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FORMATION OF DIGITAL COMPETENCIES OF HUMAN CAPITAL OF MACHINE-BUILDING ENTERPRISES

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Formulation of the problem. The article considers the problem of forming digital competencies of human capital of machine-building enterprises. It has been analyzed that the digital economy defines new requirements for enterprises, and one of the key success factors in it is the availability of highly qualified personnel with digital competencies.

The purpose of the study is to form the outline of digital competencies of human capital necessary for machine-building enterprises.

The main hypothesis is to confirm the trend in the labor market regarding the lack of middle-level personnel who possess digital skills and are provided with an effective plan for evaluating the digital competencies of human capital.

The methodology of scientific research is to ensure the development of human capital of machine-building enterprises with a unified framework of digital competences, based on the results of research using general scientific and special methods.

The results consist in the formation of proposals for the division of digital competences into basic and special digital competences, which, in turn, are divided into functional and operational ones. The functional dependencies of digital competencies of the human capital of machine-building enterprises have been formed, which include education, self-education, the worldview of the employee, biological qualities of the individual, the set of business processes at the enterprise, the peculiarities of production processes, the uniqueness of the software product used at the enterprise and practical experience of acquiring digital competencies. The logical sequence of the implementation of processes related to the improvement of their digital competences is described. The article proposes the creation of an intra-corporate framework of digital competence for a machine-building enterprise based on three levels of requirements for determining the need for the scope of digital competences and choosing the method of its satisfaction. It is noted that the basic level of digital competences of the staff of the machine-building enterprise must correspond to the Framework of digital competences for citizens of Ukraine DigComp 2.1, while the outline of functional and operational digital competences is formed in the article independently.

Conclusions. It was revealed that the proposed projects of digital competence outlines, which meet the real needs of the digital transformation of machine-building enterprises and realize the strategic orientation of the formation of the digital economy of Ukraine, can be applied for planning, analysis and formation of digital competences of the human capital of machine-building enterprises.

Keywords: digitalization; human capital; digital competences; machine-building enterprises; digital technologies.

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13	1	6

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ФОРМУВАННЯ ЦИФРОВИХ КОМПЕТЕНТНОСТЕЙ ЛЮДСЬКОГО КАПІТАЛУ МАШИНОБУДІВНИХ ПІДПРИЄМСТВ

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Постановка проблеми. У статті розглядається проблема формування цифрових компетентностей людського капіталу машинобудівних підприємств. Проаналізовано, що цифрова економіка визначає нові вимоги до підприємств, і одним із ключових факторів успіху в ній є наявність висококваліфікованих кадрів, які володіють цифровими компетентностями.

Метою дослідження є формування контуру цифрових компетентностей людського капіталу, необхідних для машинобудівних підприємств.

Основна гіпотеза полягає у підтвердженні тенденції на ринку праці щодо нестачі кадрів середньої ланки, які володіють цифровими навичками та забезпечені дієвого плану щодо оцінки цифрових компетентностей людського капіталу.

Методологією наукового дослідження є забезпечення розвитку людського капіталу машинобудівних підприємств уніфікованими рамками цифрових компетентностей, базуючись на результатах дослідження з використанням загальнонаукових та спеціальних методів.

Результати полягають у формуванні пропозицій щодо розподілу цифрових компетентностей на базові та спеціальні цифрові компетентності, які в свою чергу, поділяються на функціональні та операційні. Сформовано функціональні залежності цифрових компетентностей людського капіталу машинобудівних підприємств, які включають в себе освіту, самоосвіту, світогляд працівника, біологічні якості індивідууму, сукупність бізнес-процесів на підприємстві, особливості виробничих процесів, унікальність програмного продукту, що використовується на підприємстві та практичний досвід набуття цифрових компетентностей. Описано логічну послідовність реалізації процесів, пов'язаних з удосконаленням їх цифрових компетентностей. У статті запропоновано створення внутрішньокорпоративної рамки цифрової компетентності для підприємства машинобудування за трьома рівнями вимог для визначення потреби в обсягу цифрових компетентностей та вибору способу її задоволення. Зазначено, що базовий рівень цифрових компетентностей персоналу машинобудівного підприємства повинен відповідати Рамці цифрових компетентностей для громадян України DigComp 2.1, тоді як контур функціональних та операційних цифрових компетентностей сформована у статті самостійно.

Висновки. Розкрито, що запропоновані проекти контурів цифрових компетентностей, які відповідають реальним потребам цифрової трансформації підприємств машинобудування та реалізують стратегічну направленість становлення цифрової економіки України, можуть бути застосовані для планування, аналізу та формування цифрових компетентностей людського капіталу машинобудівних підприємств.

Ключові слова: цифровізація; людський капітал; цифрові компетентності; машинобудівні підприємства; цифрові технології.

Formulation of the problem. Currently, the majority of machine-building enterprises in the world use modern technologies and introduce innovations, while Ukraine is only beginning to implement them in production processes. If we take the level of development in the field of digitalization of Ukraine, it is appropriate to note that there are several aspects that, if properly managed, would increase the likelihood of rapid digital transformation of enterprises. Such actions include the restructuring of the education system and the scientific paradigm, which would become an impetus for further proactive development of human capital, as well as the reformatting of educational programs for the new realities of society. Adaptation to market requirements and global challenges with the creation of a highly effective personnel reserve, retraining programs should be aimed at increasing the digital intelligence of employees. The development and implementation of the legislative framework related to the digitalization and virtualization of the economy, including the definition of opportunities for remote work, would attract a larger number of enterprises to support the digitalization strategy. Currently, there is no framework of digital competencies for machine-building enterprises, which would increase the likelihood of the implementation of digital technologies in management and production processes.

Analysis of recent research and publications. The question of the formation of digital competencies for employees is in the scientific research of scientists, including T. Balanovska, O. Havrysh and B. Vyrzhikovska (2020), L. Havrilova and Y. Topolnyk (2017), L. Hrynevych, N. Morze and M. Boiko (2020), T. Semyhina and V. Fedyuk (2022) and others However, the requirements for the digital competencies of employees are deepening with the development of digital technologies. To study the applied aspects of human capital, a set of the most typical digital competencies, which the staff of a machine-building enterprise should have today, was considered. There are no methods for assessing the mastery of digital skills of human capital in the scientific literature. Therefore, we can assume that to reveal this issue, it is necessary to analyze the requests of employers regarding the necessary competencies for employees. The object of analysis was the sites of announcements about existing vacancies (robota.ua, work.ua). The analysis of information on these sites allowed us to summarize the following research results:

– today there is a significant demand for a wide list of positions that ensure the implementation of relevant functions at machine-building enterprises;

– a significant number of vacant positions at machine-building enterprises is typical for the middle level of the management structure;

– at the level of working professions, there is an isolated demand from employers for highly qualified specialists to perform high-precision milling, turning, and welding operations;

– a prerequisite for the competency requirements of all relevant vacancies. The list of digital skills that employers put forward to potential applicants is determined by the functional obligations of each position.

The purpose of the study is to form the outline of digital competencies of the human capital necessary for machine-building enterprises.

Presenting main material. As evidenced by the experience of transforming the IT sphere into one of the most powerful spheres of activity in Ukraine, the main ways of forming digital competencies are a competitive selection of "talents" with highly competitive wages; organization of a wide network of educational projects to provide basic skills in the use of digital products in the performance of each operation and implementation of each management function; a broad information policy regarding the promotion of the image of IT companies and the prestige of activities in the specified field; high requirements for the level of English language proficiency; providing opportunities for professional growth by mastering new functions; encouraging creativity and innovation; social support as a way of encouraging the development of digital competences (Digital competence, 2023).

According to the classification features of their purpose, competencies divide into basic and special digital competence, and, in turn, special, is divided into functional and operational competence.

Basic digital competence is the ability of personnel to use modern means of communication, social networks, chatbots, payment cards, money transfer systems, etc. The group of general digital competencies includes the ability of personnel to search the Internet, use Facebook, Instagram, Telegram and other social networks, Microsoft, Google applications, etc., use Internet banking services, make posts in professional chats, etc.

Basic competencies in the context of the development of the digital economy are perceived as a mandatory element of basic digital skills. The importance of having basic competencies is determined by their ability to ensure the speed and breadth of development of the social characteristics of an employee of an enterprise as an individual. Despite the lack of direct involvement in the performance of functional obligations, the presence of basic digital competencies allows the formation of social and communicative relations between members of the work team, forming the "*collective digital competence effect*". It is manifested the increase in the general level of digital competence of the staff and the reduction of the company's costs for their formation.

Given the obvious dependence of the employee's basic competence (*GC*) on the quality of the acquired knowledge (G_E), especially in mathematics, physics and informatics and the acquired specialty (P_E) in a special or higher education institution, we see the absence of the need for theoretical proof.

Regarding the influence of worldview (*W*) on the basic digital competencies of the employee, it is worth noting that worldview is a system of views that determines how a person sees the world. It includes beliefs, values, and ideals that guide a person's life (Gergen and Gergen, 1986). Worldview can be shaped by various factors, such as personal experience, culture, religion, and education, and is a powerful tool that helps people understand the world and make decisions.

The influence of the worldview on the digital competencies of the employee has a dual nature. On the one hand, the worldview (in terms of knowledge, positive views on the acquisition of digital competencies, attitude to the fulfillment of professional obligations, etc.) of each individual affects the choice of digitalization strategy, on the other hand, the implementation of digitalization strategies affects the change in the worldview of the company's personnel, expanding their boundaries knowledge, supplementing the system of values and beliefs. Therefore, the higher the level of knowledge, views and beliefs in the need for digitalization of each employee of the enterprise, the higher the level of basic competence of the enterprise will be due to the readiness of its staff to acquire digital competencies .

The biological qualities of an individual (*B*) in the concept of researching digital competencies of personnel is the ability to evaluate and analyze external changes in mechanical engineering, their causes and consequences, to position one's role and the role of all employees in the system of digital transformations in mechanical engineering. The biological component of an individual is dictated by his consciousness, accordingly, the greater the number of personnel aware of the need for digital transformations, the more effective are the processes of implementing digital technologies.

Special digital competencies are a set of skills in the use of special programs designed to perform certain types of operations within defined functions. Special digital competencies depend on the type of software products that provide automation of special functions and operations in the enterprise. For the most part, such competencies require special training through the acquisition of knowledge and the formation of skills for their application (Table 1).

As the results of the survey showed, in mechanical engineering, special digital competencies should be an element of the professional competence of a specialist of the appropriate management level. Each level of functional management has its requirements for the possession of relevant digital skills.

In general, it was found that special digital competencies, in turn, are divided into functional and operational ones. Functional skills are those digital skills that allow using special software to plan, monitor, analyze, coordinate the performance of the entire management function. This digital competence should be characteristic of heads of functional departments. Depending on the

functional level of management, a set of such functional digital competencies allows you to plan processes, aggregate the results of the implementation of operational digital competencies, distribute tasks between operational executors, set deadlines for their execution, control and coordinate work, etc. Functional digital competence depends on operational digital competencies (*ODC*), a set of business processes at the enterprise *(BP*), functional software products (PP_F). The volume and quality of functional competencies of human capital create the "*effect of digital functionality*" – as an expansion of the list of capabilities of personnel to use the functionality of IT technologies.

Table 1

Functional and operational digital competencies of the human capital of the machine-building enterprise

Position	IT programs	User competencies
Functional digital skills		
Director of the department	Navkolo (relevant modules), IT-Enterprise, A5 ERP, Oracle products, MRP, DEBIT Plus	Strategic and operational control of the implementation of all types of plans Control of the implementation of business processes and performance of business functions
Production technologist	Navkolo (production), IT-Enterprise, A5 ERP	Production planning Cost rationing
Project manager	SAP	Planning works according to the project Fixation of works by performers Calendar schedule of the project Planning and allocation of resources Sales performance management
Human Resources Department	Hurma System SAP	Employee Experience Management Basic processes of personnel management and salary calculation Talent management HR analytics and planning
Operational digital skills		
Engineer	SolidWorks, Windows, Office, Autocad, Coreldraw, P-Cad, Altium, Solid Edge	Design modeling Design of nodes, details, products Graphical image

Source: created by the author (robota.ua, work.ua).

Operational digital skills involve the use of software to perform specific operations within a defined function. Usually, such skills are narrow and require specialized knowledge. In a generalized form, operational digital competencies are a function of the uniqueness of the software product used at the enterprise (PP_U), basic competencies (*BDC*), professional and full higher education (G_E), practical experience of being digital competencies (*PE*), features of production processes (P_{pr}). The presence of operational digital competencies in the company's personnel creates the *"effect of digital uniqueness"* of the company as

an exceptional ability of the personnel of this company to produce a product or its IT service.

The formalized form of functional dependencies is described in Table 2.

All separate groups of digital competencies of personnel at machine-building enterprises are connected by production and management relationships.

The hierarchy of all groups of digital competencies in the specified classification feature will have the form shown in Table 2.

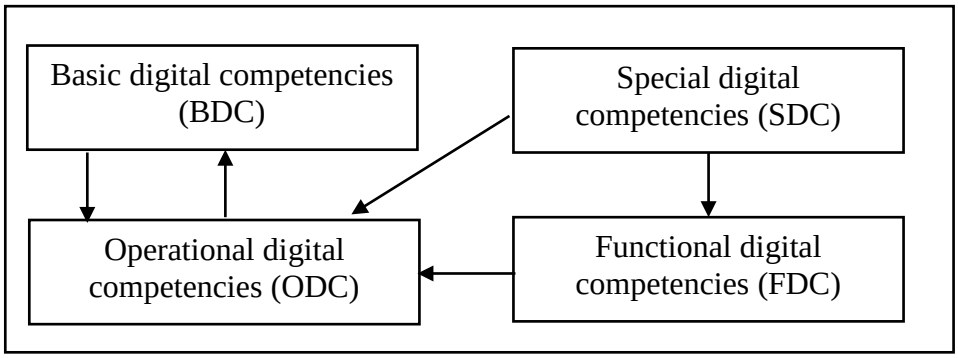
Table 2

Functional dependencies of digital competencies of the human capital of machine-building enterprises

Digital competence	**Functional dependence**	**Legend**
Basic (BDC)	$BDC = f(G_E, P_E, S_E, W, B)$	G_E – general education of the employee; P_E – availability of special professional or higher education; W – worldview of the individual; B – biological qualities of an individual; S_E – self-education; BP is a set of business processes at the enterprise; PP_F – functional software products; PP_U – the uniqueness of the software product used at the enterprise; PE – practical experience of acquiring digital competence; P_{pr} – features of production processes.
Functional (FDC)	$FDC = f(O_C, BP, PP_F)$	
Operational (ODC)	$ODC = f(PP_U, BDC, PE, P_{pr})$	

Source: generated by the author.

A formed hierarchy of digital competencies allows one to present visually the interdependencies between all their groups.



Source: constructed by the author.

Fig. 1. **Hierarchy of digital competencies of the staff of the machine-building enterprise**

By the presented hierarchy, all functional and operational digital competencies are based on the general digital competence of the staff.

Based on the above and taking into account the conducted analysis of the state of digitalization of machine-building enterprises, it is possible to form a logical sequence of the implementation of processes related to the improvement of their digital competencies (table 3).

One of the tools for determining the need for the number of digital competencies and choosing the method of its satisfaction is the creation of an intra-corporate framework of digital competence for a machine-building enterprise. Such a framework can be formed according to three levels of requirements: basic, operational and functional competencies.

Table 3

Stages of the process of assessing the need for digital competencies of human capital

Stage
1. Defining the digital strategy of the enterprise
2. Assessing the need for a set of operational digital competencies
3. Assessing the need for a set of functional digital competencies
4. Analysis of the existing state of providing the enterprise with the necessary digital competencies of personnel in terms of structural units and workplaces
5. Calculation of the need for additional digital competences
6. Analysis of possible ways of acquisition of digital competencies by existing staff
7. Assessment of the need to recruit additional personnel with the necessary list of the Central Committee

Source: built by the author.

The basic level of digital competencies of the staff of the machine-building enterprise must correspond to the Framework of digital competencies for citizens of Ukraine or DigComp UA for Citizens 2.1 [11, p. 9], which was developed based on the results of research conducted as part of the project "dComEra: Digital competence framework for Ukrainian teachers and other citizens". It includes 6 areas, 30 competencies and 6 levels of mastery of digital competencies (Table 4).

As mentioned above, depending on the digitalization strategy, engineering enterprises need the necessary set of digital competencies of their personnel. The framework of functional competencies of personnel is a set of necessary skills and abilities of the user of technologies that ensure the performance of professional functions. This is a framework of skills and abilities of managers of functional management levels (heads of departments, departments, projects, etc.) (table 5).

Table 4

Generalized structure of the framework of digital competencies for citizens of Ukraine

Sphere of competence	Name of competence
Basics of computer literacy	The use of various gadgets and basic software. Use of applications and software, the Internet and e-applications. Management digital identity
Information literacy, skill work with data	View, search, filter data, information and digital content. Critical evaluation and interpretation of data, information and digital content and reliability testing sources. Management of the data information and digital content. Realization of own requests with the help of ICT. Self-realization in the digital society
Creating digital content	Development, edition and integration of digital content. Copyright and licenses. Basic skills in programming. Creatively using digital technologies.
Communication and interaction in digital society	Communication, cooperation, sharing and exchanging data with the help of digital technologies. Digital citizenship. Use of e-services. E-signature. Responsibility. Legal and ethical norms network etiquette
Security in the digital environment	Protection of devices and secure connection to the Internet, with protection of personal data and privacy. Internet security. Defending of personal consumer rights from fraud and abuse. Protection of health and well-being, protection of surrounding environment
Solving problems in a digital environment and teaching during life	The solution to technical problems. Defining needs and their technological solution. Evaluation of the own digital competence, elimination gaps. Solution of vital problems with the help of ICT. Lifelong learning. Professional self-development in digital environment.

Source: created by the author based on (Ministry of Digital Transformation, 2021).

Each business function, each business process of an enterprise is a set of operations, the interaction and integration of which realize the tasks of each of its functional divisions. However, digital technologies used by operational actors may differ in the breadth of functionality and greater detail of technological operations. The digital competencies of the executor of technological operations are characterized by greater specialization in the performance of narrow operational actions (table 6).

Formed drafts of the framework of digital competencies of the personnel of the machine-building enterprise implement the task of developing the Roadmap of the digital transformation of the machine-building enterprise, the outline and requirements of which were formed by the Association of "Industrial Automation Enterprises of Ukraine" (APPAU, 2023).

Table 5

Outline of the generalized structure of the framework of digital functional competencies of employees of the machine-building enterprise

Spheres competence	Names of competence
Management skills	Digital management of personnel competencies Formation of the matrix of the digital competences Use of task planning technologies Forming a digital learning management program Organization of security of digital activities of personnel Use of digital technologies to perform management functions Time management The use of IT technologies for strategic planning of the development of business functions Use of digital documentation technologies
Development of rules of conduct regarding the use of IT technologies	Development of rules for the use of various types of devices Development of new forms of digital communications
Control and security	Control of "technological user instructions" Security of performance of business functions Control of communications ethics
Analysis and evaluation	Possession of technologies and methods, analysis and processing of a large amount of data Ensuring accuracy and secure data Use of visualization technologies of processes and operations
Communication	Selection of technologies and adjustment of intragroup and intergroup communication processes Organization of data transfer processes

Source: constructed by the author.

Table 6

Outline of the generalized structure of the framework of digital operational competencies of the personnel of the machine-building enterprise

Spheres competence	Names of competence
Operational	Programming, designing, modeling and working with artificial intelligence Use of automation systems and IT technologies to perform operational tasks Use remote databases, standards
Optimizing	Establishing, evaluating and analyzing performance indicators of operational IT technologies Analysis of "critical points" of a technological operation Software functionality support
Security	Safety of technological operations
Independence and responsibility	Ensuring the quality of operations

Source: constructed by the author.

Therefore, the proposed projects of the framework of digital competencies meet the real needs of the digital transformation of machine-building enterprises and realize the strategic orientation of the formation of the digital economy of Ukraine.

Conclusions. The digitalization of the enterprise requires not only the modernization of production but also the training of employees in digital competencies, which would help to adjust more effectively production processes. The presence of digital competencies in human capital is increasingly becoming a priority request among employers of various types of economic activity in industry. The developed framework of digital functional and operational competencies will enable business owners to assess the level of mastery of digital skills of employees, plan their effective training or retraining, and subsequently form the necessary digital competencies.

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