STAFF COMPETENCE AND TRAINING FOR DIGITAL INDUSTRY

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Abstract. The development of a digital economy based on effective work with big data, intelligent digital platforms, artificial intelligence, robotics technology and 3D printing requires the formation and improvement the level of employees’ competence as a set of new high-quality competencies. In recent years, the term “digital competence” has become a key one in discussions about what skills and knowledge are needed in a modern knowledge society. The term “Digital competency” has various interpretations in academic literature, in the practice of teaching, training and certification. In this article, we analyze the concept of "digital competence" and related terms as well as possible ways of its formation. Moreover, we consider an example of the “digital competence” formation that has developed at the SPbPU Advanced Manufacturing Technologies Center of NTI. It is important to note that we distinguish the concepts of “digital competence” and “digital literacy”. These concepts are not identical, but “digital competency” concept is considered as a key. In this article, we prove that the most suitable approach to training staff for the digital economy is formation of fundamental knowledge as well as developing applied skills. Due to digital platforms, the applied skills realizes fundamental knowledge through solving practical problems and challenges in the global high-tech market of products and services.

Keywords: Digital industry, Competence, Digital competence, digital modeling, Specular engineering center

1. Introduction
The competence of employees consists of a set of competencies, including digital. In recent years, the term “digital competence” has become a key one in discussions about what skills and understanding are needed for specialists and employees in the digital economy. The concept of “digital competence” has been interpreted differently (for example, digital literacy, digital competence, electronic literacy, electronic skills, electronic competence, computer literacy and media literacy) in the academic literature and in the practice of teaching, training and certification. In this article, we analyze a number of concepts and approaches related to digital competence terms. It should be taken into the account that digitalization has spread over the different spheres of economics theory and practice, e.g. digital marketing contributes to establishment of long-term relations with consumers [1, 2] enabling the process of customization.
Digital competency in the literature is analyzed from several linguistic, cultural and disciplinary positions. This article does not pretend to achieve a common understanding of the term, but provides a systematic overview of various definitions from diverse points of view. Also this article offers a specific approach to the development of “digital competencies”, based on the experience of the SPbPU Advanced Manufacturing Technologies Center of NTI.

First, it is important to note that big data and information and communication technologies (ICT) have a special role in the digital economy. These technologies connect all the technological chains of creation, production and operation of a product / service. Digital platforms, digital twins, smart digital factories are now becoming the core of the digital economy, providing a complete production cycle for the manufacture of products based on computer design, manufacturing and production. This approach is revolutionizing the technological chain of creating a product throughout its entire life cycle, which entails a change in the essence of engineering activity. The computers that appeared in the 60s of the last century led to a new subject of activity – programming. In the following decades, the ensuing avalanche-like growth in computer productivity and the widespread computing implementation led to a paradigm shift in the acquisition of engineering knowledge. If earlier a physical experiment was always at the head, then new digital technologies, mathematical modeling and a “virtual” experiment in the last decade have practically replaced the field experiment in a number of industries. So, in the automotive industry, as one of the most competitive, the amount of financial and time costs for conducting full-scale experiments over the past 20 years has decreased by orders of magnitude, giving way to "virtual" tests and the process of digital certification of the product. There was a proportion in the paradigm of the process of training engineering staff to create complex technical products that existed in the 20th century: research engineers should make up about 10-15% of the total number of trained specialists, the remaining 85-90% are operational and development engineers. Modern digital technology has virtually removed the line between research and other engineering activities. Today, with the availability of modern digital tools, almost all engineering professions are becoming research. This poses new challenges in the process of training engineering staff. A modern research engineer must be familiar with the methods of studying the world around him, understand the processes of interaction between nature and man, and be able to accurately describe the processes of such interaction. Physics, mathematics, and philosophy are becoming the main subjects of study for future engineers, and computer technology is becoming a necessary skill. Moreover, the constant emergence of new digital technologies leads to the need for the formation of a lifelong learning skill.

2. Materials and methods
Over the past 20 years, one can trace how the concept of “digital literacy” has transformed in Europe. Researchers conducted a detailed analysis of scientific publications on this topic [3]. We can agree with the fact that at present the strengthening of digital communication (digital communication) the emergence of the concepts of digital literacy and digital competencies suggests a shift in the previously established paradigm of training of economic and engineering staff for the digital industry economy. The terms characterizing digital competence and digital literacy have a different nature (according to [3]). If digital literacy presupposes a conceptual basis for staff training, then digital competence is based on a set of requirements (in subject areas) that are used in training. At the same time, the set of established concepts of digital competence and digital literacy can be grouped according to the ratio of cognitive elements into 2 groups of concepts:

1) definitions based on the assumption that the acquired skills, knowledge and understanding of digital reality will allow employees to provide for their life needs and use ICT tools for communication: 21st Century Literacy [(New Media Consortium, 2005 [4]), Media Literacy [(Aufderheide & Firestone, 1993) [5]], New Economic Literacy [(Coiro, J., Knobel, Lankshear & Leu, 2008, p. 5) [6], multi-modal literacy [(Kress, 2003, p. 40) [7]], computer literacy [National Research Council, 1999, p. 11 [8]] and [Hawkins & Paris (1997 [9])], digital literacy [(Merchant 2009, p. 39) [10]], media education [UNESCO (1999, pp. 273-274) [11]], information literacy [Jackman & Jones (2002, p. 3) [12]], multidimensional literacy [(Jewitt 2008, p. 242) [13]], ICT literacy [14], electronic literacy [(Martin, 2003, p. 23) [15]], e-skills and e-competencies, defined as a wide range of opportunities (knowledge, skills and competencies) covering three main categories: skills of ICT practitioners, skills of ICT users and
e-business skills [(European e-Skills Forum, 2004) [16], (Korte & Hüsing, 2010) [17], [18], technological literacy [Hague & Williamson (2009) [19]], media and information literacy [(Wilson, Grizzle, Tuazon, Akyempong & Cheung, 2011, p. 18) [20]];  
2) definitions formulated on the understanding of the scientific and research foundation of economic relations in the context of the new technological structure of Industry 4.0. (the definitions of digital competence that suggest the ability to study and critically analyze information, for example, [(Calvani, Cartelli, Fini & Ranieri, 2008, p. 186) [21] and [(Martin, 2009) [22])].

3. Results
In the authors’ view based on the concept of digital modelling [23], the proposed definition of “digital competency as the ability to flexibly explore and face new technological situations, analyze, select and critically evaluate data and information, use the technological potential to represent and solve problems and create common and joint knowledge, while promoting awareness of their personal duties and respect for mutual rights and obligations ”[24] do not fully reflect the emerging paradigm shift in digital design and delisting of products and processes. The authors’ view is based on the strict approach to defining the digital twins [25] as well as the specific problem-oriented scientific approach [26]. Consider, as an example, the organization of the process of digital design and modeling at the SPbPU Advanced Manufacturing Technologies Center of NTI. The process begins with the formation of a multi-level matrix of targets and resource constraints. It includes the development of “smart” digital models, tens of thousands of virtual tests, the development of digital product twins and is carried out because of a specially developed digital platform CML-Bench. The digital platform provides an extremely high automation of the development process due to the best world-class advanced computer technologies. CML-Bench is actually an expert system with built-in intelligent assistants in the complex and creative development and design process. The shift of the cost center from developing new products to the design stage, first noted by CIMdata, can actually make the transition to the situation of scientific experimentation. In the traditional situation, the increasing costs of the number of product changes are distributed throughout the entire product life cycle because of mistakes made or unaccounted data. Due to digital platform, digital design and modeling allows transferring costs to the design stage, which brings significant economic benefits to both the producer and the company operating the product. It leads to the functional transformation of economy agents in economic relations. In this approach, the platform is perceived as an element of the infrastructure of the digital economy as well as new form of the business model [27]. It greatly modifies the classical understanding of business processes, including technological transfer and commercialization of innovations [28], and also imposes new requirements and restrictions on these processes, for example, in intellectual property management, resource management, data management.

At this stage of development of the theoretical basis of economic science, the structure of digital competence is considered conceptually as the intersection of the concepts of technological, ethical and cognitive aspects of ICT, and implies the use of network technologies to create knowledge (Figure 1) [24]. “Learning through copying” leads to remarkable economic results, for example, the explosive growth of the Chinese economy over the past 15-20 years. However, such learning cannot lead to the leadership in the development and creation of new, globally competitive products. In the modern knowledge economy, the structure of intellectual property is changing. The knowledge economy embraces intellectual know-how, and is stored in digital twins of products and processes. Therefore, in our opinion, the modern understanding of the structure of digital competence does not reflect the functional transformation of the economy agents in economic relations because of inconsistency to the nature of digitalization, characterized by experimentation as the major process of creating and operating products (Figure 1).
As a result, the digital competency should include a set of employee skills in the development and application of digital twins (according to A.I. Borovkov). Such set of employee skills looks like a clusters of complex multidisciplinary mathematics models with a high level of relevance to real materials, real objects / structures / machines / devices ... / technical and cyberphysical systems, physical and mechanical processes including technological and production processes. These models are described by 3D non-stationary non-linear partial differential equations [25, p. 234 – 245]. All this points to “learning through experimentation and modeling”. Nevertheless, we don’t deny the approach of ethics, technologies and cognitive aspects of digital competence [24]. Furthermore, we propose to complete the structure of digital competence with the experimentation and scientific research skills both for engineering and economic specialists. This skill should become an integrator of technological, ethical and cognitive aspects of education.

Thus, we propose to identify the concept of “digital competence” as an ability to select, critically evaluate various data and information through experimentation, scientific research and using technological potential, being aware of their own and respecting mutual rights, to create common and joint knowledge and apply them in creating globally competitive products.

Digital literacy we suggest to identify as an understanding the principles of technology for development globally competitive products which is based on a new design paradigm, principles for working with big data and modern communication technologies.

SPbPU Advanced Manufacturing Technologies Center of NTI uses methodological base of scientific research which is based on developed by A.I. Borovkov's process of delivering projects from the market to technologies and problem-oriented fundamental knowledge. The traditional algorithm for the formation of complex scientific and technical programs guesses receiving new fundamental knowledge, then through their practical application, creation of technologies, development of products and services to the final entry into the market. Unlike the traditional algorithm, the new “reverse algorithm” allows to carry out the target research planning by initially prioritizing (global technology frontier), creating globally competitive products and services, integrating knowledge-based multi-disciplinary technologies ecologies. The contours of the problem-oriented fundamental knowledge...
scientific search are formed for new “reverse algorithm” [26, p. 53]. The products development manufactured on the basis of the proposed approach using digital twin technology, unlike traditional approaches, allows to reduce time, financial and other costs by several times, and in some cases by 10 or more times. In fact, this is exactly how leading companies in high-tech markets provide themselves with reserved development by the profession of A.A. Auzan. Using the proposed approach, the SPbPU Advanced Manufacturing Technologies Center of NTI was formed the megaproject “Factory of the Future”. In addition, our center developed the list of major competencies regarding to the megaproject “Factory of the Future”:
1) challenge-call - instant customization of the response to the customer’s request
2) system engineering;
3) multi-level matrix of targets and resources / constraints;
4) development and validation of mathematical models with a high level of adequacy;
5) product life cycle;
6) the widespread use of virtual testing - "digital certification";
7) motivation system.

Scaling up the practice of applying new production technologies and the spread of digital competencies is ensured through the development of a “specular” engineering centers network, the urgency of which is due to the complexity of forming a set of competencies necessary for implementing complex scientific and technical projects.

4. Discussion. A methodological approach to development competencies at mirror engineering centers.
The result of the digital twin development for any customer will be a matrix of target indicators and resource constraints, a set of mathematics models, and “virtual test benches” - simulating the object’s behavior in technical and / or technological parameters set by the customer. To work with such a complex product as a digital twin, professional knowledge are necessary, often multidisciplinary, as well as the ability to work with a large number of applied software products. The presence of a digital platform simplifies the work process, but does not remove professional difficulties. To work effectively with a digital twin (DT) of any product, the customer should always have the ability and competence to precisely formulate requirements for the object's DT, to provide the necessary set of input data for the development of DT and data for verification of the DT. In addition, it is necessary to provide a statement of the problem for virtual tests of the DT, and the possibility of transferring the results of virtual tests to the operation of real facilities (in fact, "digital certification").

Thus, it is necessary to form teams with the suitable digital competencies and digital literacy in the structure of industrial partners. The process of creating and operating such teams with the competence to create digital twins and conduct virtual tests was implemented at SPbPU through the practice of creating “Specular Engineering Centers”. The experience of SPbPU in fulfilling the duties of creating digital twins of complex products has revealed that in addition to directly solving the technical duty, customers have a fundamental need to ensure the sustainability of the results achieved by increasing their own engineering competencies. World experience demonstrates the need of digital transformation of the industry, a widespread transition to advanced digital technologies and platform solutions (in particular, to the development and implementation of digital twin technologies) for creating new competitive products in the shortest possible time and, as a result, ensure sustainable social and economic development of the Russian economy. A methodological approach to improving the professionalism of employees involves the development of the thesis “formation of the digital industry economy” by fundamentally refracting the nature of transaction costs (in the terminology of R. Coase), which initially increased during the first three industrial revolutions, and then dramatically decreased under the new technological Industry 4.0. At the same time, the revolution in economic relations, characterized by a dramatic reduction in transaction costs, is accompanied, on the one hand, by replacing the algorithmic actions of a person with artificial intelligence, and on the other hand, by the devel-
Development of competitive advantages of a person, manifested in limited rationality by professor A.A. Auzan.

Especially, it is important to note the emerging economy of scale provided by the network interaction of the Specular Engineering Centers teams distributed across different industries, areas of knowledge and the geography. Specular Engineering Centers network leads to cost savings, not only through the joint use of digital infrastructure, human and other resources, but also as a result of an interdisciplinary technology transfer. It allows to use the best available tools and approaches for solving breakthrough duties, including those that are beyond the established industrial practices.

5. Conclusion
Thus, it is necessary to consider the issue of training staff for the digital industry in the context of creation teams in enterprises, scientific organizations and universities that have the necessary digital competencies and digital literacy, that is, the ability to use modern methods of experimentation and scientific research technologies for development globally competitive products. This competency becomes an integrator of technological, ethical and cognitive aspects of education. In the paradigm under consideration, the basis of the methodological approach to solving the problem of staff training is a problem-oriented scientific approach, and the model for creating specular engineering centers is a possible model for scaling up competencies, disseminating knowledge and developing network interaction. Further research can include questions of building competencies for engineers and for non-engineering specialists, especially for economists and senior, middle tier managers, as well as questions to form “greenfields”, special units with the authority to experiment and propose new approaches to solving industrial problems and challenges and thereby provide a breakthrough.

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