Key Competencies in the Digital Age and Transformation of Education

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Abstract. Due to the influence of digitalization and other changes affecting different spheres of people's lives, it became clear that the modern education system must undergo a serious transformation, because the traditional education system is seriously outdated. It is expected that in the near future a significant part of education will be based on modern digital technologies, and the educational process will be implemented with the use of global educational platforms that provide students with the opportunity for global interaction and advanced knowledge and experience. The aim of the study was to formulate the features of industrial and modern education systems, to compare them, as well as to identify a set of competencies that people need to form in order to effectively cope with their professional tasks in the digital age. The issue of the optimal combination of standard educational approaches with the new technologies used in education, which allow to develop competencies that need to be formed among people in order to be in demand in the labour market, is becoming topical.

1. Introduction

The economic structure of modern society is beginning to change under the influence of key trends, one of which is digitalization, which penetrates into all spheres of human activity. The principles of VUCA-world functioning set fundamental changes in the society, and such conditions as volatility, uncertainty, complexity and ambiguity have become characteristic of it [1]. New demands for revolutionary changes in education are therefore dictated, as well as competencies that must be taught to meet the requirements of the modern labour market, which is beginning to function in the digital environment. Today's education system tries to transform itself into an ecosystem in which its elements must become connected and interacting with each other and respond flexibly to the needs of society.

2. Methods

The paper considers the data obtained from scientific papers and periodicals, which demonstrate that state of modern education system which coaches people to work in the digital environment. Based on the research conducted at IBM, the following are the skills in demand by a global corporation: flexibility and adaptability - 51%; ability to communicate effectively in the business environment - 53%; computer and software skills - 61%; STEM-skills - 61% [2]. The name of the latter group
describes the skills acquired through interdisciplinary and applied learning, which includes the study of natural sciences combined with engineering, technology and mathematics ("STEM" comes from the English words science, technology, engineering, mathematic). Thus, the modern education system must undergo a transformation, which shall take into account that, on the one hand, the educational process is associated with the transfer of knowledge, skills and experience through personal communication with the teacher, and, on the other hand, a significant part of education in the near future will be based on modern digital technologies.

3. Results and Discussion

During the expert sessions, Global Education Futures and Future Skills identified a number of trends that have a significant impact on all sectors of the economy and determine how workflow will look in the foreseeable future [3, 4, 5, 6]. Key trends are divided into the following categories: technological, social, techno-social (at the intersection of social and technological spheres) and meta-trend. These categories include the following seven key trends that form the economic structure of the future society

1. Digitalization of all spheres of life. More digitized data are becoming available, the Internet is becoming more accessible, and digitalization technologies are mastering new areas of human activity.
2. Automation and robotization. The development of autonomous systems capable of complex physical and cognitive actions transforms the role of human labour in all sectors of the economy.
3. Demographic changes. Increasing longevity, continued urbanization, the growing role of women in the economy and the changing model of childhood are beginning to determine the new social structure of society.
4. Formation of a network society. New, more flexible ways of managing companies and communities are emerging, complemented by the development of networking technologies and the proliferation of blockchain-based solutions.
5. Globalization (economic, technological and cultural). Production chains, consumer goods, scientific knowledge and cultural codes emerge and exist in a world where everything is connected and where the role of transnational cooperation is growing.
6. Ecological awareness. Consumers and producers of goods and services are becoming increasingly environmentally conscious.
7. Acceleration. All of these changes are influenced by one common meta-trend - the increasing rate of change. It sets the pace of renewal, including for the outside world, and most of the existing social institutions, including the education institute, are not yet ready for these changes properly [6].

Thus, technological trends include the first and second (digitalization and automation); social trends - the third and fourth (demographic change and network society); techno-social trends - the fifth and sixth (globalization and ecologization), and there is a general meta-trend - acceleration. It should be noted that technological trends are easily noticeable, as they appear at the physical level and have an immediate impact on the surrounding reality [7]. Social and techno-social trends may not be as noticeable as they are less visible in everyday life. However, they shape the structure of society, set the demand for goods and services, and influence the way in which work is organized. The development of these trends has already begun to show and will continue to grow at all levels of people's work activities: at a specific workplace (at the personal level), in the organization (at the micro level) and in the economic sector (at the macro level).

Today, digitalization has affected all spheres of human life, and digital transformation concerns such areas as customer centricity, partner centricity, Big Data governance, Research & Development, value management, HR strategy and digital culture [8]. All these directions concern various spheres of functioning of society, including the system of modern education.

1. Customer Centricity. The key direction of digital transformation is the need to understand and study the consumer, who consumes educational services in sphere of education [9].
2. Partnership and collaboration (Partner centricity). Digital transformation is based on the principle of development of infrastructure as a platform, or the entire ecosystem. Digital partnership
allows different elements of the ecosystem to provide their services, regardless of their geographical location, from anywhere in the world based on a common distance learning system.

3. Big Data governance. It is important to take into account Big Data when forming the strategy of digital transformation, because today they are used to model customer behavior, predict demand and form preferences.

4. Search and implementation of innovations (Research & Development). Thanks to digital technologies, various innovative forms and technologies are used in the learning process.

5. Management of product value (Value). The use of digital technologies allows companies to transform the value of their products for customers, for whom it is becoming fundamentally important to purchase educational services remotely and at a convenient time for them.

6. Digital culture. People and companies today are beginning to realize that success can be achieved by maintaining a digital culture, learning digital skills, and understanding the importance of continuous learning and development of their potential [10].

During the industrial stage, the functioning of economy and society was based on the principles of the SPOD world. SPOD is an acronym from English words steady, predictable, ordinary and definite. These words denote the conditions in which people and companies existed in an industrial society. However, the modern world has radically changed the principles of its functioning and transformed into VUCA-world (VUCA is an acronym for English words volatility, uncertainty, complexity, ambiguity) [6]. The following conditions it:

- volatility (and instability) - the world is constantly changing, the current situation is changing very quickly;
- uncertainty - it is difficult to predict the future based on the past experience, it is difficult to implement the forecast tasks;
- complexity - the world is becoming difficult to understand, the problems it faces have to be explained and solved, taking into account many different facts, factors and causes;
- ambiguity - the world becomes a place where it is impossible to answer "who?", "what?", "when?", "where?", "why?"

The VUCA-world and the meta-trend of "acceleration" demonstrate that the society and the economy demand revolutionary change (transformation) in education. For example, the condition of "ambiguity" suggests the need for several different approaches in modern education systems to improve the learning process (including the understanding of the problem and how to solve it) and the interaction of participants. These may include the following approaches, which should be taken into account in order to improve the functioning of the education system:

- theoretical and practical-oriented;
- formal and informal;
- temporary (specialized) - permanent (continuous);
- individual - collective;
- cognitive - emotional, etc.

Let us consider the features of a traditional industrial system of mass education, which exists and successfully functions in the SPOD-world. The features of the industrial model of mass education were among the first to be considered by the British expert in the field of education Ken Robinson. In his book "School of the Future" [11] he pointed out that the traditional model of education appeared in developed countries of the XIX century. It was created to meet the needs of industrialists in labour, and also prepared people to work in bureaucratic establishment. At that time, work was associated with a standardized mass production conveyor workflow pattern. The industrial model of mass education was characterized by specific objectives set for it, which we will review below.

1. The main feature of the system of mass education was its standardization, which had led to many specific features. The performance of standard tasks in line with a mandated timeframe and curricula prevailed. Pupils received similar educational tasks which did not require a creative approach for their implementation. The criteria of success in learning was conformity to a certain standard.
2. The students got used to strict regulation and schedule (for example, a bell to notify about the beginning and the end of each lesson), thus, they were adapted to the future functioning in the rhythm of the industrial society, within a framework of a mandated schedule and job roles.

3. The process of education consisted of strict observance of a linear curriculum, which only sometimes allowed for a relative freedom of choice.

4. It was assumed that a set of skills required for work would be quite static. Therefore, the employee will undergo refresher courses when he or she needs to acquire more advanced skills or move up the career ladder.

5. The focus was on the development of cognitive abilities (emphasis was placed on the development of their logical intelligence - IQ). At the same time, the emotional contact of the teacher with the students and with each other was not given a serious importance. In order to increase the effectiveness of learning process communication between students in the process of performing standard tasks, was not encouraged.

6. Individual performance of standard tasks by pupils, choice of the best among them, competitiveness, use of the rating among pupils, as well as prohibition to help each other prevailed.

7. Setting up personal goals and objectives or pursuing individual interests in the process of learning was not welcomed.

8. The traditional industrial educational system consisted of separate elements (school, technical school, university, etc.), the links between them were not sufficiently established, and each social education institute offered a standardized educational program [12].

9. In the perception of the system of "society-nature", nature was conceived as a "resource", without any regard for nature as a prerequisite for the survival of mankind.

All those mentioned specific features served the purpose of increasing the efficiency of mass education system as well as were aimed at improving control and monitoring of the process and stimulating public obedience.

Thus, the traditional model of the system of mass education has shown its effectiveness in the XIX-XX centuries, functioning on the principle of a conveyor under conditions of industrial society. It successfully prepared people to perform routine tasks typical of the industrial age, and has spread the basic skills of reading, writing, counting among the majority of people on the planet. The industrial system of mass education was created in order to shape people for conditions of the SPOD-world. However, the changed conditions of society and economy functioning, the introduction of digitalization in different spheres of life in the XXI century, led to the need to transform the education system. Today's controversial and complex VUCA-world has begun to set new goals and development benchmarks for education. Experts note that revolutionary changes in education should emerge through creation of a new educational paradigm [4]. There should be a transition from the industrial model of traditional education to integrated education, the main objective of which is to reveal the individual potential of each person and the collective potential of humanity.

Let's compare the features of the industrial and modern education systems [5, 6, 14, 15, 16] and find out what competencies become particularly important for the development of modern people and of their potential to be in demand on the labour markets and to fulfil effectively their professional tasks at the age of digitalization (Table 1).

| Features of the industrial system of mass education | Features of the modern educational system | Key competencies in the digital age |
|---------------------------------------------------|------------------------------------------|----------------------------------|
| 1. Mass education was dominated by the ability to complete standard tasks in line with a template within a set timeframe, all pupils attained the same knowledge, which did not | 1. Since the working environment will include all the features of the VUCA world, the learning process is expected to present students with non-typical and diverse tasks that require them to be creative and find non-standard solutions. | - ability to find unconventional solutions; |
|                                                   |                                          | - creativity, including the ability to see opportunities |
|   |   |
|---|---|
| **require them to display a creative approach.** | **2. Teaching was based on a strict regulation and schedule because student were educated to be able to adhere to a work timetable and specific job roles** |
|   | **2. The learning process needs to become more flexible and diverse as the individual is increasingly confronted with fluid job descriptions and situational approaches in a variety of settings as he or she pursues his or her work goals.** |
|   | **- adaptability;**
|   | **- working under conditions of uncertainty;**
|   | **- non-standard thinking;**
|   | **- critical thinking** |
| **3. The training followed a linear curriculum, which only sometimes allowed some freedom of choice. Information was limited by the requirements of the standard and was of a typical nature which suited the educational process.** | **3. A modern person receives abundance of information during education, professional and everyday life, thus it is important to be able to manage one’s attention, learn to sort information, selecting only necessary for solving the problems. Students actively use new technologies and information devices during learning process.** |
|   | **- ability to manage attention;**
|   | **- digital literacy;**
|   | **- digital (media) hygiene** |
| **4. It was assumed that the set of skills required for work would be quite static. Therefore, the employee will undergo refresher courses when he or she needs to acquire more advanced skills or to move up the career ladder.** | **4. Vocational education will face the situation of rapid obsolescence of a number of working specialties and as a result, lack of demand for certain skills among employees. Under these circumstances, it is important for a person to realize the need for continuous learning in order to meet a wide range of educational needs over the course of his or her life. And modern education should help the student by means of flexible programs to obtain the necessary skills.** |
|   | **- consciousness;**
|   | **- curiosity and learning ability** |
| **5. The students were not encouraged and sometimes not allowed to set up personal goals in the process of learning or to pursue their personal interests.** | **5. Personalised trajectories in education and career development: emphasis should be placed on students’ setting their own learning goals and following individual educational interests (including independent research) under the guidance of a mentor. Active search for new learning forms and technics will help students acquire skills and knowledge in line with set objectives.** |
|   | **- openness and development orientation;**
|   | **- ability to learn, including the ability to choose one's own learning strategies** |
| **6. Attention was paid to the development of cognitive abilities of students, and emotional development was not given a serious importance.** | **6. In the learning process, attention should be paid to both the development of students' cognitive abilities and their emotional intelligence (EQ). It is important to encourage students to communicate and interact with each other as well as to interact with the teacher (mentor) in their learning and problem-solving.** |
|   | **- emotional intelligence;**
|   | **- empathy;**
|   | **- stress management;**
|   | **- adequate perception of criticism** |
| **7. Individual performance of standard tasks by students, choice of the best among them, competitiveness, use of the rating among students,** | **7. Students should be encouraged to help each other in the learning process as well as to establish emotional contact between the teacher and the students. In modern companies, it is important for employees to** |
|   | **- ability to collaborate and work together;**
|   | **- ability to solve extraordinary problems in co-** |
as well as a ban on helping each other prevailed. Interact and collaborate with each other in the process of solving volatile, complex and ambiguous tasks. Work in "distribution teams" is becoming popular, when employees fulfill the same tasks and objectives, being in different companies, cities and countries.

| 8. The educational system consisted of separate elements and the links between them were not sufficiently established. | 8. The education system must be transformed into an ecosystem where its elements must become connected and counter-interactive with each other. | - systems thinking; - interdisciplinary |
| 9. The worldwide perception of nature has always been as of a “resource” for production. | 9. The learning process should provide people with an ecological and humanistic picture of the world, based on the principles of environmental ethics. Develop skills for environmentally responsible behavior and understanding that natural resources are scarce, and everyone is responsible for their rational use. Emphasize the importance of economical approach to consumption and reduction of waste. | - environmental thinking; - social responsibility; - lean production |

After considering the peculiarities of the modern education system, it is clear that many of its processes, technologies and formats need to be reviewed. This is important to better equip people with the competencies they need to succeed professionally, socially and personally in the 21st century in digital environment and perpetual change. It is important for today's individual to understand the need for continuous learning to meet a wide range of lifelong learning needs, and modern education should help them do so by providing flexible programs to acquire the necessary skills.

Today, the environmental metaphor of the "ecosystem" has rapidly penetrated many areas of society, such as business and education. The ecosystem shall form in an alternative way. It requires each participant to think in terms of the entire ecosystem and the benefits of its participants, to understand their role in a complex system and to assess the long-term consequences of their actions. It is becoming clear that the ability to think from an ecosystem perspective is becoming an essential skill for today's people, and especially leaders in all sectors of the economy.

The modern education system is trying to transform itself into an ecosystem. Its educational elements should become connected and interacting with each other, be open to the external environment and flexibly respond to the needs of the society. A key feature of the modern (digital) learning model is that the subject of learning is beginning to play a key role in all learning processes. The digital model of learning has such features as adaptability, individual trajectories, human self-education, peer-to-peer pedagogy. The modern education system is beginning to move away from unified standards and offers a variety of educational formats and technologies, such as digital online courses delivered through global education platforms, mobile applications and devices, participation in professional communities, augmented reality applications, gamification and others [11, 18, 19].

The annual L&D Global Sentiment Survey (GSS) survey in 2018 built the following list of educational technology priorities [1]:
1. Personalization technologies and adaptive learning.
2. Collaborative and social learning.
3. Artificial intelligence.
4. Micro-education.
5. Virtual and augmented reality (VR & AR).
A new educational ecosystem will evolve without destroying the existing traditional mass education system, it will stem from it, assuming a sideway direction. The transformation of the modern educational system should affect the following important areas:

1. Become flexible, providing educational experience, which should be diverse in such areas as:
   - duration of learning: the duration of learning can be short, medium, long (depending on the needs of the learner can last from a few minutes/hours to several years);
   - intensity of learning, which can be low, medium, high (advanced);
   - use of different educational styles (e.g. cooperative and competitive, practical and theory-orientated, cognitive and emotional, etc.).

2. Provide opportunities for participation of different independent providers in providing diverse educational experiences. This will allow them to create more complex educational products through exchange and cooperation, better meeting the needs of clients.

3. Be accessible to people of all ages who wish to engage in diverse educational processes.

The latter trend is particularly relevant as the ongoing demographic changes in modern society are beginning to affect the transformation of jobs in companies which have already affected or will affect in the future the following aspects [5]:

- Formation of demand for new services (including training in new skills) by people who are still active at the age of 60+.
- Increase in the number of people aged 60 and over who continue to work in their professional niche, which can cause tension in the younger generation of workers.
- Increased demand for professionals who understand the specifics of older and younger generations in all areas of the economy.
- The need for cross-age communication skills not only when working with clients, but also in building relationships with colleagues.
- The final destruction of the boundaries between the life periods of preparation-work-pension at the expense of demographic changes, which will lead to the universal acceptance of the need to learn and re-learn throughout life.

Thus, the educational ecosystem in the age of digitalization enables learners to rely on digital technology to continuously learn a variety of skills at any age, time and place. The ecosystem will consist of the following four types of educational environments:

1. **Personalized environments.** It is expected that schools, technical colleges and universities will use modern educational technology tools that will help to build personalized (individual) trajectories in education and career of students. That is, they will have to adapt to current goals and objectives, begin to evolve, gradually moving from traditional standard curricula of collective learning to more flexible formats, when the skills acquired will be part of the curriculum.

2. **Collective environments.** These are professional communities that will be built around groups of professionals and will rely on human interaction, creativity, transfer of experience and technology.

3. **Global environments.** They will include global educational platforms that are implemented online, and are likely to become major providers of knowledge and content (“university for million students”).

4. **Local environments.** These are local educational elements of the ecosystem, providing various formats of urban continuing education.

It is worth noting that revolutionary changes in the education system should be based on the creation of a new educational paradigm. The main purpose of modern education is to reveal the individual potential of each person and the collective potential of humanity. In addition to the formation of a set of competencies that will help today’s people to achieve professional, social and personal success in the XXI century, changes in digital environment dictate other important areas that will need to be explored and addressed by the education ecosystem in the near future [1]. These include:

- Growing scarcity of specialists with complex digital skills.
- Increased demand for digital skills in the professional environment.
- Formation of a motivation system for achieving digital literacy and lifelong learning.
- Optimal combination of standard educational approaches with new training technics.
- Assessment of the costs on and effectiveness of digital learning [20].
- Formation of digital competency models for people of different age groups and professional communities.

4. Conclusion

This study looked at the key trends that form the economic structure of modern digital society. It describes the directions of digital transformation, how they affect the sphere of education, as well as functioning under conditions of the modern VUCA-world. The features of industrial and modern education systems have been identified and compared. A set of competencies needed by human resources in order to be competitive on labour markets as well as to cope well with professional tasks in the digital age have been outlined and preferred educational formats and technologies have been discussed. As a result of this research, the directions that should affect the transformation of the modern educational system were formulated. The attempt of the modern educational system to transform into an ecosystem, where every participant will act, understand their role and advantages and realize the long-term consequences of their actions from the point of view of the entire complex ecosystem, was analyzed. The types of educational environments that can make up an educational ecosystem have been suggested.

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References

[1] Bennett, N., & Lemoine, G. J. (2014). What a difference a word makes: Understanding threats to performance in a VUCA world. Business Horizons, 57(3), 311-317.
[2] More than learning: how to develop digital skills? 2019. EduTech 10 (22). DOI: https://sberbank-university.ru/
[3] P. Luksha. Education for a complex world. Global Education Futures. DOI: https://futuref.org/educationfutures_r
[4] P. Luksha 2016, What and how to teach students in the 21st century? DOI: https://rosuchebnik.ru/material/gelp-zachem-chemu-i-kak-uchit-v-xxi-veke-pavel-luksha/
[5] P. Luksha, A. Laszlo, J. Kubista, M. Popovich, I. Nineno. Educational ecosystems for social transformation. DOI: http://school258.ru/upload/editor/files/publication
[6] E. Loshkareva, P. Luksha, I. Nineno, I. Smagin, D. Sudakov. Skills of the future: what you need to be able to know in a complex world. WorldSkills Russia. DOI: http://futuref.org/futureskills_r
[7] Rostova, O., Shirokova, S., Sokolitsyna, N. Management of project for automation of investment control at industrial enterprise. IOP Conference Series: Materials Science and Engineering. 2018. 497 (1), 012017.
[8] What is digital transformation? DOI: https://komanda-a.pro/blog/digital-transformation
[9] Disruption of the Old Consumption Logic. DOI: https://www.ericsson.com/en/trends-and-insights/networked-society-insights/commerce-reports
[10] Design a complete learning experience and transfer learning to practice. 2019. EduTech 27. DOI: https://sberbank-university.ru/
[11] Ken Robinson, Lou Aronica, Creative schools: The Grassroots Revolution That’s Transforming Education, 2015
[12] Vasetskaya, N.O., Glukhov, V.V., Burdakov, S.F. The Elaboration of the Model of
Competences of the Research and Teaching University Staff (2019) Proceedings of 2018 17th Russian Scientific and Practical Conference on Planning and Teaching Engineering Staff for the Industrial and Economic Complex of the Region, PTES 2018, статья № 8604215, pp. 98-101.

[13] Zaychenko, I.M., Kalinina, O.V., Gutman, S.S. Labor resources of the Far North territories: Problems and prospects // Proceedings of the 28th International Business Information Management Association Conference - Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth. 2016. Pp. 758-767.

[14] Aymaletdinov T., Baymuratova L., Gritsenko V., Dolgova O., Imaeva G. 2018. Children and technology. DOI: nafi.ru/upload/iblock/e65/...pdf

[15] Rasskazova O., Kalinina O., Zotova E. Modern transformation of the production structure and its impact on the content of labor and the requirements for the skills and abilities of workers // MATEC Web of Conferences: Business Technologies for Sustainable Urban Development. 2018, C. 01041.

[16] Digital skills training: models of digital competencies. DOI: http://obzory.hr-media.ru/cifrovye_navyki_sotrudnika

[17] TOP 10 Strategic Technology Trends for 2018. DOI: https://www.gartner.com/smarterwithgartner/gartner-top-10-strategic-technology-trends-for-2018/

[18] Gamers Unravel the Secret Life of Protein. DOI: https://www.wired.com/2009/04/ff-protein/

[19] Krasnov, S.V., Kalmykova, S.V., Abushova, E.E., Krasnov, A.S. Problems of Quality of Education in the Implementation of Online Courses in the Educational Process. International Conference on High Technology for Sustainable Development, HiTech 2018 - Proceedings, 8566618

[20] Bril, A., Kalinina, O., Levina, A. Two-stage commercial evaluation of engineering systems production projects for high-rise buildings // E3S Web of Conferences. 2018. 33, 03004.