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Digital Transformation of Education

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***Abstract*— The existing international education system is a product and an element of the first industrial revolution, functions on the basis of the principles of flow type production and specialization, which were established in the 18th century, and solves the problem of maximum coverage of masses of population with typical knowledge sets. At the same time, its priority is not the maximization of the quality of obtained knowledge, its individualization or universalization. Priority tasks of the outdated education system are directly reflected in the construction of its structure and functioning, the striking shortcomings of which are currently manifested, including the growth of international statistical indicators of unemployment against the background of the outstripping growth of the number of unemployed jobs.**

The article deals with the transformation of education in the transition of society from one technological mode to another and the trends of development.

Keywords*— *Digital SMART University, University 4.0., digital transformation, processes, services, electronic education, electronic educational environment, remote learning, The information and industrial revolutions, the technological stage.

I. INTRODUCTION

There is nothing more powerful in the world than an idea whose time has come.

Victor Hugo

Let us consider the main long-term factors that initiate changes in the educational system from the perspective of the stages of the evolution of the system of knowledge reproduction and the waves of the industrial revolution. This will allow us to identify the accumulated changes in the requirements for the educational system and the arsenal of tools that have been created to date, which provide the basis for the corresponding changes.

Under the system of education, we understand the model that combines institutional structures (school, university, pre-school educational institutions, colleges, etc.) whose main purpose is the transfer of knowledge to students.

Today's transformations and advances in networking and digitalization have led, among other things, to a qualitative change in the way people work with information and the means of storing, processing and transmitting it.

II. STAGES OF KNOWLEDGE TRANSFER DEVELOPMENT

In terms of the accumulation and exchange of knowledge, there is a clear trend towards increasing the availability of knowledge to the population and the development of techniques for its purposeful delivery for effective reproduction and multiplication. In order to analyze the factors of change in the education system, the evolution of the means of information storage, its controlled delivery to the "user" of the education system is of primary interest. The following stages can be distinguished [1]:

Stage 1: Before the emergence of complex speech, acquired skills and knowledge were forced to die with the next pioneer.

Stage 2: In the second stage, people learned to transmit and reproduce knowledge through speech. In the process of transmission, much of the information was distorted. The number of subjects receiving information could not be large. Transmission took a long time. Complex concepts in the process of transmission were distorted to the point of complete loss of value. The growth of total knowledge was hindered by the fact that local islands of knowledge accumulation often perished in connection with another natural or social cataclysm.

Stage 3: The invention of writing led to the growth of knowledge channel efficiency in transmission speed, capacity and resistance to interference. The author was able to communicate in parallel with many readers. At the same time the distortion of transferred knowledge was minimized. Creators of knowledge got a tool for dissemination of knowledge grains on a global scale. The probability of knowledge reaching a fertile environment increased significantly. An era of scientific growth and mass learning began. However, the production of handwritten books was not mass-produced. Books were expensive. Copyists made many distortions. The cycle of reproduction and multiplication of knowledge was unstable.

Stage 4: The emergence of book printing in the 15th century changed the situation dramatically, leading to a stable cycle of reproduction and multiplication of knowledge, creating the potential for exponential growth.

Stage 5: In the next stage came the means of operative mass distribution of knowledge through electronic mass media: radio and television. However, these tools, which greatly benefited in speed and mass, were severely limited in terms of the amount of useful information transmitted.

Stage 6: The creation and widespread dissemination of the Internet has once again qualitatively changed the information environment and the cycle of knowledge reproduction. Every person interested in the consumption and creation of new knowledge had access to almost any necessary knowledge on demand and without significant delays, as well as an operative channel of mass distribution of new knowledge with minimal costs. The potentially fertile environment has been given a guaranteed encounter with a seed pool of knowledge. Perhaps the only unresolved

problem to date is the overwhelming noisiness of the new information environment by a variety of information garbage, which is partially compensated by the efficiency of information search and self-organization tools based on data banks, World Wide Web, social networks, Wiki - technologies and blockchain. It was also at this stage that the creation and widespread use of means for protecting data from unauthorized access and its integrity by methods of asymmetric encryption and electronic signature, as well as the development of design approaches to information design (User interface) and customization (User experience) were ensured. Another striking phenomenon, not directly related to networking, emerged in the Stage 6 timeframe: the development of independent knowledge testing and certification institutions.

Stage 7: The modern stage of information environment evolution eliminated the physical attachment of its subjects to the office or any other permanent location and tied the interaction terminal to the knowledge consumer directly through the mass spread of cellular communications, smartphones, tablets and other mobile computing devices, besides providing continuous feedback of information environment to the consumer offering means of his identification, geographical search and execution of financial transactions. This gave an impetus to the development of paid network services, providing access to educational products of various kinds. In addition, the current stage of information environment evolution has provided a wide practical application of artificial intelligence technologies for the functions of user identification, information search, information organization, information adaptation for an individual user, data analysis, etc.

Thus, the modern environment of creation, accumulation, storage, transfer of knowledge is characterized by the following functionalities:

1. Knowledge can be copied many times.

2. Knowledge can be stored in volumes exceeding any reasonable need in textual, visual, sound forms (as well as in the form of algorithms, logical rules, etc.).

3. Design approaches to information design (User interface) and customization (User experience) are widely used, increasing consumer characteristics of knowledge as a product.

4. Knowledge can be promptly delivered to almost any geographical point to the direct consumer with its exact identification.

5. Information environment provides the ability to quickly manage the process of knowledge delivery, its dynamics and control the result of delivery.

6. Institutions of independent control of knowledge are developed and widely implemented at the international level.

7. There are effective mechanisms of search and selection of knowledge in the accumulated arrays.

8. There are effective means of knowledge accumulation, ensuring the integrity of knowledge and its protection from unauthorized access.

9. The knowledge system is continuously self-organized and optimized, including the results of interaction with the individual user.

10. Artificial intelligence technologies are widely used for data analysis, self-adaptation of knowledge arrays and systems of interaction with the user.

11. All operations on publication, delivery, processing, storage, copying of knowledge can be carried out with negligible financial and time costs.

12. Information environment allows full bilateral or multilateral information exchange in textual, voice and video forms.

13. Effective financial transaction management tools are implemented in the knowledge management system.

In addition, a number of features of the body of knowledge itself in modern society, significant for educational systems and programs, are manifested. Firstly, the rate of obsolescence of a single unit of information increases many times due to the increase in the rate of creation of new knowledge. Integrity and urgency of information is provided by attraction of information and data from several spheres simultaneously. Knowledge becomes more connected. Secondly, the applied universality of knowledge is changing, as practices and knowledge created by some companies and communities are not always adaptable, applicable or true to other companies and communities.

On the basis of applicability, the structure of the knowledge system begins to emerge clearly - knowledge as a product for learning must certainly stand out from the deluge of short-lived information that cannot meaningfully influence the usefulness of the learner. In addition, the importance of advanced creative knowledge, which is not a reflection of existing reality in the brain of a contemporary, and arises at the junction of other fields of knowledge and broad generalizations, is constantly increasing. It is precisely this kind of knowledge that Steve Jobs repeatedly referred to.

Probably the least affected function of institutions of higher education remains that of creating new knowledge and scientific activity.

III. Changes in the Systm of Education

The aforementioned functionality of the modern knowledge system allows for the following changes in the education system:

1. eliminate the need for learners to be physically present in certain physical centers of knowledge storage and transfer, such as universities, schools, libraries, etc.

2. Build a responsively managed self-adaptive continuous learning process with effective feedback.

3. effectively monitor the quality of the result of the learning process and its individual stages.

4. If you can assign the most part of knowledge supply functions to the consumer in a self-organizing, optimizing and adapting to the consumer personalized information environment.

5. To reduce the cost of training of individual consumers.

6. Refuse from unification and standardization of knowledge volumes in training. Manage flexibly granularity of delivered knowledge volumes and provide their product design.

7. Use a wide range of forms of knowledge delivery: video, audio, text, logical rules, algorithms, etc.

8. Implement the learning process with the connection of financial instant transactions in the form of SMART-contracts.

9. Provide effective protection of knowledge from unauthorized access and its integrity.

10. Shift the focus of learning from the accumulation, storage and transfer of knowledge in a particular area to the formation and development of tools for the creation, analysis and synthesis of knowledge both within and between different sciences to form, including advanced cognitive knowledge.

In general, the capabilities of the modern environment of knowledge reproduction and development provide effective tools for modernization of the education system, create the necessary conditions for this transformation, and so far their potential is largely unrealized. Next, let us consider the impact of changes in technological modes and the evolution of industrial production.

Technological stage is a set of technologies characteristic of a certain level of production development. Their change is determined by scientific and technological progress. Technological stage is one of the terms of the theory of scientific and technological progress (STP). The world owes the appearance of this concept to the scientist and economist Nikolai Kondratiev. This term is now widely used in Russian science by economists D. S. Lvov and S. Yu. Glazyev.

There are several approaches to the formulation of the stages of qualitative transformation of industrial production. The 4-stage vision in one of the variations described by economist Robert Gordon and described, for example, in the article of the Independent magazine [3] is widespread.

IV. Evolution of Technological Models

Let us consider the change of technological modes occurring under the influence of industrial revolutions (waves of qualitative changes) within the framework of a single vision.

The First Industrial Revolution or otherwise, the "wave of renewal" (1750-1830) was based on the invention of ways to use steam energy, coal, rail transport and textile production. This revolution formed the First technological mode.

The Second technological mode was formed in the period from 1830 to 1880 on the basis of the Second Industrial Revolution, which started with the accelerated development of transport (construction of railroads, steam navigation) and the emergence of mechanical production in all industries.

The same (second) industrial revolution has led, as a result, to a new qualitative transition and formation of the Third Age (1880-1940) by means of growth of scale of production, wide implementation of electrical engineering, internal combustion engine, use of hydrocarbons, development of chemical industry, modern entertainment industry and modern means of communication. Radio, telegraph, and automobiles were introduced as part of this pattern. Large firms, cartels, syndicates, and trusts emerged. The concentration of banking and financial capital began.

The fourth pattern (1930-1990) was formed as a result of the further development of energetics with the use of oil and oil products, gas, means of communication, new synthetic materials, mass production of cars, tractors, planes, various kinds of weaponry, consumer goods. This pattern was the source of the third industrial revolution, which emerged around computer technology and telecommunications, the use of nuclear energy.

Computers and software products and radar appeared and became widespread. Nuclear energy is used for military and peaceful purposes. Mass production is organized on the basis of conveyor technology. Oligopolistic competition dominates the market. Transnational and multinational companies appeared, investing directly in markets of different countries.

The Fourth Way was replaced by the Fifth Way. Its approximate period of prevalence is 1985-2035. The distinctive features are the focus on the achievements in the field of microelectronics, informatics, biotechnology, genetic engineering, new types of energy, materials, space exploration, satellite communications, etc. There is a transition from geographically localized firms to network globally integrated holdings that cooperate closely in the field of technology, product quality control, innovation planning, and logistics.

The fourth industrial revolution based on digitalization ("Industry 4.0") - artificial intelligence, robotics, blockchain, the Internet of Things, and big data - has emerged within this framework.

Modern science predicts with some certainty the formation of the next Sixth Way, which, for example, according to G. G. Malinetsky, will be based on a new state of biotechnology, nanotechnology. designing living things, investing in humans, new nature management, new medicine, robotics, high humanitarian technologies, future design and its management, technology of assembly, development and destruction of social subjects, flexible adaptable production. Thus, the modern Fourth Industrial Revolution turns out to be the source of formation of this future pattern, and it is in anticipation of it that the goals and objectives of education system modernization should be formed.

The revolutionary waves recognized by some authors, which are capacious in resources and bright in certain achievements, originate in the depths of existing, recognizable ways of life, but do not always lead to their immediate change, and are an indicator of the conflicts accumulated within ways of life between economic elements and institutions, which develop with different dynamics. From our point of view, a similar revolutionary conflict is currently accumulated because of the incompatibility of the modern education system with the existing fifth pattern and the Fourth Industrial Revolution, which is gaining momentum and should lead to the formation of the Sixth Pattern.

In terms of maximum impact on the growth of production and social standards, R. Gordon distinguishes the second industrial revolution. The period, which was maximally affected by these changes took about 100 years that followed. At the same time, R. Gordon notes that the third industrial revolution did not lead to the expected large-scale changes in production and social standards. To illustrate this conclusion he gives the following example - a resident of the developed countries of the 1970s is easily perceived as an equal by our

contemporary, while he will be perceived as a non-technological "savage" of the advanced townspeople of 1870.

Considering the abovementioned conclusion, we will take the name of the current stage as the revolutionary wave Industry 4.0 for synchronization with modern terminology regarding industrial revolution waves, but for more grounded analysis of educational system evolution as socio-economic institution we will use the interpretation of industrial revolution waves, which does not contradict the above mentioned, but distinguishes two main stages, which have maximum influence on industrial production and socio-economic institutions, suggested in [1].

V. Interpretation of Industrial Revolution Waves

The first wave, which provided mankind the opportunity to use the products of mass production, began in the late 18th century with the invention of the steam engine. A century later, it received theoretical support in the form of Taylorism principles, based on flow conveyor production and specialization of operations. In about 30 years, the mass of typical and cheap products of high-tech production entered the markets of developed countries. Naturally, the new organization of production required a change in the educational system to provide an appropriate highly specialized workforce. For the purposes of this study, an additional result of the development of flow production as the development in the 20s of the 20th century and the wide implementation of the Total Quality Management theory with a set of developed tools (continuous improvement cycle, the Pareto principle, etc.) is of interest.

The second wave started with the invention of the computer in the mid-20th century, based on networking, digitalization, wide penetration of automated elements in all areas of industrial activity, education and private life of people.

The form of socio-economic institution of the education system functioning today, has a 200-year history, is specialized in the reproduction of human resources supporting the modern system of economic management, based on mass, specialization, typification and standardization.

At the same time, it should be taken into account that in reality the structure of the current educational system was established even earlier - elementary school and university system were formed more than 1000 years ago in the epoch of feudalism and prevalence of theological set of basic disciplines, having kept the priorities and main approaches (standardization and mass nature) up to the present time. As part of the industrial revolution of the 18th and 20th centuries, this system of education grew considerably in volume, productivity in terms of population coverage, the set of disciplines changed and expanded, but its structure remained largely the same. The wave of the Industrial Revolution, which began in the mid-20th century, did not have time to have a significant impact on it. It is probably only in the last 2-3 years that we have seen the most marked changes in this part of the socio-economic institutions, manifested under the influence of the pandemic.

Unfortunately, a fundamental theory of the next qualitative transformation of the sphere of production, similar to Taylorism of the 19th century, has not yet been developed. It can be assumed that the widespread use of computing devices in production should, contrary to Taylorism, lead to the displacement of human labor from flowing production chains into the field of creative and scientific activity, and ensure the widespread individualization of final products with an overall decrease in their value. This transition should manifest itself, among other things, in increased opportunities for the consumer to manage the options of purchased goods at the stage of choice [6].

In 2021, labor shortages and labor market crises headlined international economic journalism. For example, The Economist in a number of key publications points to the growing crisis phenomena in the market of developed countries, which manifests itself as a parallel growth of unemployment, including voluntary unemployment, and the number of unfilled vacancies. In international publications, this phenomenon is referred to as the Great Resignation. The author of the article [4], for example, makes a similar statement. There is a growing conflict between the employers' interests to develop new high-tech productions under changing conditions and the ability or readiness of potential employees to take the offered vacancies under the previous conditions.

Probably, this phenomenon can be characterized as a growing gap between the need for certain specializations and competences and their availability at the market. In other words, the labor market has not had time to respond adequately to changes in the needs of major economies for specialists of various kinds.

Given that the quantitatively uncompensated demand for labor corresponds to the level of growing unemployment, we can reasonably assume that the source of the problem, among other reasons, is the imperfection of the existing education system. This formulation is indirectly confirmed by a wave of scientific, methodological and popular publications concerning the search for and development of talents, i.e. non-typical highly effective and bright products of the educational system.

Interestingly, a feature of the new production environment is the priority demand for portfolios of various kinds (confirmation of successful experience, creativity and adaptability) as the main indicator of a candidate's readiness for a vacant position, especially for a set of new specialties, rather than traditional standard documents (diplomas, certificates, etc.) confirming the acquisition of a set of formal knowledge. Previously, portfolios were in demand in creative professions that did not lend themselves well to standard methods of knowledge control. This is probably due not only to the outpacing growth of new professions that the educational system has not mastered, but also to the displacement of the individual in the field of non-standard creative activities.

VI. Conclusion.

New production approaches should be supported by the renewal of the education system, which should solve more complex and diverse educational tasks, become more flexible, provide more qualitative and individualized results oriented to creative tasks and scientific challenges, including future ones. At the same time, the transformation of the higher forms of education is an absolute priority. First of all, university education [7]. Let us briefly summarize the main

conclusions of the analysis of the influence of the stages of production development on the education system:

1. The existing system of higher education is obsolete both in its form-structure (a network of physically localized institutions of knowledge transfer and storage) and in its priorities (mass character and standardization).

2. Significant conflict has accumulated between the existing system of education, the opportunities offered by the evolution of the system of creation, reproduction, transfer of knowledge, the fourth industrial revolution, the existing fifth technological mode and the need for transition to the sixth.

3. The formed need for modernization of the education system, the accumulated achievements of industrial revolutions and the evolution of the system of reproduction and development of knowledge to date provide the necessary and sufficient conditions for the transition to a new state of the education system.

4. Higher education should provide the economy with an ever-growing variety of complex non-typical and creative competences, which can be constructed on the fly. At the same time, the need for narrow typical specializations is continuously decreasing due to robotization of typical processes and displacement of humans from them.

5. It is necessary to ensure a wider application in education of the approaches of the General Theory of Quality (e.g., Cycle of Continuous Improvement), which have been developed and widely tested in the last decades in industrial production, but which are not yet applied in the educational system.

REFERENCES

[1] Gromov G.R. Essays on Information Technology. - Moscow: InfoArt, 1993.

[2] https://cyberleninka.ru/article/n/elektronnaya-informatsionno-obrazovatelnaya-sreda-universiteta-printsipy-postroeniya-i-struktura/viewer

[3] https://revolution.allbest.ru/pedagogics/00710928_0.html

[4] https://cyberleninka.ru/article/n/analiz-osnovnyh-biznes-protsessov-obrazovatelnoy-deyatelnosti-vysshego-uchebnogo-zavedeniya-dlya-povysheniya-effektivnosti/viewer

[5] Textbook 4CDTO The IT Directors Club 4CDTO. M.: Sam polygraphist, 2020.

[6] Engineering methods in the tasks of digital transformation of the economy. Book1. Digital transformation. Under the editorship of Doctor of Technical Sciences, Professor Vladimir Nikolayevich Azarov. Textbook. -Moscow - Yaroslavl: Foundation "European Center for Quality" and Pastukhov Academy, 2021. - 288 p.ISBN 978-5-901771-80-8, DOI 10.31145/978-5-901771-80-8-2021

[7] V.N. Azarov, B.V. Boitsov, A.V. Chekmarev. Digital transformation during pandemic and postpandemic. Journal "Quality and Life" № 6,2021, pp.34-52.