THE MODELS OF MEDICAL EDUCATION: HISTORICAL ASPECTS, CURRENT CONDITION AND CONCERNS

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The article describes stages of medical education development in the chronological order and discusses the principal models of university organization and the process of evolution of scientific approaches to their formation throughout history. Preconditions for reviewing approaches to a subsequent change in the model of university education and direction of the search at the core of the modern educational concept are enumerated. Advantages and shortcomings of third-generation universities formed under the effect of the industrial revolution are separately discussed. The value and role of the university at the modern stage of society and economy development are being considered. It is concluded that educational needs require fundamental transformation, selection of the widest specter and most qualitative level, implemented scientific and educational programs, search for new approaches to mass and elite education. State support, protection, commercialization of knowledge, interdisciplinary integration and cooperation with the leading companies and research structures as part of national scientific laboratories will enable transfer of technologies to develop a new generation university that corresponds to modern tasks and needs of the country intensive development.

Keywords: educational models, university transformation, research university, third generation university, research skills, interdisciplinary approach

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МОДЕЛИ МЕДИЦИНСКОГО ОБРАЗОВАНИЯ: ИСТОРИЧЕСКИЕ АСПЕКТЫ, СОВРЕМЕННОЕ СОСТОЯНИЕ, ПРОБЛЕМЫ

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В статье в хронологической последовательности описаны этапы развития медицинского образования и обсуждены основные модели организации университетов, а также процесс эволюции научных подходов к их формированию на протяжении истории. Перечислены предпосылки пересмотра подходов к последовательному изменению модели университетского образования и направления поиска, положенные в основу современной концепции образования. Отдельно рассмотрены преимущества и недостатки университетов «третьего поколения», сформировавшихся под влиянием промышленной революции. Обсуждаются значение и роль университета на современном этапе развития общества и экономики. В заключение делается вывод о том, что потребности в сфере образования требуют от университетов кардинальной трансформации, выбора максимально широкого спектра и качественного уровня, реализуемых научных и образовательных программ, поиска новых подходов в рамках массового и элитарного образования. Государственная поддержка, протекционизм, коммерциализация знаний, междисциплинарная интеграция и сотрудничество с ведущими компаниями и научно-исследовательскими структурами в рамках национальных научных лабораторий позволят обеспечить трансфер технологий для развития университета нового поколения, отвечающего современным задачам и потребностям интенсивного развития государства.

Ключевые слова: образовательные модели, трансформация университета, научно-исследовательский университет, университет «третьего поколения», навыки научной работы, междисциплинарный подход

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New scientific ideas and discoveries alter the world and humanity, set up an alternative view of the surrounding reality. Rapid development of technologies of the fourth industrial revolution (4IR) and digital transformation affect every aspect of human life: health, professional activity, principles of social interaction, meaning and values of a human life and activity, ecological limitations [1–4]. In many countries, higher education reforms change the vector of university development turning it into the new center of knowledge generation and factor of economic growth [4–6]. The achievement of educational theory in the 20th century consisted in understanding that education is a part of social process and that it determines the trends of the

country development [7]. A global change in the educational model of higher medical schools directed at strengthening the share of a scientific component determined the need to combine evidence-based medicine and research activity to achieve the new quality of medical education [8].

HISTORY OF FORMATION AND BASIC MODELS OF UNIVERSITIES

The first European Universities such as the University of Bologna (1158), University of Paris (1180), University of Oxford (1188) and University of Cambridge (1209) were founded and existed under the patronage of the church. They embraced three schools (theological, medical and legal). The medieval science was based on scholasticism, ability to speculate and conduct a debate, the education was of dogmatic nature and required memorization. The basic ideas most essential to the Renaissance were those of the European humanism, when human beings, their freedoms and values were placed at the center of meaningful life. In the 16th century, the universities were separated from the church following the Renaissance ideas. During that time the methods of teaching were developed in a different way, widening the scope for development of the research thought. The University of Padua was able to maintain independence from the influence of the church. Andreas Vesalius, who was a doctor and anatomist at this University, dissected the bodies of executed criminals during his lectures to gain better knowledge of anatomy and understand how a human body is functioning. Students of the University of Padua were allowed to discuss what they saw during autopsy at the anatomical theater, have doubts and disputes with teachers and express objections to Galen's works. The scientific method of observation and discovery in the Art of Perspective and Drawing of Volume was used to create the first Handbook of Anatomical Charts with the images of a dissected body (1543). The emergence of book printing was accompanied by appearance of scientific journals to distribute research findings in the professional community.

In the 17th century, sciences associated with examination and description of nature are coming to the foreground. Willian Harvey had a series of experiments, the results of which were opposed to the known theoretical assumptions of those times, and created the basis for experimental medicine. Discovery of the circulation and description of how the heart works were published in Demotu tractate (On movement of the heart and blood). Owing to Francis Bacon, Robert Boyle and Isaac Newton, an experimental approach in the 17th century became the basis of scientific work that added to theoretical reasoning; the foundations of research thinking and basis of the scientific approach to the world were laid stating that classical physics is a deterministic science that can explain everything, and if something is unclear, then there is no knowledge of the issue. The dominant content of science included chains of reasons and consequences describing mass and energy, the fundamental theory of mechanistic understanding of the world and math of Newton, which is of quantitative nature, provided for very exact calculation of various amounts and attached special importance to thinking in exact sciences. Physics was developed launching medical discoveries. Giovanni Borelli used achievements of mechanics and physics to study the musculoskeletal system, laid the foundation of biomechanics, and developed the idea of 'structure of a human being as a complex mechanism'. Achievements of adjacent sciences allowed the scientists of those times to make such discoveries as determination of lung volume and strength of contraction of the cardiac muscle.

By the 18th century, the European science has already had the basis of an academician tradition: scientific methods that appeared out of systematic experiments and skills of scientific argumentation originating from the medieval scholasticism. These were skills of separate scientists interested in knowledge and discovery distribution and sharing. During the era of the great geographical discoveries and colonial conquests, collection of artefacts and actual data in various areas required description, systematization and analysis of obtained colonial collections and provided experience of writing and publication of scientific texts at the universities. By the 18th century every university had already issued its own journal.

The first model of a classical university was established in Prussia in the 19th century, when the country turned into a center of research innovations and attracted people from Europe and Russia being a place where they could complete their education. The new university concept was based on the Enlightenment ideas associated with development of rational and free thinking [9]. Minister of education of Prussia Wilhelm von Humboldt, a diplomat, philosopher and linguist, followed industrial and technological ambitions of Frederick William, king of Prussia, and convinced him to conduct an educational reform and establish a new university in Berlin (1810) with independent work but not pure memorizing being at the core. It was for the first time when studying and research came together at the University: a teacher was a student's academic advisor, a student had to conduct independent research, and not just learn lectures by heart. Friedrich Schleiermacher who was one of the first professors and ideologists of the Berlin University claimed that an important role of a university was to teach students to obtain new knowledge independently and stimulate their interest in scientific research.

University innovations applied during organization of the scientific process resulted in emergence of new research laboratories. They attracted leading scientists from different countries. Now not solo geniuses, but groups of scientists who conducted joint experiments and discussed the results worked on this research: the studies became organized and systemic. Research studies were based on the rational method used during experiments and ability to argue and prove their point of view, they were open for inspection and verification of the results by other researchers, and had to be published in special journals and books. The Humboldtian universities obeyed the rules of pure science development. In the 19th century, a sum of factors in the form of financial investment into the national modernization of Prussian industry, emergence of new forms of scientific work (laboratories), invention of new industrial technologies which promoted science development (for instance, first synthetic colorants that could be used to color the cell and see its structure clearly), enabled to shape the currently existing principles of fundamental research organization. Universities in different countries that followed the Humboldtian model acquired the status of national universities and became a matter of pride, especially since establishment of the Nobel Prize (1901). Even now the prize goes to the countries where the leading universities are located.

Thus, at the end of the 19th century, a model of traditional classical research university was formed in Europe and Russia; the idea of 'nourishing a spirit of a reality study in a student' proven its effectiveness in science development and its interconnection with education at universities [10].

As part of the traditional classical German university, a student needs to have the most common and universal thinking abilities, master the methodology of scientific research and reasoning. This will be the tool used to acquire the knowledge a teacher can't foresee [10]. Sergey Gessen who was one of

the leading Russian and internationally recognized researchers of education wrote that the sign of the higher scientific school and essential part of teaching included demonstration of the research process to students. Thus, in his opinion, a teacher should be an active scholar, and a student should be a participant of the teacher's research. With a lecture, a teacher aims not to report the research results, but to outline a process (how the scientists came to these outcomes to make students independently check the data and conclusions; at seminars, a teacher acts as a critic of the study conducted by the student) [10].

Academic universities of Europe based on pure science with their scientists forming a distinctive caste drew the line fundamentally and intentionally and casted anathemas on any commercialization or attempts to make scientific discoveries popular. The classical example is the Cambridge University that gave the world the largest number of Nobel laureates and where theories of Newton and Darwin were disclosed, Rutherford split the atom, James Watson and Francis Crick determined the double-helix structure of DNA. The Cambridge University strongly resisted any attempts of applied use of scientific knowledge at the University till the middle of the 20th century [6, 11, 12].

The second university model began its formation in the end of the 19th century and was the embodiment of ideas of John Dewey, an American philosopher and educator [9]. This model differs from the classical one, because science and education are intended for practical implementation and solving tasks. During the educational process, students have to master practice-oriented skills. From the very beginning, a student has to participate in applied research and transformation programs that require development of industries of the country [13]. Dewey's concept is based on pragmatism ideology: development of scientific critical thinking (study of dilemmas, formation of hypothesis and awareness of decision consequences) and practice-orientation (showing how to solve life problems) [14]. Continuing Dewey's ideas, William Kilpatrick offered to stimulate accomplishment of practical tasks in social environment; he was the first to introduce the method of projects in the educational process [15].

During the second half of the 20th century, after the World War II, funding of science and education was sharply increased leading to the mass explosive growth of higher education, including the USA, in the background of economic and infrastructure recovery. Incentives of additional financing of higher education were space exploration and cold war.

According to Noam Chomsky, before the second World War the USA were a kind of a cultural and intellectual province; scientists from the USA were sent to Europe to study culture and science [16]. During the war, a vast majority of academic staff fled from Europe to escape the Nazis, which had a major influence on universities and higher education. Transfer of scientific methodology and technologies, substantial amounts spent on science by the US Government resulted in formation of high-tech economy within 10 years (computers, microelectronics, satellites [16].

An aggregate of social and cultural processes in the 1960–1970s promoted social debates associated with the educational reform. The issues of equality of a human activity and world ecosystem have come to the forefront. Education and researches in the western countries and in Russia are now associated with fundamental tasks of human personality formation and development, and not just with preparation for professional activity [17–20].

Gregory Bateson, graduate at Cambridge, visiting professor of Harvard, professor of Columbia University and University of California (USA), was among the first scientists who initiated discussion of the systemic approach to the world and human beings. He was a founder of the systemic and holistic approach in interdisciplinary studies of natural and social sciences: synthesis of cybernetics and anthropology, biological evolution and genetics, key researches in psychiatry. His holistic view of the world contained a complex network of relations with a human being a part of it. He believed that facts could be interpreted and research-based processes could be comprehended only if the systemic worldview is available. The source of concerns and the way how they are resolved (human thinking: it is necessary to see and think in a new way) have an integral and ethical responsibility towards the world and self. Bateson introduces the term 'mind ecology'. It is a way when a research thought is developed as combined with the rational and integral vision of the examined phenomena when the pervading unity of processes, the same laws are inherent to different areas (for instance, psychiatry and quantum physics) [21].

'The nature of the study does not let the researcher know what is being examined by him until it has been examined; there is no guide in his pocket to tell him which points have to be crossed, as only the experience of those who walked through this path is available. Deep layers of the mind lead a scientist or a painter to the feelings and thoughts related to the problems that are his problems somehow. The guidance seems to act long before a scientist obtains any conscious knowledge of the purposes. But we don't know how this happens' [21].

Awareness of the need in the interdisciplinary and integral approach to the studies influenced the occurrence of research centers outside the universities. Soon after the World War II, research organizations (European Organization for Nuclear Research) were founded based on physical research. They demonstrated effectiveness of researches as part of the interdisciplinary approach, when a team of highly qualified specialists participate in the study [6]. Experience of scientists previously working in a large multidisciplinary team of Oak Ridge National Laboratory (Manhattan Project) was essential to DNA recovery. Maurice Wilkins, a biophysicist, who came to the Royal College to study chromosomes, took the task as a physicist and applied the knowledge of the structure of an atom in practice with the help of new technologies. He assumed that DNA functioning and reproduction can be deciphered if its structure is understood. Wilkins was supported by Rosalind Franklin, a biophysicist and radiologist, who took X-rays and recorded various DNA samples. Her photograph 51 made it possible for James Watson and Francis Crick in Cambridge to discover the double-helix structure of DNA. Transfer of experience, synthesis of methodology from other areas using the integral approach promoted their discovery. For now, the majority of scientists admitted that interdisciplinarity should become the quality of the modern university, a site where competing ideas and discussions intersect.

THE MODERN MODEL OF UNIVERSITY EDUCATION

We witness gradual global awareness of shifted paradigm in science and education. Just like other areas of human activity, education is associated with social and political society-based processes, fundamental scientific paradigms and conceptual frameworks of the worldview [22].

Discoveries of quantum physics in the beginning of the 20th century produced a huge impact on human ideas of the entire world and ways to interact in it, as well as scientific approaches used in natural and humanitarian experimental trials. The classical approach describes phenomena as they

are irrespective of the utilized methods of trials. As part of quantum concept, the researchers should take into account that the observation result is fundamentally dependent on the device being used. The classical system measurement can fail producing an effect on the system condition; this is not the case with the quantum system. Development of quantum physics enabled understanding the fundamental value of probability not associated with the lack of knowledge. The phenomena were described as an aggregate of interdependent conditions. Richard Feynman, a famous physicist, displayed a condition of superposition or quantum state in his experiment, the essence of which lies in the mutual interference. Thus, when an electron is being observed and when its condition is being captured, the electron acts as a common particle; when an observer doesn't look at it, the electron exerts wave properties, meaning, that it 'acts' and behaves in accordance with the observer's actions. The observation frees an object from a set of uncertain quantum conditions and shifts it into a manifested and observed condition [23]. The discoveries influenced all the areas of the scientific life. For instance, in scientific articles it was normal to mention the used system and resources of searching for scientific information, description of the used methods as factors that determine the risk of errors when estimating the research results by other researchers.

New technologies responsible for unforeseen changes in the world raised concerns about the inevitable transformation of universities as part of the 4IR. Prof. Ronald Burnett from the University College London Institute of Education was the first who mentioned the concerns in his inauguration speech in 1997. Today, his ideas serve as the social and philosophical basis for transformation at universities. According to Burnett, we live in a supercomplex world, and all our theories and structures are checked and challenged on a constant basis. That's why we need new ways of life in such a fragile and supercomplex world with variability and uncertainty of structures and systems in its basis. New methods of education should be inevitably developed. They would 'teach to formulate doubts and obtain an experience of understanding disputability as it is'. The lectures should be replaced with interactive methods of education that enable students to work with contradicting ideas and perspectives. Different forms of debates and seminars are designed to teach student how to participate in discussions and debates that were very respected by the medieval universities. Participating in giving birth to supercomplex things, the university has to show how to live with them [24, 25].

Development of the university research vector is the principle aim of higher education reform for today. Research studies require significant financial contributions. That's why universities had to solve pragmatic tasks, providing for a high-tech component of economy growth. Facing universal cuts in public financing since the 1990s in Western countries, in particular, universities had to search for additional financing sources, including commercialization of studies and deriving benefit from know-how. In Europe — but not in the USA — classical universities admitted the situation quite recently and in a reluctant way. In the 1960s only the Cambridge was slowly surrounded by consulting companies (*Cambridge Consultants* etc.) founded by the graduates 'to make the brains of the Cambridge University solve the tasks of the British industry' [6, 26]. In 1997, Gordon Brown who became Minister of Finance of the Great Britain, reported to the Government that knowledge economy depends on the possibility to turn research results into commercially successful products. His report officially recorded 'the transfer of technologies for public purposes' as a vector of development of universities along with scientific research and education [6].

The true purpose of the universities was to encourage thinking, conduct independent and creative research, question the established truths, and open new horizons without sticking to external constraints. It is important not to cause irreparable harm to the society by turning universities into the institutions aimed to commercialize science and manufacture products for the market [16]. There is inevitably a question whether a society with full contribution of education into economic reproduction or a society that creates conditions for development of every human being can be called a developed society [25]. Classical universities faced an internal dilemma: ideal scientific impulses to search for truth and meaning, on the one hand, and pragmatic need to develop knowledge for economic growth, on the other hand [25, 27]. Scientists are attracted by thinking about the meaning of life and structure of the world, a possibility to look over the edge and reveal something new about the world, but not by the future profit [27].

In medicine, new knowledge is rapidly implemented into the real practice: robotization and artificial intelligence, bio- and nanotechnologies, augmented reality and neurotechnology become the possibilities of development if they are based on the responsibility and value of serving the humanity [24, 28]. New technologies cause fear and anxiety, they try to replace the human role for the first time, and humanity hasn't faced such threats yet. Though artificial intelligence is just a combination of algorithms used to train a machine, it is progressing very rapidly and threats are so unpredictable that understanding the human place, role and possibilities is taken as forms of survival; that is why almost all discussions regarding higher education concern concepts of individual development and self-realization of a human being [29, 30].

The ethical issues such as role of science and universities in the development of a human being and society of the future are resolved using the ecological model of a university that promotes interrelation of different ecosystems: natural, social, personal, economical, educational and cultural, as they create a set of values and limitations for a university science and system of education in the 4IR era [25, 31].

The complex approach that considers all factors is basic in the development of modern education. Key features of the modern research university that follows the requirements include high level of teaching and science, modern material resources and infrastructure for research (libraries, laboratories, clinical centers), cooperation with state and commercial structures, relations with industry, collaboration with other universities [32, 33]. The universities are commonly funded at the national level and with additional private sources [32].

The university model that combines science and education is generally accepted by the modern knowledge economy. It is a mixed type of a research university with traditions of fundamental studies of a classical university which is aimed to solve applied tasks [4, 6, 32, 33]. This model forms the basis of the most effective universities such as Harvard and Stanford universities, Massachusetts Institute of Technology in the USA, Cambridge University in Europe, Zhejiang University in China and University of Technology and Design in Singapore [34, 35].

According to Prof. Johan Wissema from the Technical University Delft who suggested the concept of third generation universities, it's important for a university to develop in the vector of 'open innovations' and interact with companies and other research structures: it should become a web-based international 'know-how hub' with a developed infrastructure and different development sources within the same site. The fundamental and applied trials conducted at the third-generation universities are related not through education and research only, but also through

know-how commercialization and scaling, collaborations with high-tech companies, cooperation with high-status universities through research projects, management of interdisciplinary studies at the institutes which are part of universities [6].

CONCLUSION

Educational needs require that universities should undergo qualitative transformation, select the widest possible spectrum, most qualitative level, and implemented scientific and educational programs, and search for new approaches as part of mass and elite education. State support, protection, commercialization of knowledge, interdisciplinary integration and cooperation with the leading companies and research structures as part of national scientific laboratories will enable transfer of technologies to develop a new generation university that corresponds to modern tasks and needs of the country intensive development.

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