Co-funded by the
Erasmus+ Programme
of the European Union

HEIn4.0

Document drafted at Business and Technology University
July, 2020

Literature Study

With the development of new technologies, their dissemination into a modern production, the economy, the social sphere leads to rapid changes in global markets. Today, the rate of creation and implementation of the latest developments is faster than at any other time in history and continues to grow. This development of technology will lead in the coming years to the formation of completely new markets that will provide consumers with advanced technological solutions and fundamentally new services. We can talk about the ongoing global industrial revolution, which is the result of the latest advances in information and communication and biotechnology, robotics, and artificial intelligence. (Abele et al. 2015)

The fourth industrial revolution (early XXI century) - the emergence of smart factories, enterprises were automated and robotic industrial systems interact with each other and other enterprises based on artificial intelligence technologies and the Internet of things technologies. These changes are associated with the emergence of global industrial networks, the Internet of Things, 3D printers, neural networks, and research in the field of artificial intelligence.

The fourth industrial revolution is called Industry 4.0, the term for which was introduced in 2011 at the German industrial fair in Hanover. During this period in Germany, the program for the strategic development of industry "Platform Industry 4.0" and the state program "Industry 4.0" were approved. The main focus of this program was the development of the industrial Internet and technologies based on global communications. Similar programs have been developed in other countries, such as the USA, France, Great Britain, Italy, Belgium, etc.

There are four main features of Industry 4.0:

1. Interaction - the ability of cyber-physical systems to autonomously integrate and interact with each other through the Internet of things and the Internet of services. Cyber-physical systems are industrial equipment, robots, CNC machines, and diagnostic modules, combined with information systems, in which modeling and control of technological processes take place. This also applies to the emergence of the so-called digital factories (smart factories or smart factories), which are built based on cyber-physical systems. (Mourtzis et al. 2018)

2. Virtualization - the integration of simulation and virtual information models with real technological processes, both at the stage of designing processes and during their implementation. (Rojko 2017)

3. Decentralization - the ability of cyber-physical systems to autonomously make decisions based on artificial intelligence technologies (CARLBERG 2016)

4. Operation in real-time - the ability of cyber-physical systems to analyze technological and production data and provide them to a common industrial network, which requires the processing of Big Data. (Mourtzis et al. 2018)

The pillars of Industry 4.0 are cutting-edge technologies that made the fourth industrial revolution a reality.

The most important of these technologies include:

- Internet of Things.

- Additive manufacturing.

- Artificial Intelligence, Machine Learning, and Robotics.

- Big data, blockchain, and cloud computing.

- Virtual and augmented reality.

The Internet of Things (IoT) is a cloud environment that unites devices, devices, and entire technological systems into a single managed network, equipped with means of interacting with each other or with the external environment. The Internet of Things includes not only physical devices but also virtual models and environments, united by common communication networks. The Internet of Things is rebuilding technological, organizational, and even social processes, excluding human participation from their management. (Deloitte Development 2018)

IoT technologies are significantly expanding the possibilities of distance learning in education. Sensors, instruments, laboratory installations, and entire laboratories connected to the Internet make it possible to organize remote training sessions using real, not virtual, equipment (Deloitte Development 2018).

Additive manufacturing (3D printing) is the process of creating material objects from digital models. A three-dimensional model is designed in a CAD program, after which it preliminarily goes through the stage of dividing the model into elementary 2D layers and sent to a 3D printer for printing. The fields of application of 3D printing are practically unlimited at present. 3D printers are used in construction, medicine, education, architecture, design, marketing, advertising, automotive, clothing and footwear modeling, archeology, and the jewelry industry (Cotteleer and Sniderman 2017).

Additive technologies are being actively introduced to technological education. Consideration of these technologies is also provided for in the Model Basic Educational Program of Basic General Education. Many people use 3D printers in additional education in the design and manufacture of parts for models, robots, and various technical devices.

Artificial intelligence is a branch of the complex of computer sciences, the main task of which is to create computing systems capable of performing creative functions that are traditionally considered feasible only by humans. At the same time, an intelligent system is a software and hardware system that solves problems

that are creative, related to a certain area of knowledge. Such a system includes a computing system, a knowledge base, and an intelligent interface through which communication with the system is carried out without specialized programs for data entry. The main areas of research in the field of artificial intelligence are robotics, image, character, speech recognition systems, machine learning.

Achievements in the field of artificial intelligence have made it possible to outline a still emerging section in pedagogy. The main tasks of this area are the design and use of artificial intelligence technologies in the educational process, such as virtual teaching assistants - avatars and chatbots (tutor bots, diagnostic bots, encyclopedic bots, etc.).

Big Data is a technology for processing huge amounts of information. When talking about big data, one should keep in mind not only large volumes but high speeds of receiving, transmitting, and processing information, as well as a wide variety of types and formats of data. Big Data technologies will allow solving many scientific problems at a completely different level. Processing large arrays of information in educational systems, analyzing the learning outcome and behavioral characteristics of students will make it possible to form individual educational routes, which is currently extremely relevant.

Virtual and Augmented Reality. Virtual reality - technologies in which the control object is a computer model of reality (English virtual reality, VR). Objects and subjects of models of real objects created by technical means are transmitted to a person through his sensations: sight, hearing, smell, touch, etc., while the imitation of the impact and reaction to this effect of objects occurs. (Mourtzis et al. 2018)

Augmented reality - technologies that allow you to experiment, perceiving mixed reality, i.e. the tester perceives, in addition to real objects, information created with the use of virtual model elements "augmented" by a computer.

Virtual and augmented reality are technologies that will be effectively applied, including in distance learning, allowing to expand the possibilities of modern education. Based on these technologies, imitation laboratory stands and laboratory installations with elements of augmented reality are created.

Some examples of the influence of the advanced technologies of Industry 4.0 on the content and means of teaching in modern education are presented in the table.

Advanced technologies of Industry 4.0 in the content and means of modern education

Advanced technologies Industry 4.0	• Advanced technologies of Industry 4.0 in the content and means of modern education
Internet of things	• Remote access training laboratories • Remote laboratory stands
Additive manufacturing	• 3D printers in training workshops • 3D-modeling (in the disciplines of computer science, mathematics) • Manufacturing of parts for robots, technical devices in the additional education of students • Additive manufacturing
Artificial intelligence, machine learning and robotics	• Using avatars and chat bots in the educational process for consulting, testing and designing individual educational routes for students

	• Use of presence robots in distance learning
Big data, blockchain and cloud computing	• Formation of a protected portfolio of students and teachers • Recording the formation of educational and professional competencies • Using cloud technologies in the educational process
Virtual and Augmented Reality	• Use in the educational process of imitation laboratory stands and laboratory installations with elements of augmented reality (in the disciplines of physics, chemistry, biology, geography, etc.)

The development of industrial technologies has always led to changes in the professional activities of people, the emergence of new and the withering away of unclaimed professions. Automation and robotization of industrial production eliminated many types of manual labor and related specialties. The introduction of artificial intelligence technologies into production soon may lead to a lack of demand for some professions of intellectual work.

Of course, changes in professional activity will also occur in the education system. New specialists will appear who will possess not only modern information and communication competencies but also advanced psychological and pedagogical technologies. It is predicted that there will be game educators who create educational programs based on game techniques, developers of tools for teaching states of consciousness, designing equipment and software for teaching users a productive state of consciousness, mind fitness trainers, developing programs for developing individual cognitive skills, etc. (Hagel et al. 2015)

References

Abele, Eberhard, Joachim Metternich, Michael Tisch, George Chryssolouris, Wilfried Sihn, Hoda ElMaraghy, Vera Hummel, and Fabian Ranz. 2015. "Learning Factories for Research, Education, and Training." *Procedia CIRP* 32 (Clf): 1–6. https://doi.org/10.1016/j.procir.2015.02.187.

CARLBERG, Carolin MOELLER; Jan SMIT; Stephan KREUTZER; alin. 2016. "Industry 4.0 Analytical Study." *European Parliament*. https://doi.org/10.1017/CBO9781107415324.004.

Cotteleer, Mark, and Brenna Sniderman. 2017. "Forces of Change: Industry 4.0." *Deloitte Insights*, 1–20. https://doi.org/10.1007/s11947-009-0181-3.

Deloitte Development. 2018. "The Fourth Industrial Revolution Is Here—Are You Ready?" *Deloitte Insights*, no. January 22.

Hagel, J., J. S. Brown, R. Mathew, M. Wooll, and W. Tsu. 2015. "The Lifetime Learner," 1–19. http://www.theatlantic.com/sponsored/deloitte-shifts/the-lifetime-learner/256/.

Mourtzis, D., E. Vlachou, G. Dimitrakopoulos, and V. Zogopoulos. 2018. "Cyber- Physical Systems and Education 4.0 -The Teaching Factory 4.0 Concept." *Procedia Manufacturing* 23 (2017): 129–34. https://doi.org/10.1016/j.promfg.2018.04.005.

Rojko, Andreja. 2017. "Industry 4.0 Concept: Background and Overview." *International Journal of Interactive Mobile Technologies* 11 (5): 77–90. https://doi.org/10.3991/ijim.v11i5.7072.