set new goals for modern education, without which it is impossible to create and accelerate the development of an innovative economy (Order of the Government of the Russian Federation of December 8, 2011 No. 2227-r "Strategy of innovative development of the Russian Federation for the period up to 2020, 2012). Among the urgent tasks in the field of training for high-tech areas of the economy, we highlight the following:

- modernization of the training system for high-tech sectors of the economy, including by increasing the efficiency of the educational, scientific, and industrial facilities use, and the integration of theoretical and practice-oriented training;
- the formation of a creative personality that can adapt to rapidly changing conditions;
- creation of conditions for continuing professional education;
- organization of training, including internship, using the network form of educational programs implementation;
- incentive to learning and self-education throughout life, the implementation of the open education concept;
- implementation of the educational process using digital technologies and e-learning techniques;
- development of the intellectual potential of the territories.

The fulfilment of these tasks is hindered by a number of currently unresolved basic contradictions. These, in particular, include contradictions between the needs of the real sector of the economy and the qualification requirements (competencies) for graduates of professional education institutions; the need to create knowledge-based industries and a knowledge-based economy as well as the human resources of the regions; e-learning opportunities (Ershova & Nazarov, 2017), digital technologies and the scale of their practical implementation in education (Serditova & Belocerkovskii, 2020); technocratization and humanization of education (Shutaleva et al., 2019).

The search for specific ways to resolve these, as well as identifying other contradictions that are characteristic of professional education in the field of high technology, as well as ways to overcome them, are aimed at solving the problem of ensuring the quality and effectiveness of CPE.

## 3. Research Questions

The article discusses the characteristic contradictions that exist in modern professional education, and approaches to their resolution. Modelling of the network form system for the implementation of continuing professional education in the field of high technology is carried out, its integrative functions are considered.

The mechanisms of the practical realization of the system advantages from the point of view of solving the problems of concentration and consolidation of the higher education institutions resources and enterprises of knowledge-intensive industries; improving the quality of the educational environment; improving the content, methods and technologies of continuing professional education are studied.

## 4. Purpose of the Study

To develop and theoretically substantiate a model of a network form system for the implementation of continuing professional education, focused on knowledge-intensive areas of production. Demonstrate with specific examples from the field of nano industry and mechanical engineering fundamentally new system capabilities in terms of fulfilling the tasks of modernizing professional education, building a knowledge economy, developing human resources, human and social capital of territories.

## 5. Research Methods

### 5.1. Analysis of contradictions in the professional training system

Using scientific methods of analysis, systematization, classification and pedagogical experience study, we highlight the characteristic contradictions associated with the specifics of professional engineering education and consider possible approaches to their solution.

As contradictions of the mismatch arising from the interaction of the educational system with the economy, we highlight the following:

1) The contradiction between the tasks of a dynamically developing innovative economy and the content of training. The observed gap between education and knowledge-based production is manifested in the lag of the content of educational programs from the current state of science and technology (Konovalova, 2013). The elimination of this gap is possible on the basis of mutually beneficial integration carried out by universities and high-tech enterprises in the within the frame of the network form of implementing educational programs, creating a single educational space.

2) The contradiction between the need for creative development of the personality in the learning process and the educational process uniformity at the university, focused on the average level of knowledge and cognitive abilities of the student. To resolve this contradiction, it is necessary to find ways to enhance the interaction of subjects and objects of the educational process with enterprises of the economy real sector, and not only in the course of group, but also individual work aimed at the formation of independent, creative thinking.

3) The contradiction between the tasks of modern professional education and outdated educational technologies. In resolving this contradiction, the personnel potential of universities, proven methods of open learning, and the potential of scientific and educational centres can be useful.

4) The contradiction between the educational standards of higher education and professional standards (Dementev, 2018). Often, professional standards in the field of knowledge intensive technology do not contain descriptions of the professional activities types that are in demand in modern production. At the same time, professional competencies recommended by educational standards are weakly correlated with the labour functions specified in professional standards. The resolution of this contradiction is possible

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by ensuring regular systemic interaction between educational and scientific institutions with the structures of the real sector of the economy.

*The contradictions of consciousness* as internal contradictions of the educational system itself are caused by psychological difficulties in the perception of the new by the subjects of the learning process. That group includes:

1) The contradiction between the goals of higher education, focused on academic, fundamental science and professional competencies in demand in high-tech fields of production. The resolution of this contradiction can be facilitated by the variety of forms of organization of production practices, research activities of students, providing them with modern software and technological complexes of enterprises access, the opportunity to experience the value of acquired knowledge.

2) The contradiction between the nature of the educational process in a university and the approach to learning in a professional environment. The educational process in the university is largely theorized, and its practical part is not tied to technological solutions that are in demand in production. In enterprises, as a rule, the emphasis in training is on achieving a specific result of professional training, which is important for both the enterprise and the student. In this regard, students are in demand for a continuous increase in their educational level. This contradiction can be resolved by involving students in the implementation of projects relevant to science and production. Motivation can be increased by using the modular construction of educational programs and the inclusion of entrepreneurial content in them (Marge et al., 2014). At the same time, the practice-oriented or theoretical module selected by the student may not be included in the curriculum but provide for the development of the student's personal and professional qualities. In particular, upon graduation, he may be issued a diploma of continuing education or the acquisition of a working profession.

In the group of *contradictions of external conditions resources*, we distinguish the following:

1) The contradiction between the needs of enterprises and territories for highly qualified specialists and the resources of universities in the provision of educational services adequate to these needs. One of the options for resolving this contradiction is the development of joint educational programs by universities and their industrial partners (IP), the network form of implementing these programs, and the introduction of dual training (Listvin, 2016).

2) The contradiction between the target orientation on the development of research abilities of students and the insufficient range offered for the development of modern software and technological systems. It is possible to resolve this contradiction by organizing production practices in high-tech industries, involving students in the work of scientific and educational centres created on the basis of universities in partnership with private entrepreneurs, design bureaus, etc.

3) The contradiction between the regulated terms for the implementation of educational programs and the need for continuous training in knowledge intensive fields of production. To resolve the above characteristic contradictions as a whole, the authors used methods of systematization and modelling. The network form of CPE implementation can help here.

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### 5.2. Modelling the network form of continuing professional education

To find ways to resolve the above characteristic contradictions, the authors used systematization and modelling methods. Within the framework of a systematic approach, a model of a system for the network form of CPE implementation has been developed. When creating this model, we proceeded not only from the form of ownership and sphere of activity of individual institutions and enterprises, but to a greater extent from the functionality of the designed system in terms of solving the problems of professional education modernization in the field of high technology. In accordance with the structural-functional approach, the developed model is characterized from two sides:

- structural - formed from many interconnected elements that ensure the achievement of the goals and objectives of continuing professional education;
- functional - matching the integral properties of the designed system with the functions and relationships of its elements.

The construction of the model included the following steps:

1) the formation of the composition of the system basic structural elements and the definition of the corresponding functions;

2) determination of the relationship between structural elements;

3) formation of a model diagram;

4) determination of system functions as integral.

In accordance with the digital technologies capabilities and the professional education goals, the following are among the main elements of the system:

- objects of professional training in the field of knowledge intensive technology;
- subjects of educational activities carried out by universities and entrepreneurship in the frame of the network form of educational programs implementation;
- sources of educational, scientific, and technological information in the whole variety of forms and types of its presentation;
- digital technologies as a necessary means of learning and providing continuing education;
- a modern scientific and technological base as a means for practical training, testing of new technologies and knowledge intensive products;
- institutional structures created by participants in the network form of CPEs implementation as centres for the scientific and production activities organization;
- methodological complex based on the use of modern teaching aids and technological solutions.

Let us consider these elements in terms of their content and functions.

*Objects of professional training.* The objects in the simulated system are: students, teachers, researchers, engineers, and their joint productive activities in the field of knowledge intensive technologies. The practical implementation of the activity approach (Lopanova & Lalov, 2017), combined with the importance of the tasks to be solved, is the basis for the formation of professional competencies, the

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development of personal qualities and creative potential of students. This is decisive in the formation of a strategy for continuing professional education.

*The subjects of educational activity.* In connection with the practical orientation of the main educational programs implemented by universities in accordance with the requirements of FSES 3 ++, and the applied orientation of continuing education programs, the need for rapid changes in their content, the traditional functions of a teacher are fundamentally changed. In the simulated system, the faculty of universities, researchers, and engineers as subjects of educational activities perform a number of new functions:

1) personal mentors, consultants, assisting partners in expanding and mastering the students' independently acquired experience;

2) the initiators of creative innovative activity, which is based on the capabilities of new teaching aids and the production and technical base of enterprises;

3) by authors of digital educational resources and educational programs that are actively influencing the content of training;

4) intermediaries between students, the electronic educational environment, and modern technological and software solutions in the field of high-tech production;

5) the organizers of the discussions distributed in time and space in the subject area;

6) advisers in choosing the optimal learning path;

7) the organizers of the process of lifelong learning in all the diversity of its forms.

In the context of the professional training implementation in the field of knowledge intensive technologies, the role of the teacher as a carrier of professional experience and his personal qualities significantly increases. This necessarily requires continuous improvement and success in the professional sphere of all subjects of the system, so that their achievements represent a guideline for development for students. In contrast to the traditional approach, students are not only an object, but also a subject of the system, productively interacting with educational content, forming their educational route in the procedural and substantive aspects.

*Sources of educational, scientific, and technological information.* The source of knowledge in the model of the CPEs implementation network form, as well as in the model of traditional education, is educational and scientific publications, technical literature, personal and social experience. However, the forms of presentation of these sources and their complexity for educational purposes are significantly expanding and deepening. This is made possible thanks to the development of online educational modules (Nazarov & Sergeeva, 2016), new basic educational programs, further professional education programs, e-learning courses (Uziak et al., 2018), information databases of enterprises, etc. It is important that these sources of information are constantly updated, and access to them can be obtained at any time.

*Digital technologies as a necessary means of learning and providing continuing education.* The model under consideration expressively reveals the possibilities that digital technologies possess in methodological, didactic and organizational aspects. Let us analyse the main of these functions.

1) Ensuring accessibility and rapid dissemination of information resources. The opportunities offered by modern telecommunication technologies make it possible to organize training in various formats, including distance and online ones (Volungeviciene et al., 2020), at a level that meets modern requirements

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for the quality and effectiveness of professional education. Along with educational, information resources are becoming available that meet the current state of science and the innovative economy.

2) Technical support for the creating digital educational resources process. There is a wide variety of educational platforms (Coursera, EdX, etc.), e-learning platforms (Moodle, Blackboard, CourseLab, etc.), on which the development and implementation of online and offline courses is possible. At the same time, it is possible to organize training in any format: full-time or part-time study in undergraduate programs (Nazarov & Sergeeva, 2016), master's programs (Ershova & Nazarov, 2017), further professional education (Korshunov et al., 2019), independent professional development and etc.

3) Ensuring the joint activities of all participants in the educational process, separated by space and time. Thanks to dual training, in which, along with university teachers, subjects and objects of educational activity are employees of enterprises, it becomes possible to quickly adjust educational programs in accordance with rapidly changing conditions and learning objectives (Andreev et al., 2020).

4) Providing learning process flexible management. The formation of individual learning paths is of fundamental importance here. Differentiation of training is achieved through the use of a modern technological base of enterprises, integrated information and analytical systems, e-learning platforms. The optimization of the educational process is possible through the implementation of operational control (self-control) of knowledge and evaluation of the results achieved during training, including in automated or online modes.

5) Providing the ability to conduct a remote experiment, work with software systems available in scientific and production centres.

6) Providing opportunities for the formation and improvement of students' information culture, development of skills to evaluate the effectiveness and reliability of information obtained from various sources. The use of digital technologies helps to overcome the modern form of social inequality - information inequality, which allows each member of the society to get a professional education and find a job.

*Modern scientific and technological base.* The tasks of the knowledge-based economy determine the need to combine the personnel, technological and production potential of universities and enterprises. The key here is the development of their training and production base, carried out within the framework of the network form of CPEs implementation, the development and use of methods in which theoretical training and industrial training practice are tightly integrated.

*Institutional structures as centres for the scientific and production activities organization.* Such structures created by participants in the network form of CPE implementation are designed to provide organizationally and technologically advanced practice-oriented training and design and research activities in the field of knowledge intensive technology. These tasks can be performed by: scientific and educational centres; scientific and pedagogical schools; centres for knowledge intensive technology the development and testing; centres of students and teachers academic mobility; design centres, etc.

Institutional structures as a whole provide the following functions:

- the combination of advanced scientific research and educational programs;
- involvement of teachers and students in planning and design and innovation activity;

- organization of small-scale knowledge intensive production;
- training for the territories;
- creating conditions for ensuring continuing professional education;
- stimulation of universities and enterprises to organize joint educational activities;
- search for sources of joint educational activities financing etc.

*Methodological complex of CPE.* New forms and means of training predetermine the need to create an adequate methodological complex that ensures the following functions:

- methodological substantiation of the educational material content selection for various forms of its presentation in the educational programs training modules;
- methodological substantiation of the choice and ensuring the tools consistency for the digital educational resources design;
- providing guidelines on the use of digital educational resources for various forms of training and educational programs;
- methodological support for independent, educational, research and innovative activities of students;
- methodological support of practices at knowledge intensive enterprises;
- methodological substantiation of an individual educational trajectory and vocational guidance choice;
- assistance in the implementation of the advanced education concept, focused on living conditions and changes in professional activities;
- widespread use of digital technology in continuing education.

It should be emphasized that a complex of interconnected and mutually reinforcing methods, the functional properties of which as a whole make it possible to form a learning environment that is not limited to a specific university or enterprise is being spoken about.

### 5.3. The relationship between the structural elements of the model

We analyse the relationship between the elements of the model, which are based on the use of modern technologies, methods and teaching aids, human and scientific and technical potential of enterprises and educational institutions.

Firstly, the interconnection of institutional structures, the modern scientific and technological base as the necessary means of organizing and conducting practice-oriented training in the field of knowledge intensive technology and subjects of the educational process. Undoubtedly, the scientific and technological base of enterprises is a necessary element for conducting practices carried out by representatives of employers. But this function is significantly expanded by combining the efforts of individual entrepreneurs and universities. This, in particular, can be achieved through: joint operation and maintenance of educational equipment and technological resources; organization of basic departments at enterprises work; participation in dual training; joint participation in scientific, inventive and rationalization activities; the formation of joint design and scientific-educational centres with the involvement of students in their work;

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conducting an independent examination of the professional training quality of students both in universities and in enterprises; development of indicators and criteria for assessing the professional competence of students, etc.

Secondly, the relationship of sources of educational, scientific, and technical information, digital technologies with objects and subjects of the educational process. Both teachers and students are actively using digital technology as one of the main means of CPE. At the same time, with the help of digital technologies, the necessary completeness and breadth of the information provided is offered; efficiency in its exchange; communication of training subjects using tools of social networks and messenger applications (VKontakte, Instagram, Facebook, Viber, etc.), participation in thematic video conferences on Zoom, Trueconf platforms, etc .; differentiated access to information; individualization of learning paths.

Thirdly, the interconnection of digital technologies, the methodological CPE complex and learning objects. The methodological system provides the teacher and student with a set of methods, techniques and teaching aids that combines the best achievements of traditional academic and professional education, and innovative online and offline teaching methods based on the use of digital technologies. The possibility of accessing methodological complexes, for example, network educational modules (Nazarov & Sergeeva, 2016), makes the learning process meaningful, satisfying the tasks of practice-oriented preparation. The interactive nature of training allows to achieve a high degree of diagnostic of the knowledge, skills, and competencies level.

Continuity of professional education in this context means the possibility for subjects to choose a set of tools, techniques and activities that meet the goals of modern education, and the role of digital technology is to accompany variational training within the network form of CPE programs implementing.

### 5.4. System model of a network form for the continuing professional education implementation

The established interconnections made it possible to construct a structural diagram of a system model for a network form of CPE implementing in the field of high technology, which is shown in Figure 01. It is important that objects of professional activity are in interaction with all structural elements of the system and are its focus.

By the system of the network form of CPE implementation, we mean the set of actively interacting on a regular basis personnel, information-educational and production-technological resources, institutional structures, methodological and program-teaching tools aimed at achieving the continuing professional education goals.

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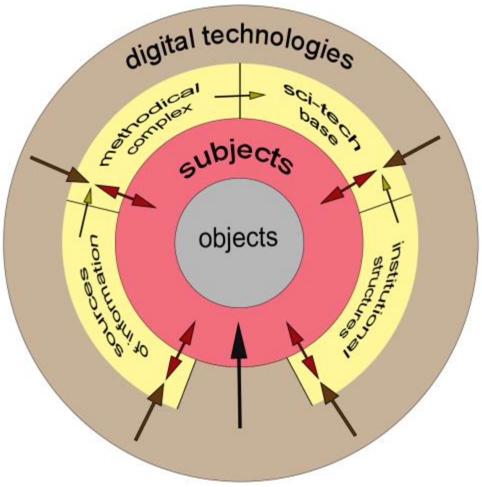


**Figure 01.** Structural diagram of a model of a system for the network form of CPE implementation

To identify the effectiveness of the system of the CPE network form implementation, carried out in accordance with the developed model, we used methods of system analysis, questionnaires and monitoring of learning outcomes. For example, during the implementation of further professional education programs, all teachers keep diaries of discipline testing, where they record the activities of students: activity, difficulties, results; perception of educational materials; deviation of time for the planned activities implementation, material and technical resources completeness and adequacy. At the end of each training module study, a survey of students is conducted, and upon entire program completion, as a rule, interviews with the management of the enterprise or company that initiated the development of the program.

## 6. Findings

The analysis made it possible to identify the integrative functions of the CPE network form system implementation and to substantiate its advantages in the realisation of professional education for students. Let us consider this as an example of the practical implementation of graduate educational programs and continuing education programs in the field of nano industry and mechanical engineering, implemented with the participation of Petrozavodsk State University (PetrSU).

### 6.1. Differentiated Learning Approach

This integrative function of the system is manifested in the embodiment of personality-oriented professional training, which was achieved by the transition to flexible learning schemes both in the university and in enterprises. Within the network form of CPE implementation, it was possible to ensure close cooperation between PetrSU and the Fund for Infrastructure and Educational Programs (FIEP) of the RUSNANO group. Modular programs aimed at improving the qualifications of engineering personnel of various profiles have been developed. Six program modules have been successfully implemented in the educational process of PetrSU for the preparation of masters.

As an example, we consider the structure of the further professional education program in the design and production of micro- and nanoelectromechanical systems. Training begins with a general theoretical discipline implemented in the format of a remote module. Further training is provided. During the

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development of the basic part of the program, depending on the engineering training profile, students learn one of the professional modules. The variable part of the program is formed on the basis of the personal preferences of the students. So, mastering a professional module designed for process engineers, a student, as a variator, can choose an academic discipline from the base part, for example, a program for design engineers.

### 6.2. Practice-oriented approach to professional training

In the process of lifelong learning, situations arise that create the need to acquire new knowledge that is important for an innovative economy and for a particular student. Specifically, the programs implemented by PetrSU together with the FIEP are initiated by the management of a certain enterprise to fill the shortage of qualified employees. The development of the training program takes into account plans for the technological base modernization that specify the production strategy of the enterprise; defines new and / or clarifies the existing labour functions necessary for the implementation of new technological processes, industries, and equipment. All programs are practice-oriented, and the educational activities of their students are relevant and in demand.

For example, in 2018, the further professional program was successfully implemented in the field of hardening technologies for wear-resistant nanostructured coatings used in the Petrozavodskmash plant (AEM-technology JSC Branch in Petrozavodsk). Subsequently, a Welding Centre was opened to improve the qualifications of the company's employees and undergo practical training for students, and the introduction of laser robotic welding began at the enterprises of State Atomic Energy Corporation Rosatom.

### 6.3. The organic connection of motivation, content, and methodology with the science and high technology achievements

Several aspects can be highlighted here. Firstly, the formation of a value attitude to theoretical and practical knowledge as the basis for the creation of innovative technologies. This is achieved by involving leading Russian and foreign scientists and practitioners in the development and implementation of educational programs. For example, A. E. Fedotov, Doctor of Technical Sciences, President of the All-Russian Public Organization “Association of Microcontaminants Control Engineers” developed and conducted training on the professional module “Technologies in Nanoelectronics”. Future engineers studied the Mentor Graphics computer aided design system (CAD) at the Mentor Graphics training and research centre, and Cadence CAD was taught by the official distributor of Cadence Design Systems and the German branch of this company.

Secondly, the opportunities that modern information resources provide to bring the content and methodology of professional education in accordance with the current state of science and high technology. The adaptation of modern scientific knowledge to the educational process is especially significant here. Four distance modules created during the interaction between PetrSU and FIEP were successfully implemented in the educational process of the magistracy in the areas of training "Electronics and Nanoelectronics" and "Instrument Making".

Thirdly, the relationship of the content and methodology of continuing education with the achievements of digital technology. On the one hand, these technologies are important as a means of training, contributing to the improvement of its quality and effectiveness. On the other hand, the adaptation

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of a man to the information environment, the formation of his digital culture meets one of the most important tasks of modern education modernization. If the first training modules for distance learning were slides with text and pictures, then in the future, animations, videos, virtual simulators, online communication tools, as well as online educational modules developed on e-learning platforms were actively used (Ershova & Nazarov, 2017; Nazarov & Sergeeva, 2016).

### 6.4. Integral involvement of institutional structures and system actors in the educational process

Here we are talking not only about planned actions related to rational cognition, but about future employment as well. As part of the network form of CPE implementation carried out by PetrSU and FIEP, masters and university teachers were involved in training along with the engineering personnel of the enterprise that initiated the design and testing of a specific program. Three projects were conducted to improve the skills of employees of JS Nanotech JSC, one of the leading microelectronics enterprises in the Russian Federation. As a result, 12 Masters of PetrSU who took part in testing the further professional education program were employed at this enterprise. In 2016, the GS-Nanotech enterprise opened the base department of PetrSU, and then the Nanocenter was opened on the university campus to solve the research problems of an industrial partner.

In 2017-2018, two joint projects in the field of creating solid-state data storage systems and a hybrid technology for the production of multi-chip microcircuits were launched as part of the Federal target program “Research and Development in Priority Directions for the Development of the Russian Science and Technology Complex for 2014-2020”.

### 6.5. Democratic organization of the educational process

In conditions when a student becomes a full-fledged subject of educational and cognitive activity, relations between students and teachers that are qualitatively different from traditional ones are formed. They can be characterized as partnerships, when students are not forced to, but voluntarily, on the basis of their own experience, recognize the stimulating role of teachers who meet modern requirements in terms of their personal and professional qualities. For example, when implementing the further professional education program for the branch of AEM-Technology JSC, initially the students of the program did not believe that it was possible to use laser welding for large objects and argued with teachers. However, after completing a practice at the Vladimir Engineering Centre for the Use of Laser Technologies in Mechanical Engineering at Vladimir State University (VlGU), the students of the program initiated the introduction of laser robotic welding at their enterprise, pushing for the need for this process in defense of final qualification works.

### 6.6. The ability of the system to develop and modernize

The feedbacks existing in the system between its elements provide the ability to control the educational process based on its results.

The ability to modernize is ensured by the participation of subjects of the educational process in the educational environment formation and the capabilities of the institutional structures of the system. For example, based on the results of testing further professional education programs, changes were made both

https://doi.org/10.15405/epsbs.2020.10.03.110
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Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

to these programs and to university curricula and academic course working programs; developing the material and technical resources of the university due to the technological base of individual entrepreneurship; Research centres (R&D) of enterprises are being created. In particular, based on the results of studying the professional module “Designing Microelectronics Devices Based on FPGAs”, the discipline “Designing Microprocessor Systems” of the master's curriculum was modernized, and the discipline “Quality Management” is read on the example of the quality system organization of the “JC Nanotech JSC”.

As for the development of the institutional structures of the system, in 2019–2020 the base department of PetrSU was opened at the enterprise Petrozavodskmash Foundry LLC, within the framework of which a metallography laboratory and a mathematical modelling laboratory for thermal processes of cast crystallization were created.

## 7. Conclusion

Based on the analysis of the challenges facing professional education in knowledge intensive fields of production, characteristic contradictions are identified, without the resolution of which it is impossible to train personnel for an innovative economy. In particular, contradictions were established between: the goals of a university education focused on academic, fundamental science and the competencies demanded in an innovative economy; regulated deadlines for the implementation of the basic educational programs of undergraduate and graduate programs and the need for continuous training in knowledge intensive fields of production; tasks of a dynamically developing innovative economy and the content of educational programs.

It is shown that the resolution of these contradictions is possible by combining the efforts of universities and enterprises of knowledge intensive sectors of the economy in the practice-oriented educational programs development and joint implementation. On the examples of cooperation between industrial partners (IP) and educational organizations: The Design Centre KM211, a leading developer of VLSI, “JS-ES Nanotech”, CJSC Petrozavodskmash, the Fund for Infrastructure and Educational Programs of the RUSNANO Group, PetrSU, VlGU, etc. proved that the network form of continuing professional education is an effective means of training in the field of high technology.

A model of a network form system for the continuing professional education (CPE)implementation is proposed. The simulation results allow us to talk about the network form of CPEs implementation as a system, which is a holistic object, whose functions are much wider than the functions performed by its individual elements.

One of the main integrative functions of the system is to stimulate the joint development of educational programs by universities and individual students. It is shown that because of the delayed educational result of the preparation of bachelors and / or masters, the role of further professional education programs is increasing, and as a means of training in the digital environment - distance educational resources. The methodological complex of the system provides teachers and students with a set of teaching methods, delivery, and techniques, combining the best achievements of academic and professional education, and the possibility of knowledge intensive innovative production.

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eISSN: 2357-1330

Having mastered the technology of developing further professional education programs, representatives of higher education begin to transform the main professional educational programs, which is especially important when designing them within the framework of FSES 3 ++ on the basis of professional standards. Guided by the deficit of qualification personnel of enterprises in the region, it has become easier to choose the types of professional activity that are in demand and to highlight generalized labour functions. Based on them, it is subsequently easier to determine the current profile of the educational program, formulate professional competencies and learning outcomes.

Another main function of the system is to create conditions for the practical CPEs implementation. Continuity of professional education, implemented within the framework of the system, is provided by the opportunity for students to choose multilevel educational programs in the field of high technology, means, methods and activities that meet the needs of the individual and the goals of modern education. At the same time, the role of digital technologies is to accompany variative learning and create comfortable conditions for self-education. Creating conditions for lifelong learning has made it possible to increase the competitiveness of graduates in the modern labour market. So, over the past 5 years, about 300 participants: engineering personnel of enterprises, masters, employees, and teachers of PetrSU, have improved their qualifications according to the programs of further professional education developed by PetrSU with FIEP.

The integrative properties of the system are expressively manifested in the results of its practical use. The network form of CPEs implementation made it possible to ensure a high level of interaction between universities, scientific and educational structures, and enterprises, forming the organizational and pedagogical conditions for the continuing professional education implementation in the field of knowledge intensive industries. The interaction of the university with SE has become complex. Representatives of the higher education faculty got the opportunity to study production processes in detail and continue cooperation not only in educational, but also in scientific and innovative fields. At the same time, the institutional structures of the university fulfil some of the functions of the enterprise research unit.

The functions of the system made it possible to obtain the following fundamentally new results in the professional and educational fields:

- top up the qualifications of employees of enterprises in the framework of the joint implementation of programs of further professional education and ensure the subsequent operational introduction of new innovative technologies in production;
- to provide practice-oriented training for bachelors and masters using the educational modules of further education programs in the educational process;
- implement lifelong learning, including the use of the digital technologies capabilities and networking educational and methodological complexes;
- create institutional structures in enterprises that ensure the passage of student practice and advanced training for employees of enterprises;
- create institutional structures in universities that ensure the implementation of research and development work carried out on the initiative of the SE, and the testing of new technical solutions;
- accumulate human, intellectual, technical and financial resources to organize the educational process that meets the requirements of an innovative economy.

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eISSN: 2357-1330

The joint activities of the university and the SE implemented within the system allowed initiating and implementing a number of large projects in the field of nanotechnology and engineering, such as “Nanoporous Alumina Membranes”, “Development of a hybrid technology for the production of multi-chip microcircuits with the simultaneous use of Flip-Chip and Wire Bond packaging processes”, “Creation of solid-state storage systems using integrated circuits with a high degree of integration”, “Two-stage installation for wood modification” etc.

In general, the proposed network form system for the implementation of continuing professional education creates the conditions for the formation of the personnel potential of the territory in the field of knowledge intensive technology, the development of its social and human capital.

## References

Andreev, V. V., Gorbunov, V. I., Evdokimova, O. K., & Rimondi G. (2020). *Education and Self Development, 15*(1), 21-37. https://doi.org/10.26907/esd15.1.03

Arkannikova, M. S., & Kondin, B. I. (2019). Russian engineering education in the context of the social demand transformation. *The European Proceedings of Social & Behavioural Sciences,* 601-617. https://doi.org/10.15405/epsbs.2019.12.65

Baygusheva, I. A., Danilov, A. N., Zabudsky, G. G., Kalnitskaya, I. V., & Shmakova, A. P. (2018). Smart technologies in creation of open system of professional education in Russia. *The European Proceedings of Social & Behavioural Sciences,* 516-524. https://dx.doi.org/10.15405/epsbs.2018.12.61

Choi, J., & Kim, J. (2018). Dancing between Nordic and neoliberal: Lifelong learning in South Korea. *Journal of Adult and Continuing Education, 24*(1), 5-17. http://dx.doi.org/10.1177/1477971417751738

Davydova, M. V., & Kudryavceva, V. S. (2017). Ekonomika znaniy kak sreda ajhvbhjdfybz innovatsionnoy ekonomiki [The knowledge economy as an environment for the innovative economy formation]. *Current trends in the development of science and technology, 3-6,* 129-131. [in Russ.]

Dementev, D. V. (2018). Vzaimisvyaz’ obrazovatel’nykh i professional’nykh standartov [Interconnection of educational and professional standards]. *Accounting. Analysis. Auditing, 5*(3), 120-127. https://doi.org/10.26794/2408-9303-2018-5-3-120-127

Ershova, N. Y., & Nazarov, A. I. (2017). Praktika primeneniya aktual’nykh elektronnykh resursov dlya podgotovki magistrov [Practices of application of topical electronic resources for preparation of masters]. *Scientific notes of the Institute of Social and Humanitarian Knowledge, 1*(15), 221-227.

Golaydo, I. M. (2017). Sistema vysshego obrazovaniya I ekonomika regiona [The system of higher education and the region economy]. *Education and science without borders: fundamental and applied research, 5,* 129-132. [in Russ.]

Hodgson, A., Spours, K., Smith, D., & Jeanes, J. (2019). Beyond employer engagement and skills supply: building conditions for partnership working and skills co-production in the English context. *Journal of Education and Work, 32*(1), 36-51. https://doi.org/10.1080/13639080.2019.1593331

Konovalova, E. A. (2013). Integratsionnye vzaimodeystviya obrazovaniya, nauki i proizvodstva kak factor progressa sovremennogo rossiyskogo obshchestva [Integrational interrelations of education, science, and industry as a factor of modern Russian society progress]. *University proceedings. Volga region. Humanities. Philosophy, 2*(26), 79-86. [in Russ.]

Koretsky, M. D., & Magana, A. J. (2019). Using Technology to Enhance Learning and Engagement in Engineering. *Advances in Engineering Education, 7*(2), 1-53.

Korshunov, I., Peshkova, V., & Malkova, N. (2019). Uspeshnye strategii realizatsii program dopolnitel’nogo professional’nogo obrazovaniya v professional’nykh obrazovatel’nykh organizatsiyakh i vuzakh [Successful Strategies of Vocational Schools and Universities in Implementing Continuing Education Programs]. *Voprosy obrazovaniya – Educational Studies Moscow, 1,* 187-214. https://doi.org/10.17323/1814-9545-2019-1-187-214

Listvin, A. A. (2016). Dual’noe obuchenie v Rossii: ot kontseptsii k praktike [Dual training in Russia: from the concept to practice]. *Obrazovanie i nauka – The Education and science journal, 3,* 44-56. https://doi.org/10.17853/1994–5639–2016–3–44–56

Lopanova, E. V., & Lalov, Yu. V. (2017). Organizatsiya leyatel’nostnogo obucheniya v professional’noy podgotovke budushchego spetsialista [Organization of the activity orientated learning in the future specialist professional training]. *The Science of Person: Humanitarian Researches, 4*(30), 80-84. https://doi.org/10.17238/issn1998-5320.2017.30.80

Marge, T., Tynjala, P., Toding, M., Kukemelk, H., & Venesaar, U. (2014). Engineering Students’ Experiences in Studying Entrepreneurship. *Journal of Engineering Education, 103*(4), 573–598. https://doi.org/10.1002/jee.20056

Nazarov, A. I., & Sergeeva, O. V. (2016). Preimushchestva distantsionnykh obrazovatel’nykh tekhnologiy-vzglyady studentov i prepodavateley [The advantages of distance learning technologies: students’ and university lecturers’ views]. *Otkrytoe obrazovanie – Open Education, 6,* 42-50. https://doi.org/10.21686/1818-4243-2016-6-42-50

Nurutdinova, A. R. (2012). Osnovnye napravleniya integratsii nauki, obrazovaniya i proizvodstva [Main directions in integration of science, education, and industry]. *Modern high technologies, 4,* 24-27. [in Russ.]

Order of the Government of the Russian Federation of December 8, 2011 No. 2227-r "Strategy of innovative development of the Russian Federation for the period up to 2020 (2012). http://www.szrf.ru/szrf/doc.phtml?nb=100&issid=1002012001000&docid=216

Romanova, I. N., Shenderey, P. E., Turkina, A. Yu., & Prasolov, S. G. (2019). Nepreryvnoe obrazovanie pri podgotovke spetsialistov v sovremennykh usloviyakh [Continuous education in training of specialists in modern conditions]. *Vestnik Bashkirskogo universiteta (Bulletin of Bashkir University), 3*(24), 754-758. https://doi.org/10.33184/bulletin-bsu-2019.3.37

Serditova, N. E., & Belocerkovskii, A. V. (2020). Obrazovanie, kachestvo i tsifrovaya transformatsiya [Education, quality, and digital transformation]. *Vysshee obrazovanie v Rossii (Higher Education in Russia), 4,* 9-15. [in Russ.]

Sharshov, I. A., & Belova, E. A. (2018). Analiz pedagogicheskikh vozmozhnostey elektronnykh obrazovatel’nykh resursov s elementami avtodidaktiki [Analysis of Pedagogic Potential of Electronic Educational Resources with Elements of Autodidactics]. *Integration of education, 22*(1), 166-176. https://doi.org/10.15507/1991-9468.090.022.201801.166-176

Shutaleva, A. V., Kerimov, A. A., & Tsiplakova, Yu. V. (2019). Gumanizatsiya obrazovaniya v tsifrovuyu epokhu [Humanization of education in digital era]. *Perspectives of Science and Education, 42*(6), 31-43. https://doi.org/10.32744/pse.2019.6.3

Sokolova, E. V. (2017). Sistema obrazovaniya v Rossiyskoy Federatsii: model’ sistemy obrazovaniya v perspective 2020 goda [The education system in the Russian Federation: the model of the system of education in the perspective of 2020]. *Sustainable development of science and education, 5,* 147-152. [in Russ.]

Uziak, J., Oladiran, M. T., Lorencowicz, E., & Becker, K. (2018). Students’ and Instructor’s Perspective on the use of Blackboard Platform for Delivering an Engineering Course. *The Electronic Journal of e-Learning, 16*(1), 1-15.

Volungeviciene, A., Teresevičiene, M., & Ehlers, U. (2020). When is Open and Online Learning Relevant for Curriculum Change in Higher Education? Digital and Network Society Perspective. *The Electronic Journal of e-Learning, 18*(1), 88-101. https://doi.org/10.34190/EJEL.20.18.1.007