“Transformation of the human capital reproduction in line with Industries 4.0 and 5.0”

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TRANSFORMATION OF THE HUMAN CAPITAL REPRODUCTION IN LINE WITH INDUSTRIES 4.0 AND 5.0

Abstract

The study's relevance relates to the transformation of the human capital reproduction during the transition to a new socio-economic model and changes (digitalization, cyberization, customization, etc.) that are now taking place within Industries 4.0 and 5.0. The purpose of the study is to formulate the content and key directions of learning processes based on modeling and the formation of digital twins for the production and consumption of goods. The research method is based on the analysis of structural links in socio-economic systems, where the potential of human capital is realized. The study describes a trialectic model for the system development mechanism, which gives grounds to distinguish three types of essential components of implementing the specialists' competencies (material, information, and communication). Based on the concept of "system of systems", the necessity of multifunctional training of specialists for socio-economic systems is substantiated and shown on the list of personal knowledge/skills in the renewable energy sector. Recent trends in the reproduction of human capital, such as intellectualization, increased communication, internationalization, acquisition of skills, customization, and communication with consumers, are stated in line with Industries 4.0 and 5.0. The potential for future research is aimed at harmonizing relations between humans and cyber-physical systems, motivating the needs for self-development, and using disruptive technologies in the reproduction of human capital.

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INTRODUCTION

Humanity is going through a transition to a new socio-economic reality, where a person will have to live in completely different conditions and need to act in accordance with completely different principles and laws. The reality dictates the need for critical changes in the education system based on total informatization, computer modeling, virtualization of the learning process, and artificial intelligence. Quite a lot of studies were devoted to these issues. In particular the changes caused by Industry 3.0 were analyzed in publications (Rifkin, 2013; Shahan, 2020), Industry 4.0 (Schwab, 2017; Schwab et al., 2018; Skinner, 2018; Kartanaitė et al., 2021), and Industry 5.0 (Rossi, 2018; Rada, 2018) bring to humanity. Vikhman and Romm (2021) concluded that in learning processes it is necessary to ensure the perception of the trialectic nature around a man: the world of real objects; the world of relations and the world of virtual digital data. David et al. (2018) have analyzed three key concepts in learning theory: behaviorism, cognitivism, and humanism, which allowed tracing the evolution of modern learning processes and digital twins. Tvende et al. (2019) have analyzed the role and use of simulation-based learning in a manufacturing learning factory, which could be seen as a factor of increased productivity in a sec-

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tor. Many scientists (Arcelay et al., 2021; Dozortsev, 2020; Shkarupa et al., 2021; Sabadash & Petrovska, 2014; Koblianska et al., 2020; Polyakov, et al., 2020; Suknunan & Maharaj, 2019) investigate the characteristics of the reproduction of knowledge and skills (job profiles) in various sectors of the economy. At the same time, these studies lack an analysis of transformation processes related to human capital reproduction and the formation of digital twins, which can be effectively used in learning processes.

The study aims to formulate the directions of transformation of educational processes in line with modern industrial revolutions and to develop critical elements of learning processes. For this purpose, the nature and vectors of influence of three modern industrial revolutions (Industries 3.0, 4.0, and 5.0) on the socio-economic systems are revealed.

1. THEORETICAL BACKGROUND

1.1. Current industrial revolutions as prerequisites for the transformation of the education system

The modern generation has to live in conditions of three industrial revolutions simultaneously. Therefore, every industrial formation is interconnected with the other two and has its separate focus, development, logic, and goals. It just so happened that the formal birthplace of this industrial formation is the European Union countries.

The goals of the Third Industrial Revolution (Industry 3.0) were proclaimed in the second half of the 2000s by the European Commission and aimed to prevent a global environmental crisis. The EU has formulated the following specific tasks: transition to alternative energy sources, in particular through the introduction of state support mechanisms aimed at encouraging green energy production, consumption, and transmission (Kurbatova et al., 2018; Prokopenko et al., 2021; Skibina et al., 2021), electrification of transport; the formation of horizontal production systems (in particular, EnerNet); fast dematerialization of the processes of production and consumption (Rifkin, 2013; Shahan, 2020; Shkarupa, et al., 2017; Klymchuk et al., 2020).

The fourth industrial revolution (Industry 4.0) was initiated in 2011 by the business and scientific community in Germany to increase the competitiveness of enterprises through the development and use of automated cyber-physical systems (Schwab, 2017; Schwab et al., 2018; Skinenner, 2018; Sotnyk & Zavrazhnyi, 2017; Sotnyk et al., 2020; Kolot, et al., 2020).

The goals of the Fifth Industrial Revolution were formulated in the mid-2010s in the works of individual scientists. And since 2019, a special Industry 5.0 department has appeared in the scientific management of the European Commission. The main direction of this revolution is the search for the role and place of a man in the processes of production and consumption for better use of artificial intelligence and automated means (Rossi, 2018; Rada, 2018; Gauri, 2019; Østergaard, 2021).

Digitalization of socio-economic systems and cyberization of living space in the course of Industry 4.0 requires a transition to new methods of human capital reproduction. Therefore, today the main objective of education and training is the formation of a synergetic unity of a person's cognitive abilities with cyber-physical systems, as well as the development of personality nature to activate his/her creative potential in line with Industry 5.0.

1.2. Main directions of digital-related transformation in education

The complexity of the phase transition to the digital economy requires addressing issues related to the management of economic systems in the context of three industrial revolutions. Such radical changes in social life lead to revolutionary changes in education, which is schematically shown in Figure 1.

Source: Authors' development.

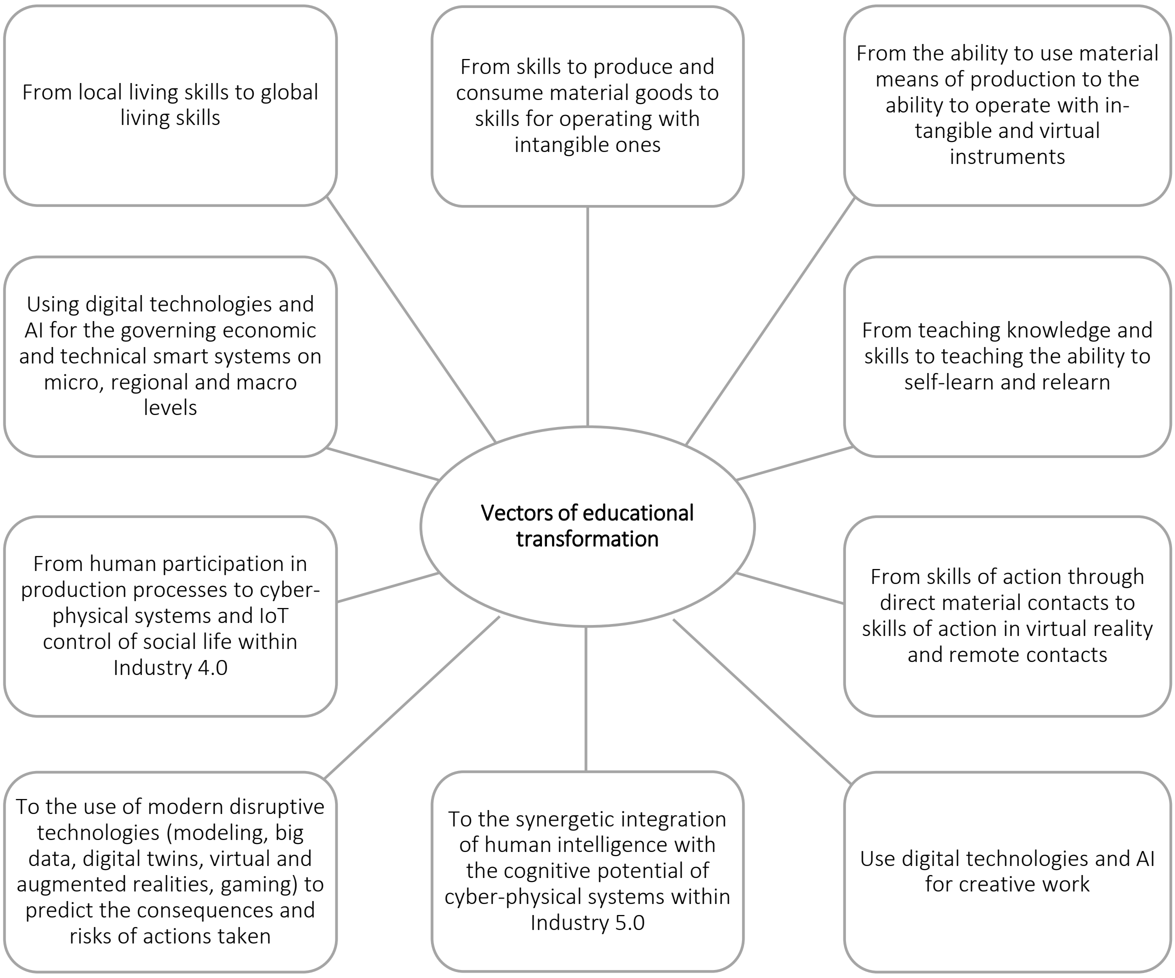

Figure 1. Key vectors of education transformation in the context of current industrial revolutions (Industries 3.0, 4.0, 5.0)

1.3. The growing role of modeling and a digital twin in education and training

Human capital formation in modern realities requires good teaching and training systems to obtain current knowledge and skills. David et al. (2018) have incorporated the three critical social concepts in learning theory: behaviorism, cognitivism, and humanism. Thus, *behaviorism* is based on the maximum use of the material signaling system of influence on the student and experimental methods. *Cognitivism* learning theory advocates that "people are rational creatures and learning involves active participation and actions that are consequences of cognition… As such, the learner assumes a very active role" (Ertmer et al., 2013). In the learning theory, *humanism* is seen as a need for learning as an innate desire. Therefore, the learning process proceeds most effectively when it is consistent with the subjective desire of a learner to study throughout life. Thus, a learner is assumed to be an active subject, and a teacher acts as a facilitator. Analysis of modern teaching methods convinces the objective necessity to activate methods based on humanism learning theory, where the student is an active subject, and his/her desire to learn is an essential component of the educational process.

The increased relevance of digital modeling in life and education relates to several important points:

- The general trend of digitalization of production processes. The modern means of production are increasingly acquiring information entities both in performing essential func-

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tions by information and in the cost of the information.

- The growing efficiency of digital models. Thus, the replacing of physical objects and the use of digital models predict the behavior of physical objects and minimize costs (including environments), and potential consequences and risks of their actual use (Veklych et al., 2020).

- Increasing opportunities for enhancing educational processes. The computer models made it possible to bring students closer to real-life processes and realize their activity and creativity.

A digital twin is a basis for computer simulation and is seen as a software analog of a physical, biological or social system that models its internal parameters, algorithms, behavior, and reactions to influencing factors. Depending on the functions performed, the digital twins can be differentiated into some groups (Table 1).

Table 1. Types of digital twins depending on the functions performed

Source: Compiled by the authors based on Bacic (2005), Dozortsev (2020), Derev'yanko et al. (2020), Grives et al. (2017), Skytt et al. (2015).

Functions	Examples
Data storage	Databases for 3D-models creation
	Digital containers (digital prototypes) at the design stage
Duplicate of an original	Computer simulation for training
	Software simulation for testing engineering systems
	3D and VR/MR interfaces in remote control systems
Reality continuation and augmentation in space and time	Virtualization of unmeasured parameters of a physical object
	Predicting the trajectories of changes in the parameters of a physical object in response to a change in the environment
Simulation for simplified demonstration	Simplified models of physical objects for visual demonstration in education
	Simple simulators and gaming
Basis for analysis	Modeling rare and non-existent states of a physical object
	Analysis of "bottlenecks" and possible emergencies
	Simulation for emergency training

Depending on the tasks being implemented, digital twins (DT) can be differentiated into the following groups (Dozortsev, 2020): *information DT* serves for the accumulation, storage, and reproduction of information about a real object; *diagnostic DT* serves to monitor the current state of a real thing, identify bottlenecks and the possibility of unforeseen situations; *predictive DT* helps to predict and visualize the form of a real object in the future or hypothetical scenarios; *operating DT* helps to control production processes and optimize the operations performed.

1.4. Results

1.5. Formulating the content of the digital twin for the learning model

1.5.1. Trialectics modeling system of the digital twin

Essential natural origins are the fundamental forces determining the occurrence, self-organization, functioning, and development of natural and social systems. As such systems, one can consider structures with coordinated behavior (physical particles and molecules), living organisms, ecosystems, and public organizations (firms, macro-organizations, markets). The emergence and existence of any system occur in the interaction of essential natural origins. When modeling the state of any system, one should consider the trialectic nature of its essence (Melnyk, 2021):

- *material and energy* are needed to form the movement in the system (the implementation of metabolism, interaction with the environment, the development of the system);

- *the information* provides directionality of movement in space/time, and forms an algorithm for the interaction between individual parts (subsystems) in length and a program to develop the system in time;

- *synergetic* provides the implementation of links between the interaction of subsystems with each other and the system with the environment; there is an integration of individual elements into a single system.

The key directions of the reproduction mechanism could be reflected in computer modeling and education (Figure 2).

Source: Authors' development.

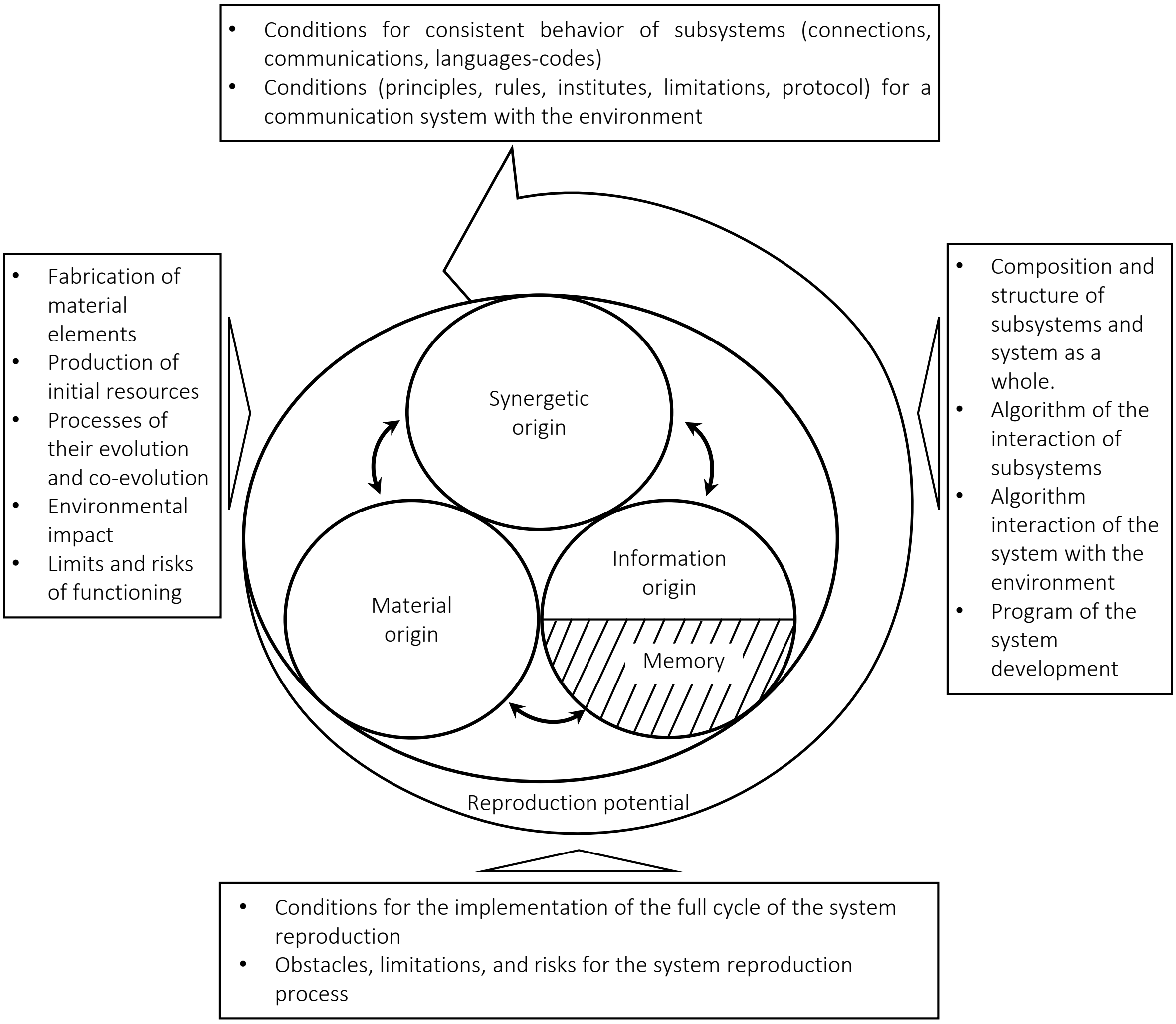

Figure 2. Directions of modeling key processes of system reproduction and their simulation in education

1.5.2. Modeling the social systems

The importance of studying the trialectic nature of the system and its formalization in the digital twin is underlined by Vikhman and Romm (2021), and modern people should perceive that they live in three worlds:

1) the world of natural objects, processes, and interactions;

2) the world of social relations, meanings, and people; and

3) the world of virtual digital data, technologies, and content.

In addition, it is needed to deepen the content of the socio-economic system in the formation of a digital twin. Any socio-economic object is a complex system of material and information blocks, each of which is a system that realizes and reproduces itself in space and time. The consistency of this construction lies in the interconnection and mutual conditioning of all blocks. Their joint functioning can be understood only by taking into account the interaction of individual blocks:

- the behavior of each element affects the behavior of the whole;
- no block affects the behavior of the system without the influence of other blocks;

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- each block has properties that are lost if separated from the system.

Based on this, any economic entity can be called a "System of Systems", when there is an integration of systems within a common supersystem (more is presented in Figure 3 and Table 2). Each of the lower-level system can also act as a subsystem in other higher-level systems that goes beyond this supersystem. For example, people who are part of the conventional concept of "human capital" for a certain enterprise can also act as subjects in other supersystems: public organizations, voluntary associations (hunters, gardeners, members of housing and other cooperatives), sports teams, amateur art groups, etc.

Once again, it is needed to emphasize the interconnection and systemic interdependence of individual blocks of the "System of Systems". In particular, the human factor determines the state of all other blocks (subsystems) of a given system (Tarkhov et al., 2012). To be more specific, the human factor affects the parameters of physical capital, defines the goals and functions of an enterprise and its divisions, determines the dynamics of processes and material metabolism at the enterprise, establishes relationships

Source: Authors' development.

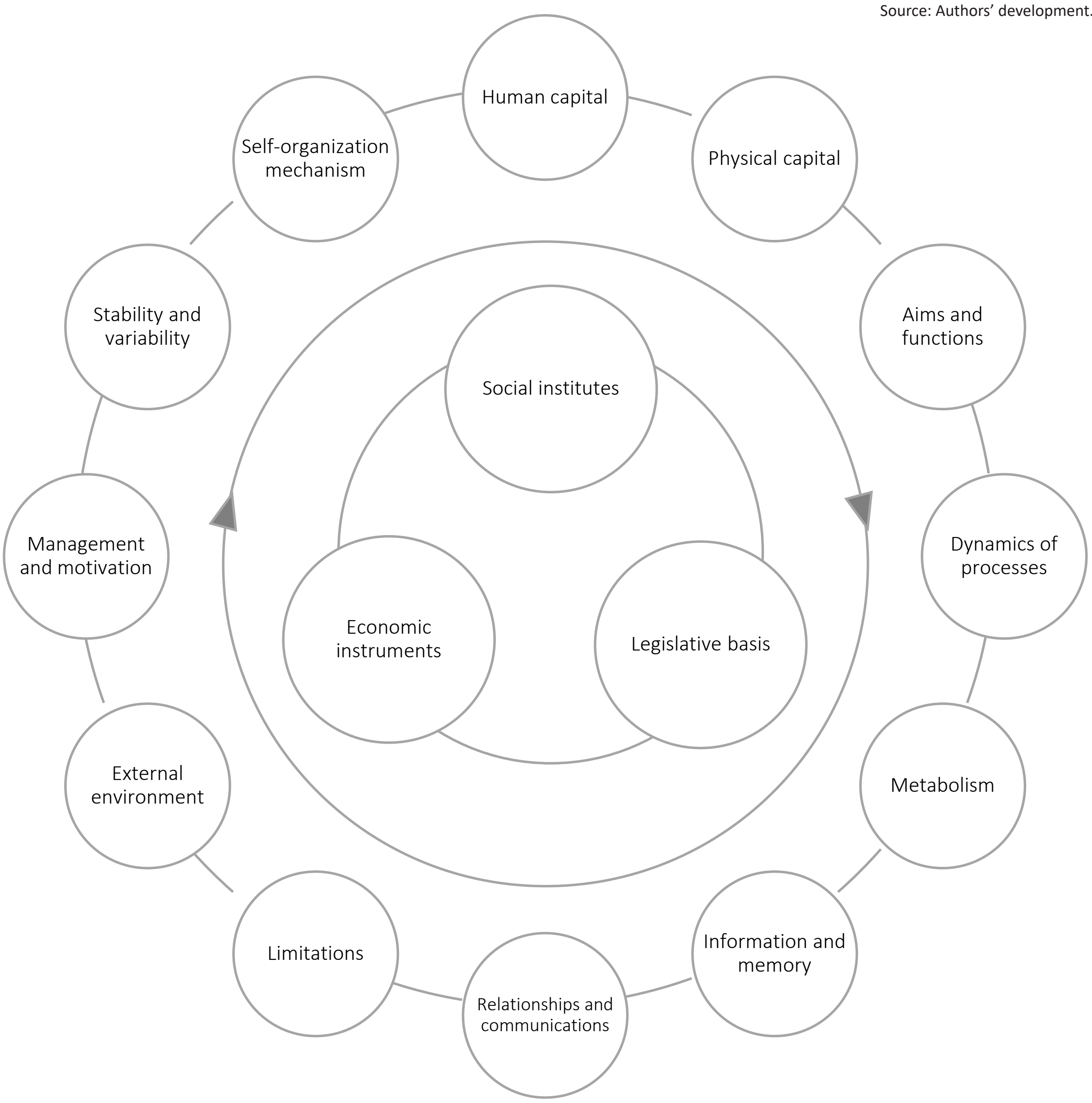

Figure 3. Conditional scheme of the reproduction mechanism of the principal block of the "system of system" for a social-economic structure

and connections between individual performers and departments, forms the content of information capital and memory, determines external and internal constraints, forms the behavior of the enterprise with external factors, implements management and motivation, provides stability (Melnyk et al., 2019) and the necessary variability of the system. On the other hand, all of these subsystems define a person as a subject of the implementation of the production process and economic relations at the enterprise. In one case, these factors are a tool for selecting people with the necessary competencies to work at the enterprise. On the other hand, they have a stimulating effect on reproducing the required properties (skills, knowledge, worldview, moral foundations, and other qualities) among the enterprise's employees.

The phase transition within modern industrial formations requires a radical change in the form of the above-mentioned "Systems of systems" blocks of an enterprise. Only those economic structures that pass the phase barrier will receive the chances and advantages of competition in the new socio-economic conditions.

The reproduction mechanism of the "System of Systems" properties is realized as a result of the interaction of "economic instruments", "legislative framework", and "social institutions" (which formally belong to the category of institutions).

The *Legislative basis* forms a framework for economic entities to operate. Legal actions include prohibitions, recognition and registration procedures, environmental standards, resource quotas, waste quotas, environmental regulation of advertising, restrictions, manufacturer's obligations, declaration of content, etc. In particular, the EU Directive 2010/31/EU19 of May 19, 2010, on the energy consumption of buildings, stimulates each EU member state to ensure that after December 31, 2018, all new buildings occupied by public institutions (or owned by them) must have "zero energy consumption", and after December 31, 2020, all new buildings must meet this requirement.

The *Economic instruments* form a motivational field (incentives and disincentives) that determines the motives of an enterprise to act in a specific direction. As an example, one can name environmental taxes and tariffs, payments, other forms of financial assistance, market licenses, transfer of forms of ownership, economic sanctions, etc. (Lindsay & Hudson, 2019). Several economic instruments can make laws, but not all eco-

Table 2. Main blocks (subsystems) of "systems of systems"

Source: Authors' development.

Block conditional name	Subsystem content and characteristics
Human capital	Includes knowledge, skills, competencies, worldview, physical condition, motivation of the enterprise personnel to achieve its specific goals
Physical capital	Includes material and energy resources (fixed and circulating capital), which a company has to perform its functions
Aims and functions	Includes strategic and tactical goals, as well as operational tasks, functions, and processes that an enterprise carries out in space and time
Dynamics	Characterizes the functioning processes of an enterprise in time (speed of operations, their sequence, cyclicality, etc.)
Metabolism	Characterizes the flows of material resources going through an enterprise, as well as the processes of material and energy transformations
Information and memory	Characterizes the system's ability to process, store and reproduce information
Relationships and communications	Characterizes external and internal relations and communications of individual structural sub-blocks of an enterprise
Limitations	Characterizes the system of material, information, financial, natural, institutional, and legal restrictions in which an enterprise operates
External environment	Characterizes the state and impact of natural factors of the social community, as well as economic entities external to the enterprise
Management and motivation	Characterizes the driving forces (incentives and demotivators) that determine the organization, coordination, desires, and motives of individual performers in achieving the goals and solving problems of an enterprise
Stability and variability	Characterizes the dialectical relationship of two polar states of the enterprise, namely, to maintain and change its structure and basic characteristics
Self-organization mechanism	Characterizes the ability of an enterprise to maintain its functional activity without direct external influence

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nomic instruments have a legislative basis. Some of them can be formed by the initiative of local administration bodies, state and private enterprises, international and non-governmental organizations. In particular, the International Bank for Reconstruction and Development compensates legal entities and individuals up to 20% of the cost related to the installation of heat pumps. In addition, many international non-governmental organizations provide grants and awards to cities, businesses, and individuals for work related to the implementation of Industries 3.0 and 4.0.

Social institutions create a social atmosphere of tolerance or intolerance towards specific actions of economic agents. Such measures include informal norms, social foundations, customs, traditions, moral incentives, people's worldview, cultural and religious values, public actions (for example, protests, appeals, etc.), influencing public opinion through social networks, etc. In particular, in some countries, due to social intolerance towards manufacturers of environmentally unfavorable products, it is possible to form consumers' preferences not to purchase products associated with harmful effects on nature.

One of the most complex and vital problems is harmonizing the motivational tools to achieve the goals and objectives of the three industrial revolutions. In particular, the stimulation of the cyber-physical systems development and the orientation towards increasing efficiency and productivity (which are declared by Industry 4.0) often contradict the tasks of the humanizing output and consumption of products (which are declared during Industry 5.0). To achieve such harmonization, it is necessary to clearly understand the events' logic, cause-and-effect relationships, and industrial revolutions' interdependence.

Source: Compiled based on literary sources.

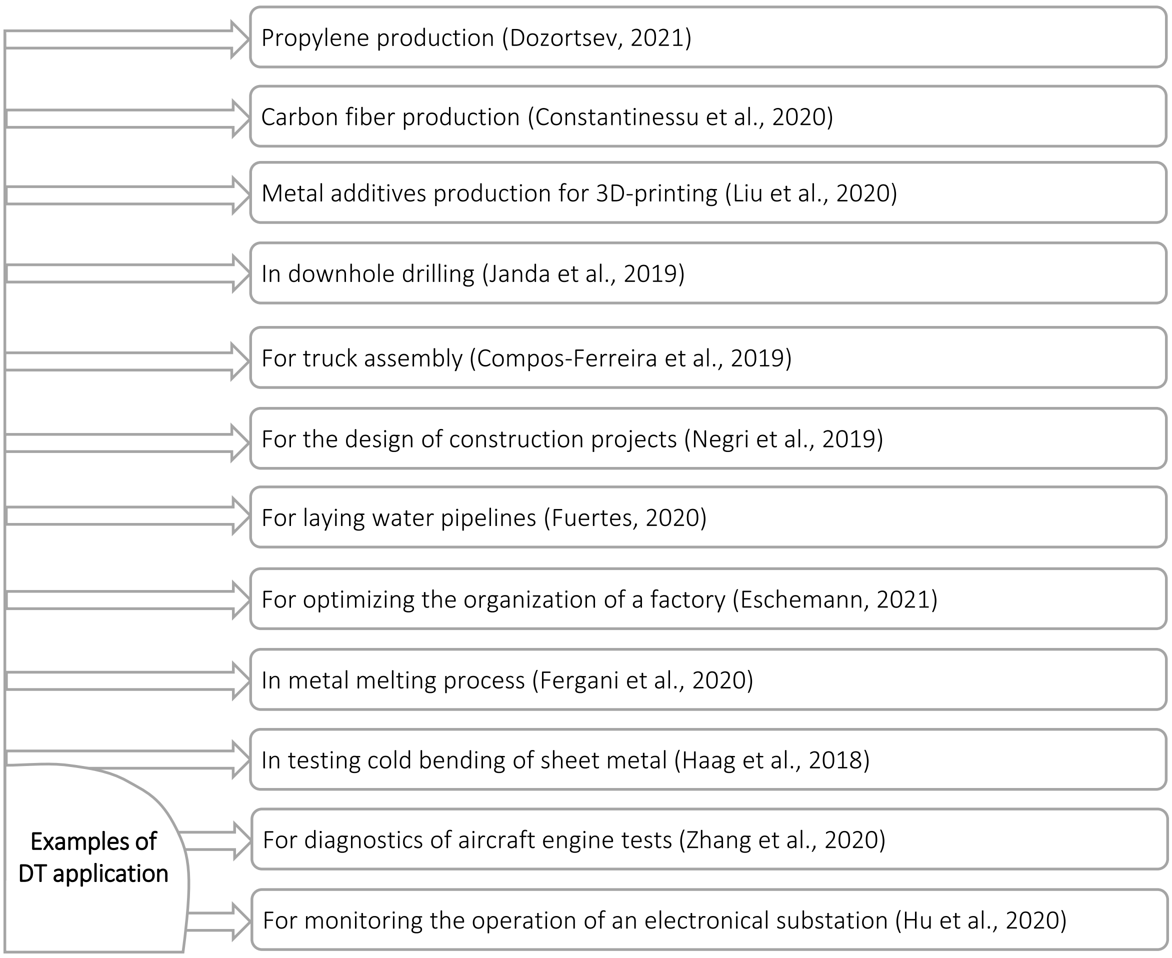

Figure 4. Examples of DT application in industries

1.6. Practical application of digital twins (DT)

Recently, the scope of DT has expanded significantly. Their use is especially effective in industries with harmful and hazardous working conditions in hard-to-reach control areas (Dozortsev, 2021). DT are used to identify ineffective equipment operation and potential safety threats to optimize equipment operating parameters. Some examples of practical applications of DT are shown in Figure 4.

Table 3. List of selected future green knowledge and skills/competencies for the renewable energy sector

Source: Complied based on Akyazi et al. (2020), Sineviciene et al. (2021), Arcelay et al. (2021), Voronenko et al. (2017).

Knowledge	Skill/competence
Adapt energy distribution schedules	Adaptability and adapt to change
Adjust engineering designs	Advanced data analysis and modulization
Advanced literacy	Advanced IT skills and programming
Approve engineering design	Analyze energy consumption
Carry out energy management of facilities	Appropriate linguistic skills
Circular economy	Artificial intelligence (AI)
Civil engineering	Assess project resource needs
Complex information processing and interpretation	Augmented reality
Continuous learning	Big Data
Cybersecurity	Climate change risk management
Design wind turbines	Cloud computing
Digital twin communication among components, equipment (M2M), and environment	Complex problem solving
Electrical engineering	Coordinate electricity generation
Energy performance of buildings engineering principles	Create AutoCAD drawings
Engineering processes	Critical thinking and decision-making
Ensure compliance with safety legislation	Cross-functional process know-how
Environmental awareness	Data management-safe storage
Environmental engineering	Develop material testing procedures
Fluid mechanics Industrial heating systems	Examine engineering principles
Inform on government funding	Electric generators
Knowledge and understanding of international and national standards and legislation	Electrical power safety regulations in the energy market
Knowledge and understanding of quality procedures related to digital transformation	Energy efficiency
Manage engineering project	Entrepreneurship and initiative-taking
Mechanical engineering	Identify energy needs
Mining, construction, and civil engineering machinery products	Inspect facility sites
Opportunity assessment	Inspect wind turbines
Perform project management	Interdisciplinary thinking
Perform scientific research	Acting IoT
Platforms for energy management of equipment and plants	Machine learning
Power engineering	Maintain photovoltaic systems
Promote sustainable energy	Make electrical calculations
Provide information on geothermal heat pumps	Manage contracts
Provide information on solar panels	Monitoring systems of energy consumption
Provide information on wind turbines	Oversee quality control
Renewable energy technologies	Power electronics
Research locations for wind farms	Prepare technical reports
Solar energy	Quantitative and statistical skills
Sustainable resource management	Report test findings
Technical drawings	Risk management
Use technical drawing software	Sensors technology
Water conservation	Traceability
	Troubleshoot
	Use CAD software
	Use of digital communication tools
	Use software tools for site modeling
	Waste reduction and waste management

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Preparing future professionals for the renewable energy sector requires computer models and digital twins in training. This is evident from the knowledge and skills they need (table 3).

It should be noted that the competence of future employees should be much broader than the performance of technical functions at a particular workplace. It is also extremely important to implement the various communication relationships provided by the synergetic origin (see Figure 2). In particular, Koilo (2021) and Jakobsen et al. (2020) draw attention to four important types of relationships:

- *vertical links* – companies associated with a customer-supplier relationship (the latter is seen as a value chain);
- *horizontal links* – companies linked to each other through complementarity (e.g., tourism, where different industries such as accommodation, catering, and culture together create a coherent product) or substitutability in the market;
- *knowledge and competence links* – companies and knowledge actors aligned by common or complementary input factors, technologies, processes, and competency needs (e.g., energy-intensive industry or technology industry);
- *ownership links* – individual companies can be part of the same group and be able to distribute capital and resources between divisions.

In the future, the relevance of these groups of relationships will only increase, and there are several reasons for this:

- *customization of customer-supplier relationships* meeting the individual needs of customers when a manufacturer goes into direct contacts with a consumer;
- *the transition of production to horizontal networks and a solidarity economy* – manufacturers become owners of the means of production and must also implement economic relations;
- *digitalization of the economy* causes the transition from the priority of material production to the importance of information production, and the manufacturer also becomes a communicator;
- *globalization* leads to the internationalization of economic communications, and the manufacturer must ensure cross-cultural and transnational relationships.

Traditionally, economists associate the concept of "human capital" with the production sphere. Meanwhile, customization of production, individualization of products for orders of specific consumers by introducing constructive or design changes make the consumer an active participant in the production process. This means that speaking about the reproduction of human capital, one should consider the directions of knowledge and skills (by producer and consumer) that ensure their readiness for such an active role.

2. DISCUSSION

A trend analysis of knowledge and skills of personnel that are already being formulated in new sectors shows the impact of Industries 4.0 and 5.0 on this process. A renewable energy professional must know and operate with Industry 4.0 products such as the Internet of Things, Big Data, artificial intelligence, augmented reality, machine learning, cloud computing, digital twins, cybersecurity, etc. On the other hand, Industry 5.0 forces a person to look for a new place and new creative functions in the cybernetic world. This gives rise to personnel requirements such as adaptability, critical thinking, decision-making, cross-functional process know-how, advanced literacy, complex problem solving, advanced data analysis, and others. These transformations in the reproduction of human capital are a consequence of the changes taking place in society and a factor that accelerates these changes.

The possibility of full automation of economic processes based on the Internet of Things has sufficiently alarmed the world community with the prospects of "dehumanizing" the spher4e of production (Sotnyk & Zavrazhnyi, 2017). It took only a few years for the concept of Industry 5.0 to appear, which, relatively speaking, "returned" a

Source: Compiled based on Backford (2020), The future (2018).

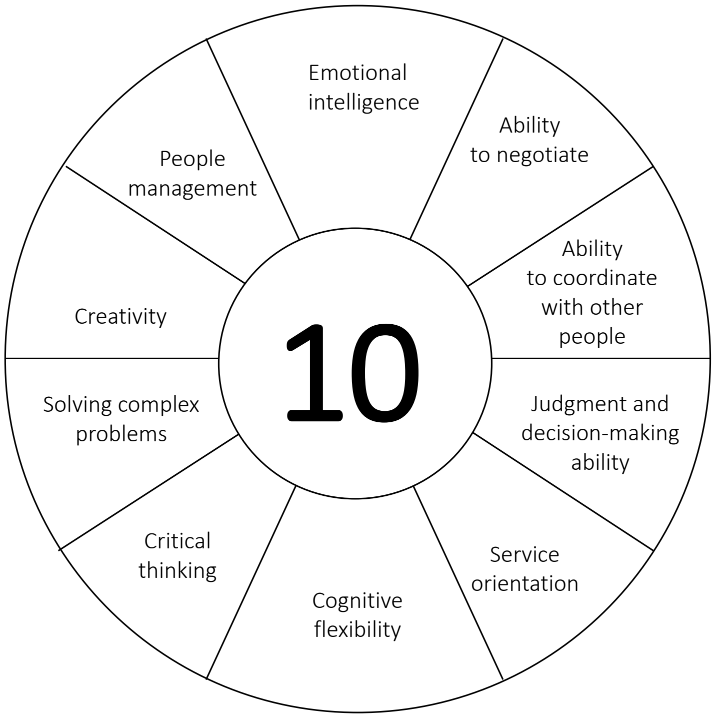

Figure 5. Ten critical work skills projected for 2022

person to the production environment, but only transformed production functions in such a way that the creative (personal) principle of a person would be applied there. In the new economy, the need for low-skilled personnel skills is significantly reduced, which is noticeable from the forecast of labor automation trends for 2022 in the course of Industry 4.0 (Table 4 and Figure 5).

Table 4. The average likelihood of work automation across industries during Industry 4.0

Source: Compiled based on The future (2018), Skinner (2018).

Field of activity	Average probability score, %
Low-skilled workers	78
Care, entertainment, and other services	77
Sales and customer service specialists	75
Qualified exchange workers	75
Process plant and machine operators	62
Administrators and Secretaries	41
Junior technicians	38
Managers, directors, executives	16
Qualified specialists	13

The production skills that will be in demand in future production are quickly intellectualized and computerized. Skills that were among the leading ones five years ago came to the background: "quality control", "dexterity", and "orientation in space" (Matsenko & Ovcharenko, 2013). New technologies provide new opportunities, and we need to make most of them.

3. FURTHER STUDIES

Improving production both along the path of its digitalization (Satell, 2019) and cyberization and humanization is possible only if a person sets more and more complex tasks for himself and artificial intelligence. Development is possible only when new problems arise, which is true both for large systems and functions. However, the harmonization of objectives implemented, on the one hand, by cyber-physical systems and artificial intelligence, and, on the other hand, by human creativity, requires additional studies. The main idea that can be traced is the need for human co-evolution/co-adaptation with developing artificial intelligence and cyber-physical systems. This forces to

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change the content and direction of the essential components of the mechanism of influence (economic instruments, legal framework, and social institutions). The new economy requires the reproduction of a new person (including his knowledge, skills, moral principles, the fundamental basis, which is the personal principle). On the other hand, the person himself is transforming the Industry 4.0 and must control the trends in the development of the technological environment. In Industry 5.0, the tasks of increasing efficiency and productivity are replaced by improving the conditions for the social development of a human personality. In this regard, it is important not only to determine the objectives and content of a human's social (personality) development but also to form a motivation system for self-improvement and self-development of the human personality.

CONCLUSION

The implementation of three Industrial Revolutions simultaneously and the increased requirements for human capital's cognitive and creative skills in connection with the development of artificial intelligence and the cyberization of socio-economic relations require an early transformation of the training and retraining system of human capital. But, unfortunately, relatively few companies and enterprises realize the importance of using digital twins and augmented reality in training human capital in practice.

The literature review pointed out that the human learning system must be transformed with the development of the person himself and the influence of technological progress. The humanistic theory of learning comes to the core today, recognizing that a person has an innate quality to lifelong learning. It is becoming clear that it is necessary to reproduce human capital throughout life, and the most successful models meet human needs by integrating learning based on smart manufacturing and smart economy, where developing and reproducing digital twins is an essential component of such training. To perform the learning function, the digital twin must simultaneously reproduce the effect of contact with the material (physical) entity, information data, and simulate the synergistic component (interconnection of subsystems). It is necessary to reproduce such a learning model that would enable a person to integrate, find himself and reproduce in a "system of systems", which, thanks to digitalization, becomes a part of every person's life. Due to the Internet of Things, a person becomes an intelligent consumer though the individualization of the processes of production and consumption of products, which can affect this production. Therefore, along with the creation of digital twins, which are an analogy of goods, one could talk about the creation of a digital twin that would characterize the main features of the consumer.

The importance of transforming the training system is related to constant changes in production processes and value chains. The study reveals that a person needs to acquire new knowledge and skills in the shortest possible time. To achieve this goal, it is necessary to use modeling and digital twins and other disruptive technologies (virtual and augmented reality, artificial intelligence, gamification, Big Data, Cloud Technologies) to reproduce digital analogs of specific tasks and simulate practical situations.

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