# Competences as Educational Microcosms of Digitalization

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**Abstract**

Technological processes of digitalization of all spheres of society led to the emergence of a new paradigm, which became the basis for the development of standards of competencies of specialists and changed the content and methods of learning. On the one hand, the requirements for the personal qualities of a digital economy specialist contribute to the study of humanitarian courses, on the other, it is necessary to study the professional courses in detail. The article discusses the main components of the digitalization paradigm; requirements that are presented to a specialist in a digital economy, especially for IT specialists; digital competencies necessary for it; educational microcosms are built on this basis. The article built a hierarchy of digital competencies on the main types of specialist's activities in the digital economy. There is professional kind of activities on the economic theory of the digital economy, the development of artificial intelligence systems, data analysis, work with Big Data, digitalization of business systems, and information security. Educational microcosms are a set of training courses, practices, as well as individual and group projects that form a specific competence. Educational micrometers allow you to build a modular system for professional learning and students or workers receiving additional education. The use of computer learning technologies in the formation of digital competencies is justified.

**Keywords 1**

Digitalization, digital competencies, digital economy, educational microcosms, IT specialist, computer learning.



## 1. Introduction

Digitalization began in the middle of the 40s of the last century when the first computer Mark-1 earned and since then, before the beginning of the 90s, the generation of computers replaced by the generation of computers, their element base and software performed. The familiar term ICT meant information and computer technologies and communications at the time reduced to using email. Everything has changed with the advent of WWW - World Wide Web or, as you used to talk, the worldwide computer network. It was the Internet phenomenon, which led to the rapid growth of information and communication technologies, including the exchange of data and the emergence of global processes. Now we call these processes digital transformations.

These processes led to the fact that the knowledge and skills obtained by future specialists in the field of ICT began to be completely outdated quickly. At the same time, the concept of competence appeared as generalizing specific skills and it allowing make education more flexible. However, the problem of learning and, especially, leading to the development of ICT learning, becomes more and more acute every day. This is connected not only with constantly emerging new information technologies, but also with the need to predict their further development, and together with them the development of society as a whole.

The sources discussed in this article allowed formulate the following research problems: first, the need to consider the main trends in the digital transformation of society and the economy as a consumer

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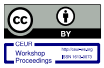

and the customer of the specialists of the new type [1, 2]. Secondly, to analyze the requirements for a new employee [2-10]; thirdly, determine the composition, structure, and maintenance of digital competencies as indicators in training specialists [11-18]. Fourth, consider the discussion issue of the formation of competencies as the creation of educational micrometers of digitalization, understanding under this logical chain of academic disciplines, which give the possibility of creativity and further development of the student. Fifth, we propose the methods of achieving competencies as the purpose of training specialists, the cognitive human-machine communications, which combining traditional training and computer learning.

## 2. The Paradigm of Digital Economics

The paradigm is the system of scientific views established at some historic period, in a digital economy it is associated with across information and communication technologies [1]. Digital transformations affected all spheres of public life; they mostly influenced the economy. Education, adhering to the traditional forms of training specialists, forced accelerated to switch to the computer and remote learning forms, which caused many discussions, but also gave positive results. One of the main such results was the rapid mastering of basic information technologies, both students and teachers, increasing their computer literacy and, as a result, strengthening motivation to study new methods of training and software, work in virtual educational environments. Such an educational environment may be, for example, a widespread Moodle platform, which allows to represent educational material in the text and visual form and control the process of forming the competencies; carry out interactive lectures, and use other convenient functions. In addition to this platform, the software systems themselves, in which various applications are developed, often provide training services, contain lessons and reference books for the convenience of developers, and create a high-quality product with a minimum number of subsequent corrections.

The need of society to accelerate the development of science and technology ensures the formation of innovative technological development. These processes affect the speed of innovative development, and at the peak of a certain cycle of the innovation wave, a change in the technological mode [1

The question of the correct choice of the priorities of innovative technological development, which is exclusively related to the topic of high technology and digitalization of the economy, remains fair. Digitalization, which is gaining wide distribution today, is mainly associated with the diffusion of the basic technologies of the previous technological wave (information) in the real sector of the economy, and not with the introduction of fundamentally new technological solutions. In addition, it is impossible to make this breakthrough only on the digital technologies, without the corresponding development of the high-tech technologies themselves associated with materials, energy, cognitive technologies, and biotechnologies. Therefore, when preparing a modern specialist, which is needed in the future, he needs to gain knowledge and skills on the natural sciences and their modern technologies, which, among other things, will be informational.

The continuous creation of new knowledge about new trends and opportunities is the basis for training specialists in specific industries and management that use information technologies [2]. In the old paradigm, the main principle of management was the observance of instructions and distribution of responsibilities; in the new paradigm, the main thing is to implement the possibility of rapid changes, analyze data on production, resources, and markets. Business analysis and business models based on comprehensive information technologies become a guarantee of success. The following digital economy technologies must not only be the theoretical learning subject of specialists, but also practical, which he using in developing of real startups, which created in the process of training of specialists. These are algorithms for analyzing large data, the use of cloud technologies, the development of projects for the introduction of the Internet of things, artificial intelligence, and machine learning [3]. The training based on flexible educational content, innovative pedagogical computer and network methods is the result of a digital economy paradigm. The simultaneous creation and modernization of the knowledge base of the learning courses, their availability will create a synergistic effect of training for specialists.

## 3. Requirements for the Employees in the Digital Economy

ICT is the activity that is most rapidly changing in its content, it requiring not only today's skills, but also preparing for tomorrow. For a specialist, digital competencies are especially important, from simple computer users to highly professional production activity, including the social sphere. Education in its nature has always been quite inert relative to the development of the economy; it adhered to traditional forms and content. Quickly changing technology, the Internet as a phenomenon of modern society requires the same rapid response from education. However, the current structure of the education system, multi-level subordination, bureaucratic requirements for approved nomenclatures of specialties and standards do not allow to education adequately respond to the requirements of a digital society and its economy.

The following requirements are present to higher education in a digital economy: individualization of training; the possibility for students of the rapid passage of educational modules and, if possible, several modules simultaneously; interdisciplinary. The higher school should provide the following ten fundamental skills: complex problem solving; critical thinking; creativity; the ability to lead people; the ability to interact with people work in a team; emotional intellect; availability of own opinion and responsibility for the decision making; customer orientation; the ability to negotiate; cognitive flexibility. These requirements were formulated at the annual Economic Forum in Davos and focused on 2020. As you can see from the list of skills, there are not their content and techniques that allow you to form the skill. As one of these new methods, N.A. Guz offers to use Blockchain technology for distance learning, storage of data about trainees, and courses content [4].

The economy needs IT specialists and this need is constantly growing. If in 2017 the forecast of the demand for 2024 amounted to about 300 thousand people per year, then in 2021 they talk about a lack of 1 million, and the growth of their number from 2010 to 2018 is practically absent and is 0.29% [5]. Russia lags behind the number of IT professionals 1.5-3 times from developed countries [6]. The complexity of preparation is also in high psychological requirements. In addition to the general professional competencies, IT specialists should have a concentration of attention and its management, have emotional literacy, environmental thinking, cross-culturally and possess the ability to study alone. Here arises a contradiction between narrow special requirements for future students and the responsibility of a higher educational institution not only to prepare a professional, but also to engage in in-depth psychological training, or to include additional barriers to entering the university or college.

The Ministry of Science and Higher Education of the Russian Federation in January 2020 issued order No. 41, which lists the competencies of the IT specialist:

- Communication and cooperation in a digital environment (the ability to use digital means, allowing interacting with other people to achieve his goals);
- Self-development in conditions of uncertainty (the ability to put educational goals, select ways to solve problems, and develop own competencies);
- Creative thinking (the ability to generate new ideas, find alternative action options);
- Information and data management (search new sources of information and data, organize the data processing using digital tools);
- Critical thinking in a digital environment (to evaluate the information received, check its accuracy, build logical conclusions).

In our opinion, any specialist in the digital economy should have such competencies.

The report on the skills of workers in 2020 highlighted six drivers of changes that define new skills [7]. First, a long extreme situation that affects the structure and nature of the career and training of specialists, which is associated with an increase in the number of older people over 60 in developed countries. Secondly, an increase in "smart" machines and systems, automation of jobs. Over the next decade, new smart machines will enter offices, factories, and homes in numbers we have never seen before. Third, universal computerization, distribution of the Internet of things, and digitalization of each object and each communication. Fourth, a new media ecology associated with multimedia technologies: video products, digital animation, augmented reality, and gaming. Fifth, the new structure of the organization, the influence of social media and the creation on their basis collective intelligence, expansion of the organization scale. Sixth, the emergence of a globally interdependent and associated world, in which the United States and Europe will lose their monopoly on the creation of new jobs,

innovation, and political force. These factors substantiate new requirements for digital economy specialists in general, including IT specialists.

For IT specialists there are some requirements relating to specific areas of activity. The appearance of cryptocurrencies and their consistent official recognition by several countries as the means of payment and investment requires training specialists for mining and trade in cryptocurrencies [8]. The development of virtual entrepreneurship on the Internet requires knowledge and skills in Internet marketing, consumer behavior in a virtual environment, mathematical modeling and forecasting, methods for assessing the virtual market, the quality of incoming information. The virtual entrepreneur should be able to manage risks, common to all enterprises and special for the Internet, which include informational risks [9]. The new profession of digital economy also includes a virtual environment designer, which develops virtual reality applications for various consumers, Internet data analyst, drone operator, a digital society lawyer; specialists in the field of robotics, genetics, and nanotechnologies [10]. If you build a pyramid of digital skills, then it will be customary skills in the base, the middle makes up professional skills in the digital economy and information society, and the top is the digital business [11].

We offer structuring digital skills, highlighting a global, comprehensive, level is global digital transformations that include both user skills and all sorts of professional. The following macro-level contains requirements for specialists of a digital economy, working in production, service, social, and management. IT specialists of specific professions have narrower special skills; the inner sphere or the top of the hierarchy is a microcosm of formation of a specific digital competence using training courses and projects, as well as cognitive techniques

## 4. Digital Competences

Today, teachers and economists write about the need to form digital competencies, while many authors emphasize that it is not enough to learn a set of facts and patterns because now you can find answers to most questions on the Internet; more important skills become formulate a problem.

Young people already have many formed digital competencies on the household level; therefore, the task of digital literacy is more relevant for the older generation. In the preparation of specialists, it is necessary to increase the competence from user-level students to the ICT developer-level [12]. Recently, educational institutions implemented a project training technique. However, leading ICT specialists to say that it is not suitable for practical developments due to a global approach, from researching problems, through planning and creating an object before implementation, because it takes a lot of time and created technology (program, system, etc.) can be outrageous by the time the work is completed. It is recommended to use short development cycles that occupy one or two weeks and allowing iterations, starting from the "kernel" layout, immediately acting, approach the ultimate goal. At the same time, without waiting for its turn in the traditional design, business analysts, product designers, encoders, testers, and accompanying documentation developers work. Such a technology called Agile (flexible) is used in the preparation of ICT specialists, both with traditional training in undergraduate and magistracy and the system of additional education. The student should immediately see the product of his studies in the form of a working program created individually or in a team as part of a general task, which gives powerful motivation for further study and development. Such a technology called Agile (flexible) is used in the preparation of ICT specialists, both with traditional training in base and magistracy and the system of additional education. The student should immediately see the product of his studies in the form of a working program created individually or in a team as part of a general task, which gives powerful motivation for further study and development. From the standpoint of socialization, studying, as a future specialist, has the most important competence - the competence of the time evaluation as the main non-renewable resource of the digital economy.

The high tempo of the information technologies development requires constant advanced training of the professorship-teaching staff, the formation of digital competencies has a higher level than that of students who, due to the youth, the presence of free time, communicate with peers are more advanced in certain matters. The role of the teacher, in this case, is to send the existing skills from the student to the creative channel, give him a more difficult task, provide an opportunity to be a leader, and get a significant practical result.

The teacher must constantly study new information technology; tools for developing software, deepening own knowledge, and forming new skills. However, at the same time, a teacher has to see a more general picture of the development of scientific and technological progress, create new training courses. Using a virtual educational environment in this case allows you to replicate the knowledge and experience of the teacher, attract colleagues to your courses to increase their qualifications, to receive advice from them to improve the content and course structure. Modular course structure, in turn, allows you to adapt it to new methodological and technological requirements, change individual theoretical blocks and tasks. Although there is an opinion on the need for strict standards of ICT competencies for teachers, we believe that the apparatus of competencies aimed at narrow skills, quickly change in some positions. To maintain the general direction it must the combined with basic, slowly changing theory and many possible technological incarnations.

Digital competencies are necessary for employees of various professions; this is due to the following features of the modern system of management: the use of Internet technologies, information management systems, data intelligent systems, automation of production processes [13]. Digital competencies are necessary, including civil servants [14]. For civil servants developed requirements for the three levels of digital competencies: basic, advanced, and special; there are specified knowledge and skills for each level. The basic level requires knowledge of hardware and software, opportunities and features of the application of information and communication technologies in government bodies, including the use of opportunities for interdepartmental document management, as well as general issues of information security. Skills include work with computers, the Internet, email, textual and tabular editors, preparing presentations, work with graphic objects and databases. For an advanced level, it is necessary to know the legal basis for using information systems and have strategic planning and project management skills. The special level includes knowledge of communications with citizens and organizations, archives management systems, and other special systems, as well as skills to work with state information resources, information security systems, and interdepartmental interaction systems.

Requirements for the presence of digital competencies are the basis for constructing career trajectories [15]. The modern specialist should be able to integrate the subject and information world, search and analyze data, structure the incoming information. According to researchers, *soft skills* are much more valued than *hard skills*; also digital and other skills, additional to the main profession. Digital competencies include informational, communication, and technological competence. The ethical side also plays an important role, especially when using licensed software, data exchange, and technologies. To build a career, a future specialist should study work in-group projects, communications in a virtual environment, and legal norms, creating digital content, and build a personal educational trajectory.

The lag of higher education from the needs of the labor market necessitated additional education courses for continuous advanced training. Many employees, teachers, and students undergo such courses on their own in their free time, as well as during the holidays [16]. The main part of the courses organized in the Internet environment, which creates additional amenities for students, makes it possible to study educational items at a free pace, repeat fragments, look for additional materials or use online consultations with teachers. Good quality courses often contain branching trajectories that allow personifying training, passing the course more quickly or more detailed. The same applies to the control of the knowledge of the student.

Today, digital competencies make digital career capital, which makes a significant contribution to productivity [17]. Unfortunately, in Russia, labor's pays often do not correspond to the skill-owned skills, which leads to a lack of motivation to obtain digital skills in an adult employee.

## 5. Competence as a Tool for Creating Educational Microcosms

According to the Federal State Educational Standard of Higher Education in Russia (Order of the Ministry of Science and Higher Education No. 838 of July 29, 2020) defined three types of competencies: universal, general professional, and professional. Digital competencies refer to the general professional and professional competencies levels; the last determined by each educational organization independently. This approach makes it possible to formulate competencies to prepare

students and for listeners of additional education; forming on their basis the educational modules - microcosms of preparation of narrower professionals for solving problems in a particular subject area. Today, additional education courses with different levels of preparation and, accordingly, with a different number of academic hours are highly sought-after. Such courses make it possible to study quickly the software and methods for solving problems with its help, studying several types of software applications and, as a result, improving erudition and qualifications. Especially this method is important for the leaders of all linksж it allows them to understand the questions that their subordinates occupied. A consistent study of different levels of one educational program also makes it possible to improve the qualifications of employees depending on the tasks solvable. The hierarchy of competencies also allows you to form teams that work on one project (for example, competencies related to the development of artificial intelligence systems). In addition, the specification of competencies is a tool for developing a curriculum, the content of training courses.

We have developed a structure of digital competencies that meet specific activities in the ICT (Table 1), having allocated a digital economy as a macro of activity, the development of artificial intelligence systems, data analysis, business digitalization, information security, and management of Big data. As follows from the classification, the main end-to-end technologies and specific skills in working with them are reflected here.

**Table 1**

Microcosms of digital competences

| | Competences | Activities |
|---|---|---|
| A | The ability to analyze and exercise digital transformations in the modern socio-economic system | Digital economy |
| B | The ability to collect, process, and interpret the experimental data necessary for artificial intelligence systems in the field of design and production and technological activities | Development of artificial intelligence systems |
| C | The ability to build neural networks and implement them in computer programs to solve various problems of economics, business, and social sphere | |
| D | The ability to formalize a dialogue in artificial intelligence systems and programming chatbots based on depth machine learning | |
| E | The ability to apply system analysis and modeling methods for analysis, enterprise architecture | Data Science |
| F | The ability to analyze data of the digital economy | |
| J | The ability to manage the electronic enterprise and units of the e-business of the offline companies | Digitalization of Business |
| H | The ability to conduct research and search for new models and methods for improving enterprise architecture | |
| I | The ability to assess the risks of economic activity and build economic and mathematical models | |
| K | The ability to develop methods, models, and software for the information security of enterprises | Information Security |
| L | The ability to work with Big Data, develop algorithms and computer programs | Big Data Management |

Specialists in economic theory, senior executives should have the competence of "the ability to analyze and carry out digital transformations in the modern socio-economic system", which will allow them to create countries and regions development strategies; to formulate the tasks of macroeconomics; to make forecasts using ICT. Developers of artificial intelligence systems may have different qualifications and activities, from preparing data in a special format, to produce neural networks and a dialogue organization. To do this, they must have the following competencies: first, "the ability to collect, process and interpret the experimental data necessary for artificial intelligence systems in the

field of project and production and technological activities"; second, "the ability to build neural networks and implement them in programs for a computer to solve various problems of economics, business, and the social sphere". Third, "the ability to formalize a dialogue in artificial intelligence systems and program chatbots based on depth machine learning". Project managers must have all the competencies, participants - one or two. Business analysts, Data Science experts, have the competence "The ability to apply system analysis and modeling methods for analysis, enterprise architecture", the formulation of this competence allows many mathematical methods and software applications". The competencies related to the digitalization of the business belong to the heads of small and medium enterprises, as well as to individual entrepreneurs. They suggest knowledge and skills on the management of electronic enterprise and units of e-business of the offline companies; conducting research and search for new models and methods for improving the enterprise architecture; assessing the risks of economic activity and the construction of economic and mathematical models. Big Data Specialists should be able to develop algorithms and programs for processing large data sets of the digital economy and implement them on computers and computer networks.

## 6. Conclusion

The digital economy paradigm is a new system of scientific views on socio-economic development, which is based on the global technological transformation of modern society. Digital transformations require the preparation of a new specialist with creative personal qualities capable of making responsible and competent solutions in a composition of human and machine environments and possessing special digital competencies.

New kinds of activities have emerged in the digital economy, both in the field of economic theory and in data processing and the development of artificial intelligence systems, data analysis, information security, and digitalization of the business. For these activities, the formation of relevant competencies is required. A set of training courses, practical tasks, group, and individual projects form an educational microcosm for each digital competence. The microcosm is a separate preparation module that is implemented in the learning process for students as a basic or additional set of courses.

The created-in this article hierarchy of digital competencies allows you to build educational micrometers, flexibly manage the curriculum and allow receiving additional skills to students of various preparation directions.

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