Received: 9 Jan. 2024 | Revised: 23 Jul. 2024 | Accepted: 19 Aug. 2024 | Published online: 26 Aug. 2024

RESEARCH ARTICLE

Contemporary Education and Teaching Research

2024, Vol. 5 (8)301-310

DOI: 10.61360/BoniCETR242016820806

End-to-End Technologies in Medicine, Pharmacy and Biology

Denisova Olga[1]*, Abramishvili Yaroslava[2]

1 Department of Physics, Ufa State Petroleum Technological University, Russia, denisovaolga@bk.ru. ORCID: https://orcid.org/0000-0001-6374-3109

2 Faculty of Medicine and Prevention with the Department of Biology, Bashkir State Medical University, Russia, abramishviliyaroslava@gmail.com.

***Corresponding author:** Denisova Olga, Department of Physics, Ufa State Petroleum Technological University, Russia, denisovaolga@bk.ru.

Abstract: The article raises the topical issue of the use of end-to-end technologies for medicine, pharmacy, and biology. The analysis of the use of new technologies in these areas is carried out at the present time. The authors are looking for ways to solve the problem of teaching humanities and natural sciences at a medical university using the capabilities of modern technologies. A random sampling method using the capabilities of Goole forms was used to conduct a survey of 2nd year students of the medical university and teachers working with them. The level of training, the needs of students for new knowledge on modern end-to-end technologies, and the possibilities of implementing training programs are discussed. The survey showed that despite the widespread introduction of end-to-end technologies, the knowledge of students and teachers in this area is extremely limited. Students have a need to acquire new knowledge that can be applied in their future profession. Several solutions to the problem of teaching student's new technologies and their practical application in medicine, pharmacy, and biology are proposed. The survey also showed that there are two possible options: 1) the introduction of a separate optional course into the curriculum; 2) teachers can talk about the possibilities of new technologies and their use during the study of the discipline. For effective teaching, teachers must improve their skills in a timely manner by taking courses. With an integrated approach, a quick and effective solution to the task is possible.

Keywords: end-to-end technologies, medicine, pharmacy, biology

1. Introduction

Nowadays, more and more information technologies are being offered by researchers and developers, which are firmly entrenched in our daily lives, at home, at work. Despite the fact that healthcare is one of the most conservative areas associated with a huge number of treatment protocols, drug testing, it is advisable to introduce modern digital information technologies in medicine to reduce routine work on collecting and processing information. By conducting a timely analysis of medical information, there are good prospects to optimize the time and material costs of treatment. It is possible to prevent an outbreak of infectious diseases or pandemics. Life expectancy is increasing all over the world, which creates new challenges for modern treatment methods.

Artificial intelligence (AI) information technologies, neural networks, the creation of databases that identify, for example, cancer cells, bacteria, viruses; virtual or augmented reality technologies that make it possible to plan complex operations, train them, develop different scenarios for their course, all this will allow medical professionals – general practitioners and surgeons to make a decision about the patient's treatment, based on databases of huge research by colleagues and clinical trials, and not only based on their own professional experience, knowledge and intuition. In this regard, the demand for big data analytics technology in medical and polyclinic institutions will be increasingly in demand.

There is more and more data in the world, especially in medicine, where, as a result of regular activities, a huge stream of data is constantly generated, which, by law, must be stored for more than one year All this will expand the capabilities of medical professionals in collecting data, conducting patient examinations, as well as planning and conducting minimally invasive operations.

The digital transformation of healthcare, the active introduction of artificial intelligence technologies and digital services for patients make it possible in some cases to replace the need for an in-person visit to a doctor with virtual help. It can be assumed that face-to-face visits to polyclinics will be halved by 2030. The introduction of digital services for

Corresponding Author: Olga Denisova,
Department of Physics, Ufa State Petroleum Technological University
Email: denisovaolga@bk.ru

patients, such as telemedicine consultations, nutrition selection, symptom checkers, can also reduce the burden on medical organizations, especially in the primary sector, which is important in conditions of personnel shortages and "burnout" of health workers. The use of digital technologies improves the quality and efficiency of the work of health workers, as well as has a positive effect on their mental health. AI systems allow doctors to help diagnose diseases, predict outcomes, recommend treatment, and provide rapid analysis of medical data in real time, thereby increasing the effectiveness of medical care. Doctors need to prepare for the transformation of medicine with the help of AI and they need more knowledge to adapt to the new era. End-to-end technologies offer great prospects and can be widely used in practical medicine, education, and scientific research.

Thus, the main idea of the study was to clarify the level of awareness of students and teachers on the issue of end-to-end technologies, their capabilities and prospects for use in a future profession; the need and request of students for new knowledge; the readiness of teachers to give this knowledge. In this article, the authors propose the introduction of modern digital technologies into the educational process in the training of specialists from medical universities and colleges. To achieve this goal, a survey of students and teachers was conducted, and according to its results, several solutions to this problem were proposed.

How many staff are needed in a given period of time to provide high-quality medical care? If there are too many employees, this will lead to unnecessary costs, if there are few, then patients will suffer (Jieyi et al., 2023). This problem was solved by several centers in Paris using big data analytics. In the USA, Electronic Health Record (EHR) is used - a system that stores all possible records of the patient's condition, in all areas of medicine, throughout the patient's life. Almost 94% of clinics are connected to it (Denisova, 2021).

Real-time Analytics (Real-time Alerting) - helps doctors through a decision-making system to correctly diagnose and prescribe treatment, as well as receive alerts from devices worn by patients. For example, if blood pressure reaches an alarming value, the doctor, upon receiving notification, will be able to adjust the treatment and immediately help the patient. Another example can be given, inhalers for asthmatics are equipped with GPS trackers, and the Asthma polis system monitors the patient's condition in real time. This makes it possible to monitor the course of the disease both for an individual patient and for larger groups of the population. This information can be useful for adjusting the treatment plan for patients with asthma. The purpose of the medical decision-making system is to help doctors make informed decisions within seconds and improve patient care. The new tools will also be able to predict the risk of developing diabetes and other diseases. Optum Labs has collected more than 30 million patient records through EHR (Baldwin et al., 2015).

The Cancer Moonshot program is a project to accelerate the implementation of a cancer treatment program, it is the result of combining and processing data on research in the field of oncology from hospitals, universities and non-profit organizations. This program allows researchers to access biobanks of tumor cell samples, as well as to track the dynamics of the reaction of cancer proteins and mutations depending on the protocol of the chosen treatment (Denisova et al., 2021).

1.1. Modern technologies in pharmacy

The use of artificial intelligence technologies in drug development will make it possible to reduce research time by five times and reduce costs by 20%. The first stage of development is the detection of the target that is responsible for the disease, its mechanism of action. AI collects information from all sources and identifies the protein responsible for the disease. Next, an inhibitor is selected that will bind firmly to the protein and at the same time not cause corky reactions in the body. This is done with the help of AI, since there are 10^{60} total molecules in the chemical space. The advantage of AI is that it can analyze huge amounts of information, or independently generate the necessary molecules using generative models. AI is also able to predict in advance the toxicity of a molecule and its synthesizability. It is important not only to give the molecule, but that it is synthesizable, stable in the body, and that it can be reproduced (Aziz et al., 2023). An international group of scientists from the Russian Quantum Center and the Singapore-based Gero company has achieved a breakthrough in the field of medical chemistry, for the first-time using quantum machine learning algorithms to search for new chemical compounds with potentially medicinal properties. Despite the fact that all these structures have yet to be thoroughly investigated in the laboratory, the work demonstrates the possibilities of quantum machine learning to accelerate developments in the field of medical chemistry, biotechnology and healthcare, opening up new horizons for the rapid creation of effective medicines (Aziz et al., 2023).

The use of the DeepMind AlphaFold neural network makes it possible to make significant progress in predicting the three-dimensional structure of proteins, which is crucial for understanding how proteins function, as well as for drug development (Denisova, 2022).

SmartID identification technology is able to work without accessing centralized databases. This is a mechanism for determining the authenticity of medicines where the original packaging is used. The idea is that high-quality packaging has differences in the surface structure, which can be determined by a scanner based on a smartphone camera (He et al., 2023).

Students of Lomonosov Moscow State University have developed a mobile application and special containers that help control the contents of a home medicine cabinet. The application stores all the necessary information about the medicine: expiration date, indications for use, possible allergies and much more. The plans include the implementation of a quick drug search function through virtual organizers (He et al., 2023).

European and American molecular biologists have for the first time discovered a new class of antibiotics using neural network algorithms. During the analysis of artificial intelligence, the researchers were able to identify two molecules that were capable of destroying several "invulnerable" variations of microbes at once, including some strains of hay bacillus, Staphylococcus aureus and enterococcus, which were invulnerable to the action of

methicillin, oxazolidinones and vancomycin. Further study of these substances will allow the creation of new drugs capable of overcoming the constantly evolving protective systems of microbes. With the help of artificial intelligence, researchers from the University of Galway and the Massachusetts Institute of Technology are developing a smart implant capable of recognizing changes in surrounding tissues and adapting to them (Papanagnou & Matthews-Amune, 2018).

Scientists have developed a molecular "syringe" that can inject proteins, including cancer drugs and gene therapy, directly into human cells. The upgraded injection complexes represent an exciting set of biotechnological tools that can be used in various biological systems. It is noteworthy that in the study, biologists used an artificial intelligence (AI) program created by DeepMind from Google — AlphaFold. The biocompatible material is made from bacterial cellulose modified with gelatin. Once in the body, it can restore tissues or replace their lost parts, reduces the likelihood of complications after surgery and accelerates recovery (Chen et al., 2022).

The Russian startup Silkins wants to launch a laboratory that will produce components for regenerative medicine and cosmetology. The laboratory will begin to produce components for gels for rapid wound healing based on fibroin and spidroin, a care cream for complex skin nutrition, a decomposable patch for rapid recovery after cosmetic procedures. Specialists of the Institute of Cytology of the Russian Academy of Sciences in St. Petersburg have developed a technology to improve the process of regeneration of body tissues, which is based on a complex structure of collagen and fibronectin protein. The new technology has shown high efficiency in interaction with living cells of the body, in the future it can be used to create ready-made products for regenerative medicine (Frestel et al., 2023).

Scientists at the Mendeleev Russian State Technical University have developed a new technology for heterophase 3D printing with biopolymers for the production of implants and matrices for accelerated healing and restoration of bone tissue and soft tissues of the body. The new design of the printer and the extruder allow the use of an expanded range of "inks" – materials that can be used for printing. The developed special heterophase system, in which the printing object, the future matrix or implant, is formed, will help to accurately set the geometric and other characteristics of the product and print with low viscosity ink (Sahu et al., 2022).

Researchers from Tel Aviv University have developed a hybrid micro robot the size of a single biological cell. The micro robot is able to move between different cells in a biological sample, distinguish between different cell types, determine whether they are healthy or dying, and then transport the desired cell for further study. The robot can also transfect a drug and/or a gene into a captured target single cell. The development can contribute to the advancement of single cell analysis research, medical diagnostics, drug transportation and screening, surgery and environmental protection (Sahu et al., 2022).

Researchers from the Max Planck Institute for Intelligent Systems used the ability of pangolins to quickly curl into a ball to design soft robots. The device is about 2 cm long and consists of two layers: a soft layer of polymer studded with small magnetic particles, and a rigid component of metal elements arranged in overlapping structures. When the robot is exposed to a low-frequency magnetic field, it curls up into a ball, scales outwards. By controlling the field, researchers can move the robot. In the future, this can be used, for example, to deliver drugs by moving a robot inside the body through the esophagus (Puranik et al., 2019).

1.2. Digital technology trends in medicine and biology

A new GOST for AI services in medicine has started operating in Russia. This is the eleventh GOST for testing artificial intelligence. The document defines the requirements for each process of the life cycle of artificial intelligence systems. The standard allows the creation and maintenance of AI systems in clinical medicine, establishing the basis for the life cycle processes of neural networks.

Specialists from the St. Petersburg Federal Research Center of the Russian Academy of Sciences and St. Petersburg State University have developed a multiparametric database for training neural networks. It classifies the states of fatigue and cheerfulness of the computer operator. The collected dataset has a unique set of different labeled indicators: eye movement, physiological indicators, psychological tests for respondents. The Kurchatov Institute Research Center has created individual polymer implants — biodegradable cages. They connect the vertebrae, and after their fusion, they are replaced by the patient's bone tissue at the specified time. In the laboratory, the cage design was developed according to the sketches of doctors, then its model was created based on a CT scan of the patient, after which the implant was made on a 3D printer. The cage itself consists of two parts: a frame that takes on all the load, and zones with a porous structure (Torrente et al., 2019).

European neurophysiologists have developed a specialized temperature sensor that can be installed on the surface of prosthetic hands and connect this sensor to the patient's nervous system. This will allow patients with similar prosthetic limbs to feel touching various objects. Prosthetic limbs can be further improved with the help of developed sensors that allow a person to feel heat and cold. Their creation became possible due to the fact that scientists accidentally discovered that stimulation of certain areas of skin on the surface of the forearm leads to patients beginning to feel a phantom hand and fingers (Torrente et al., 2019).

Silicon Labs has developed miniature xG27 chips for medical applications. The technology allows you to place a chip along with a special sensor on one of a person's teeth for constant monitoring of saliva characteristics — this will allow you to continuously monitor health and prevent many diseases. The xG27 is already being used in a real solution — a sensor integrated into the tooth. The sensor is so small that it can actually be attached to a tooth for continuous monitoring of saliva, taking into account more than 1000 parameters. In addition, the company produces smart medical patches, sensors for constant monitoring of blood glucose levels, and wearable ECG equipment (Moratinos & de Miguel Beriain, 2020).

What can big data give medicine? If you need to answer in a nutshell, then they will be "personalization" and "optimization". Big data analysis technologies can give

doctors the opportunity to make the most accurate diagnoses, predict the development of the disease, calculate risks for each patient, and sometimes prevent them.

The "optimization" in the context of big data - over the years, information collected and processed allows analytical centers to understand that conditions are developing this year in such a way that an influenza pandemic cannot be avoided. Such information appears in the hands of experts several months before the "hot" season begins, which means they have time to take action.

A team of researchers from the University of Cape Town (UCT) analyzed the six most common types of cancer and concluded that each of these cancers is characterized by a distinct combination of genes. An analysis of the accumulated health results of thousands of patients from a genetic point of view has shown that breast, bowel, lung, ovarian and brain cancers have distinct genetic markers. The team would not have been able to make the discovery if it had not had access to big data arrays (Seghatchian, 2020).

Researchers from the nonprofit Christiana Care Health System Institute analyzed data on patients suffering from chronic urolithiasis and kidney failure. It turned out that by monitoring blood pressure levels, as well as the occurrence of acute respiratory diseases, hypervolemia and hyponatremia, complications arising during the disease and hospitalization can be predicted. A study by scientists at Queens University in Belfast, Great Britain, is also devoted to the search for the possibilities of the earliest diagnosis and the least invasive treatment. The purpose of their work was to lay the foundations for the creation of a single international database that would store diverse information, the very big data on the largest possible number of cancer cases around the world. The search for patterns inside such an endless "file cabinet" could save many lives. For the first time, modern technologies have created tools to describe tumors found in cancer patients as quickly and inexpensively as possible. The combination of these two factors, together with the availability of medical databases aggregating big data, suggests the proximity of a breakthrough in the treatment of many types of cancer (Wu et al., 2024).

Thus, having worked out the issue of the use of modern digital and information technologies in medicine and pharmacy, we can say that "The ice has broken." Progress has been made in this area over the past three years. Regulatory documents are being adopted, research and production organizations are conducting their research using digital technologies, and significant results have been achieved. There are a number of obstacles that will need to be overcome on this thorny path, for example, the use of modern digital technologies requires computing power and high-performance systems, or the long-term introduction of new treatment methods into clinical practice. It is necessary to review the competencies that a modern specialist should possess, update the programs of the disciplines taught, and therefore build interdisciplinary links between medicine and computer science, physics, robotics, and materials science.

Most employees of medical institutions (hospitals, polyclinics, hospitals) are not software developers, they can use a ready-made software product. But they are responsible for patient care and the quality of their treatment. A specialist with academic knowledge, his own clinical experience, proficient in modern information and digital technologies, will expand his professional opportunities and prospects. In the meantime, currently, the introduction of capabilities, for example, artificial intelligence, should take place in tandem with doctors and programmers in order to eliminate possible risks.

The curricula and study programs at medical universities have been adopted and adapted for a long time, we suggest not making a revolution, but starting small. We need to integrate elements of new digital technologies into the existing training program. They should be an addition to academic education, allowing to broaden the horizons of future specialists, and therefore, the possibilities of development, in particular, medicine, pharmacy and biology.

2. Materials and Methods

To analyze the current needs of students and teachers in the field of medicine, pharmacology and biology, the presented study used a random sampling method. For this purpose, a survey was conducted of 67 2nd year students of Bashkir State Medical University who study in the specialties "Medicine", "Pediatrics", "Pharmacy", "Biology". We also asked to answer the questions of 30 teachers of natural sciences and humanities of the same university, who are taught in the 1st and 2nd courses. The students' questionnaire contained 8 basic questions; the teachers were asked 7 questions. To achieve this goal - to try to find ways to solve the problem of introducing modern digital and information technologies into the educational environment, a questionnaire was formed using Goole forms resources that allow you to conduct a survey remotely and at any convenient time; then analyze the data obtained in Excel in the form of tables, graphs, diagrams.

3. Results and Discussion

We now propose to consider the questions and analyze the answers received to them. First, the results of the student questionnaire are presented.

To the question: "What end-to-end digital technologies have you heard about?", 100% replied that they had listened about artificial intelligence; 86.7% about neural networks; 63.3% about augmented and virtual reality technologies; 60% about robotics and sensor components (Figure 1).

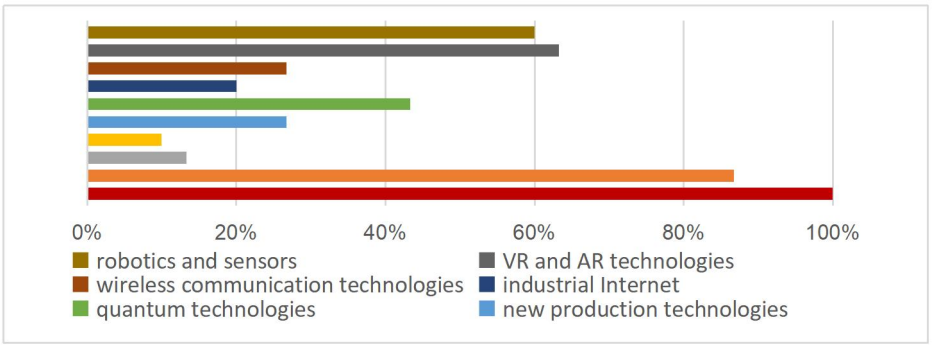

Figure 1. Students' answers to the question: "What end-to-end digital technologies have you heard about?"

To the question: "Do you know where and how end–to-end technologies can be used, what opportunities do they have?" 60% answered yes; 40% - no.

The results of the answers to the question: "What end-to-end technologies have you used?" are shown in Figure 2.

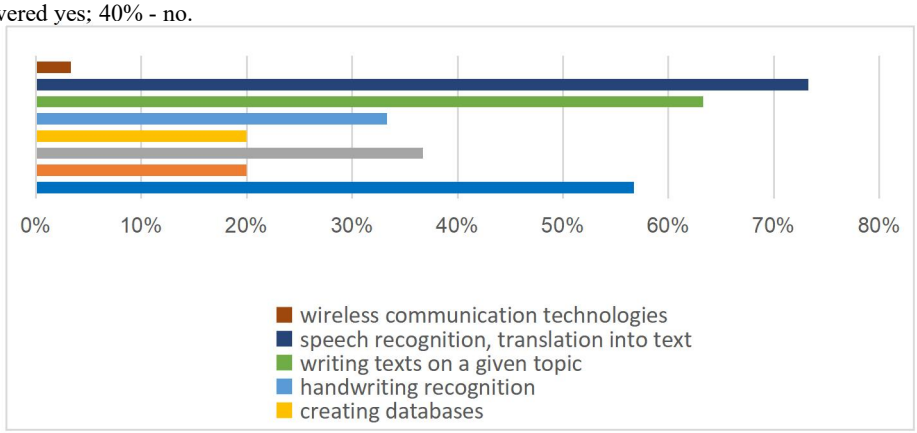

Figure 2. Students' answers to the question: "What end-to-end technologies have you used?"

60% answered, they know where and how to use end-to-end technologies, what capabilities they have; 73.3% used a voice recognition and text translation program in everyday life; 63.3% used artificial intelligence capabilities to write texts (abstracts); 56.7% generated images.

To the question: "Do teachers use new digital technologies in teaching disciplines?" 13.3% answered yes, 86.7% answered "no".

To the question: "Do you understand the prospects of using end–to-end technologies in your future profession?" 86.7% answered "Yes", 13.3% answered "no".

86.7% answered "Yes" and 13.3% answered "no" to the question: "Would you like to gain additional knowledge in the field of end–to-end technologies?"

To the question: "What technologies would you like to learn?", 76.7% chose artificial intelligence; 66.7% chose neural networks; and 56.7% want to get a general idea of all the possibilities of new end-to-end technologies (Figure 3).

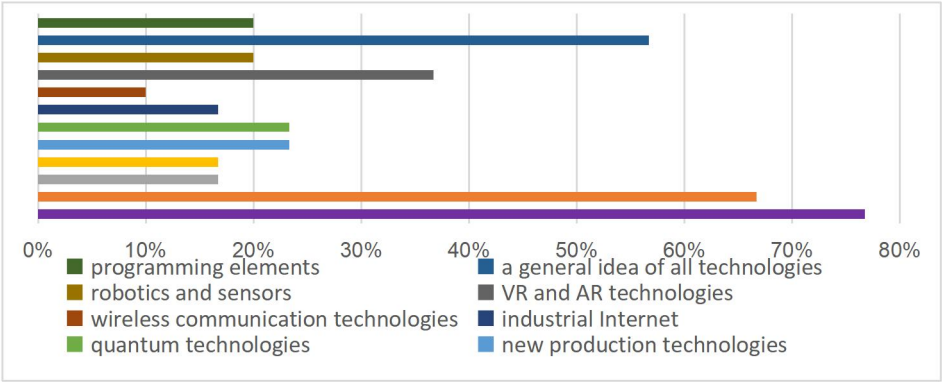

Figure 3. A list of end-to-end technologies that students would like to learn

To the question: "How do you think end-to-end technology training should be organized?" We have received the following response. Students believe that teachers, within the framework of their discipline, consider certain issues that have the prospect of being used in a future profession – 50%; optional course (optional) – 40%; a separate discipline in the curriculum -10%.

83.3% of respondents said that teachers do not use new digital technologies in teaching disciplines. At the same time, 86.7% understand the prospects of using end-to-end technologies in their future profession. They also want to gain additional knowledge in the field of end-to-end technologies.

Thus, most students would like to know about the possibilities of modern technologies, their application in science, production, their significance and development prospects. Most of the students are a bank, having invested knowledge in which the state will receive decent dividends in the near future.

A survey of teachers of humanities and natural sciences was conducted. The questionnaire and the results of the survey are presented below. An analysis of the teachers' survey showed that 64.7% know where and how to use end-to-end technologies and what opportunities they have. Moreover, everyone knows about artificial intelligence, and only 58.8% about neural networks, quantum technologies, wireless communication technologies, augmented and virtual reality. 58.8% used the program to recognize handwritten text; 47.1% used voice and text translation, as well as writing texts on a given topic. 76.5% showed that they do not use end-to-end technologies in teaching (Figure 4, 5).

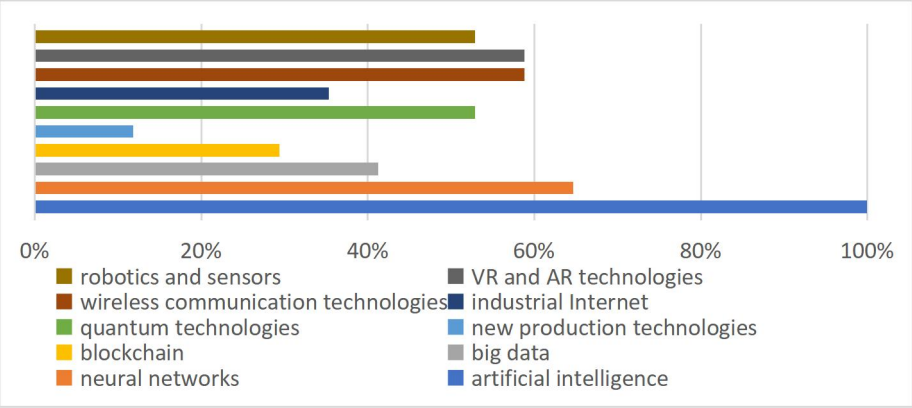

Figure 4. Results of teachers' answers to the question: What end-to-end digital technologies have you heard about?

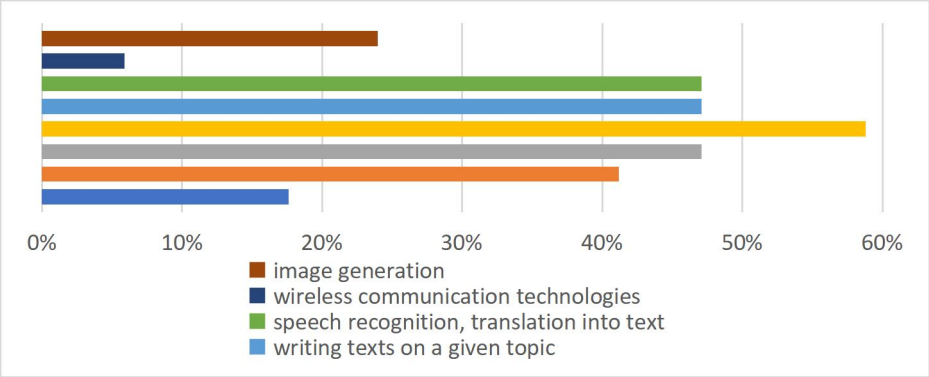

Figure 5. Results of teachers' answers to the question: "What end-to-end digital technologies have you heard about?"

35.3% believe that teaching on new technologies should take place in the form of an elective; 29.4% - there should be a separate discipline in the curriculum; 23.5% - it is necessary for teachers to talk about the possibilities of new technologies within this discipline (Figure 6).

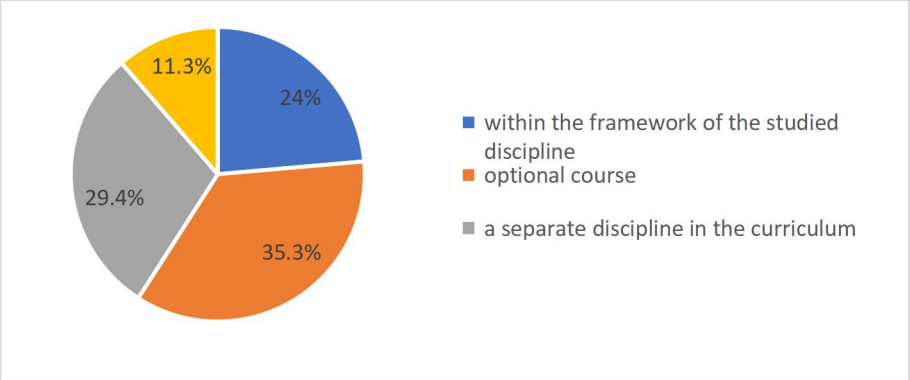

Figure 6. Results of teachers' answers to the question: "In your opinion, how should students be trained to use end-to-end technologies?"

To the question: " What technologies do you consider necessary to teach students?", the teachers noted artificial intelligence, big data, and programming elements in programming languages (Figure 7).

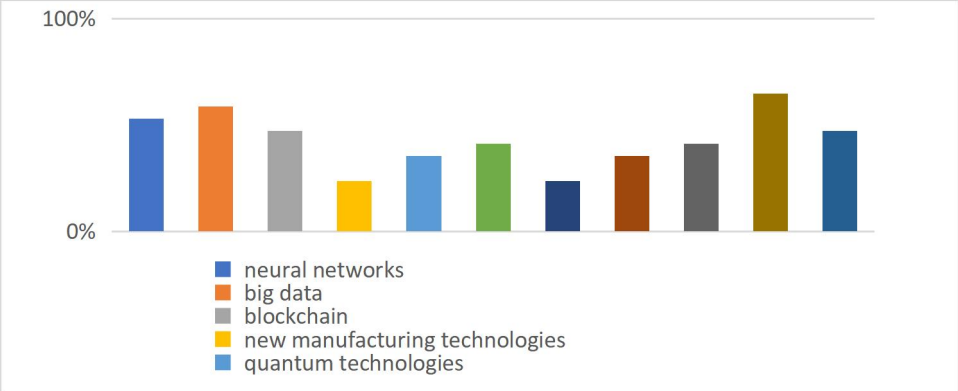

Figure 7. Results of teachers' answers to the question: "What technologies do you consider necessary to teach students?"

Having studied the scientific literature on this topic, it was found that the topic of introducing new digital technologies into the educational process of training medical personnel is relevant not only for Russian, but also for foreign universities around the world. It can be stated that most universities offer elective courses with different duration and depth of study of the material.

Duke University (USA) offers its students an optional course "School of Machine Learning of the Faculty of Medicine" lasting 6 months, where cases of specific areas of machine learning are studied, taking into account clinical experience. Harvard University (USA) conducts a monthly elective "Clinical Informatics", which provides computerized call entry, clinical decision support, optimization of current work, big data, and public health analytics. The University of British Columbia (Canada) hosts a two-month elective program "Introduction to Medical Artificial Intelligence", where students learn how data is processed in an artificial intelligence application, analyze clinical results and use collaboration opportunities with software developers (Gupta & Kumar, 2023).

The National University of Singapore teaches the compulsory discipline "Bioinformatics and artificial Intelligence in Medicine" for students of the bachelor's degree program in biomedical informatics, during the study of which such issues as natural language processing, computer vision, medical data processing, deep learning are considered (Biswas & Hasija, 2022).

Tsinghua University (China) has included a six-month optional discipline "Artificial Intelligence for Medicine" in the curriculum. During the course, students will learn about the implementation of the artificial intelligence paradigm, including machine learning methods and neural network algorithms, as well as the application of these methods in various medical applications such as medical image processing, intelligent healthcare systems, drug development (Thirunavukarasu et al., 2022).

The competence center of NTI "Bionic Engineering in Medicine" on the basis of Samara State Medical University presents a platform of digital 3D models of the human body. The development will allow creating personalized digital human models, bionic prostheses, and analyzing pathologies. Scientists have the opportunity to detail organ systems to search for cause-and-effect relationships of pathological changes, which allows using a systematic approach in the organization of highly qualified medical care. The development became part of the Pie simulator program for visualizing the anatomy of the human body. On the screen of the interactive table, it is possible to examine in detail all the systems and organs of the human body - the resulting models can be rotated 360 degrees (Sen et al., 2023).

The Veterinary Faculty of Orenburg State Agrarian University uses an interactive 3D atlas to train veterinarians. This is an innovative textbook for studying animal anatomy, veterinary medicine and zoology in specialized educational institutions. The 3D atlas is intended for future specialists dealing with internal non-communicable animal diseases, their clinical diagnosis, and general somatic diseases. It allows you to study the anatomical structure of an animal in layers by demonstrating three-dimensional models of organs and systems - the program can make objects transparent or remove them. A similar training stand can also be used to train doctors in medical schools (Mathis et al., 2023).

The SKADI Technologies development team from St. Petersburg Mining University has created a prototype of Russia's first mixed reality glasses (MR glasses). They can be used in medicine, education and manufacturing, and in the future, they will be able to replace smartphones (Stengel et al., 2023).

Digital doubles can be used for training. A digital twin is a virtual model of an object or system with the necessary characteristics, on which you can test the effects of various drugs, procedures and visualize processes. In healthcare, digital twin technology could revolutionize the future by allowing doctors to work with virtual patients. In healthcare, digital twins are already being used for the development of personalized medicine, as well as the development of new drugs and devices. The field of digital twins' development is rapidly expanding due to advances in real-time data transmission, machine learning, as well as virtual and augmented reality technologies (Gupta et al., 2023).

Another option is training programs for students of medical universities in conjunction with technical universities where programmers are trained, or, for example, another option is to open a department with a profile in computer medicine, pharmacy, biology. Software developers can use related and modern technologies in the development and implementation of new healthcare applications. In addition, the implementation of such projects in the future will allow the state to benefit economically (Ellili et al., 2023; Mohammad et al., 2023).

All specialists working in healthcare (doctors, administrators, biologists, pharmacists), as well as data analysts, must cooperate to provide healthcare based on artificial intelligence. The problems of integrating information technology into medical education:

- studying at a medical university is a very difficult task, which is associated with a fairly intensive schedule of classes. It is necessary to master a large amount of theoretical information, which is supported by practical and laboratory classes. It takes time to practice in the "field" conditions, and then to prepare reports. Students are severely overloaded, and the introduction of additional hours for completing another course in digital technology should be voluntary. Students should feel the need for additional knowledge;

- to implement ambitious plans for the introduction of artificial intelligence, big data processing, machine learning, and the creation of powerful neural networks, computer equipment is needed that can solve the tasks set. This is quite an expensive pleasure that requires financial investments. Universities are budget–funded organizations that may have problems with this. In addition to material resources, teachers are also needed – specialists in the field of IT technologies who will be able to teach at the junction of interdisciplinary connections between engineering and technology and healthcare. There are not many such specialists now, they need to be trained;

- the level of digital competencies of all students is very different. Someone can somehow print text, and someone knows how to work with tables, graphs, diagrams. Therefore, due to the different levels of initial training of students, problems may arise with the preparation of an optional course program. It may be necessary to test applicants before starting training, and then divide them into groups according to their level of training;

- the next problem is the consolidation and application of knowledge. Due to the lack of opportunity to use the acquired knowledge, they will eventually be forgotten. Therefore, training should be structured in such a way as to raise the bar of knowledge on digital technologies at an older course, which should be more and more profound.

The application of new end-to-end technologies in the healthcare sector provides huge potential for improving the quality of healthcare, optimizing processes and making informed decisions. Some areas where end-to-end technologies find application in healthcare:

Diagnosis and prognosis of diseases. By analysing large amounts of medical data, including clinical records, images, laboratory results, genetic data, and patient monitoring data, big data analytics enables the development of machine learning and artificial intelligence algorithms for the diagnosis and prediction of diseases. This helps in early identification of risks, determining appropriate treatment regimens and predicting the effectiveness of treatment.

Personalized medicine. End-to-end technologies allow you to create models that take into account the individual characteristics of the patient, including genetic data, physiological indicators, personal medical history and lifestyle. This helps in developing individualized treatment approaches, selecting the most appropriate medications, and predicting treatment responses.

Healthcare management and process optimization. End-to-end technologies help improve healthcare management. Data analysis makes it possible to optimize the allocation of resources, plan medical services, predict the burden on medical institutions, identify treatment effectiveness and morbidity trends, as well as reduce costs and improve the quality of healthcare.

Medical research and development. Thanks to the large volume of data being processed, researchers can identify connections, trends and patterns that contribute to the development of new drugs, therapeutic approaches and technologies. Big data analytics also contributes to more effective clinical trials and improved outcomes.

Ensuring patient safety. Big data analysis helps in detecting anomalies, errors and undesirable events in medical practice. By analyzing large amounts of data on drug side effects, treatment outcomes, and other factors, risks can be identified and patient safety measures can be taken.

Thanks to data analysis, a pharmaceutical company will be able to pay attention to drugs that, as a rule, are always bought together, and draw appropriate conclusions. In real time, you can analyze sales reports and identify fraud attempts during operations, or quickly change marketing

campaigns based on incoming information about new sales and even help bring new products to market.

The main reasons that encourage companies to invest, for example, in Big Data analytics are process optimization; in-depth analysis of business processes; improvement of customer service; reduction of production and sales costs; assistance in understanding the needs and behavior of patients, companies can attract a new target audience, assess customer satisfaction, predict the result; faster, better and to respond to their requests with lower costs; to predict the demand for drugs in advance; to sell goods where they are not sold, but would most likely be in demand. The natural consequence of this approach is an increase in sales of medicines and an increase in revenue.

4. Conclusion

Thus, the article considers the use of end-to-end technologies in medicine, biology, and pharmacy. The purpose of the study was to assess the level of awareness of Bashkir State Medical University students studying in the 2nd year of the specialties "Medicine", "Pediatrics", "Pharmacy", "Biology" about end-to-end technologies, their capabilities, their application in the future profession, as well as the opinion of teachers of humanities and natural sciences on this issue. A random sampling method was used to conduct a survey of students and teachers using the Google Forms resource, which made it possible to fill out the questionnaire remotely with further processing of the results.

The results of the study showed that currently students of medical higher educational institutions are insufficiently informed about new digital and information technologies. The opinion of teachers was divided: 35.3% believe that teaching on new technologies should take place in the form of an elective; 29.4% supported a separate discipline in the curriculum; 23.5% suggest informing students about the possibilities of new technologies within the framework of the discipline being studied. Teaching is organized in the old-fashioned way, the extensive capabilities of modern technologies (open access databases, digital twins, neural networks, artificial intelligence, big data analytics, augmented and virtual reality technologies) are not used. Teachers should improve their skills by taking additional training.

Half of the students preferred that no additional disciplines be introduced into the curriculum, and that teachers talk about end-to-end technologies within the framework of the studied discipline; 36.7% are ready to attend elective classes. The important thing is that whatever program you offer to students, it must be relevant for the specialty of study and applicable in further work. Both students and teachers must improve their digital competencies in a timely manner in order to be competitive in the modern world.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

References

Jieyi, Z., Qinghua, P., & Junfeng, Y. (2023). Bibliometric analysis on research hotspots and evolutionary trends of artificial intelligence application in traditional Chinese medicine diagnosis. Digital Chinese Medicine, 6(2), 136-150. https://doi.org/10.1016/j.dcmed.2023.07.004

Denisova, O. A. (2021). Big Data technology: assessing the quality of the educational environment. Journal of Physics: Conference Series, 2001, 012027. https://doi.org/10.1088/1742-6596/2001/1/012027

Baldwin, J. N., Bootman, J. L., Carter, R. A., Crabtree, B. L., Piascik, P., Ekoma, J. O., & Maine, L. L. (2015). Pharmacy practice, education, and research in the era of big data: 2014-15 Argus Commission Report. American journal of pharmaceutical education, 79(10). https://doi.org/10.5688/ajpe7910S26

Denisova, O. A., Kunsbaeva, G. A., & Chiglintsiva, A. S. (2021). Big data: some ways to solve the problems of higher education. Journal of Physics: Conference Series, 2001, 012021. https://doi.org/10.1088/1742-6596/2001/1/012021

Aziz, M. M., Alboghdadly, A., Rasool, M. F., Shaalan, M. S., Goresh, H. K., Najjar, M. F., & Alshawwa, S. Z. (2023). A discursive presentation of community pharmacies: Premises, storage, staff, documentation and legal compliance. Heliyon, 9(12), E23112. https://doi.org/10.1016/j.heliyon.2023.e23112

Denisova, O. (2022). Processing of Streaming Weakly Structured Data. In DITEM 2021: Digital and Information Technologies in Economics and Management, 432, 47-58. https://doi.org/10.1007/978-3-030-97730-6_5

He, H., Luo, Y., Yu, B., Lai, Y., Zheng, J., & Ban, J. (2023). Analysis of clinical drug use and construction of pharmacy service model for children with Kawasaki disease based on integration concept. Journal of Holistic Integrative Pharmacy, 4(2), 133-139. https://doi.org/10.1016/j.jhip.2023.10.001

Papanagnou, C. I., & Matthews-Amune, O. (2018). Coping with demand volatility in retail pharmacies with the aid of big data exploration. Computers & Operations Research, 98, 343-354. https://doi.org/10.1016/j.cor.2017.08.009

Chen, K. C., Lin, S. Y., & Yu, M. M. (2022). Exploring the efficiency of hospital and pharmacy utilizations in Taiwan: An application of dynamic network data envelopment analysis. Socio-Economic Planning Sciences, 84, 101424. https://doi.org/10.1016/j.seps.2022.101424

Frestel, J., Teoh, S. W. K., Broderick, C., Dao, A., & Sajogo, M. (2023). A health integrated platform for pharmacy clinical intervention data management and intelligent visual analytics and reporting. Exploratory Research in Clinical and Social Pharmacy, 12, 100332. https://doi.org/10.1016/j.rcsop.2023.100332

Sahu, M., Gupta, R., Ambasta, R. K., & Kumar, P. (2022). Artificial intelligence and machine learning in precision medicine: A paradigm shift in big data analysis. Progress in molecular biology and translational science, 190(1), 57-100. https://doi.org/10.1016/bs.pmbts.2022.03.002

Puranik, C. J., Rao, S., & Chennamaneni, S. (2019). The perils and pitfalls of big data analysis in medicine. The Ocular Surface, 17(4), 838-839. https://doi.org/10.1016/j.jtos.2019.07.010

Torrente, M., Núñez-García, B., Franco, F., De Juan, V. C., Menasalvas, E., Rodríguez-González, A., ... & Provencio, M. (2019). MA16. 03 Big Data Analysis for Personalized Medicine in Lung Cancer Patients. Journal of Thoracic Oncology, 14(10), S313-S314. https://doi.org/10.1016/j.jtho.2019.08.630

Moratinos, G. L., & de Miguel Beriain, I. (2020). Big data analysis and machine learning in intensive care medicine: identifying new ethical and legal challenges. Medicina intensiva, 44(5), 319-320. https://doi.org/10.1016/j.medin.2019.11.003

Seghatchian, J. (2020). An introductory commentary on the use of artificial intelligence, machine learning and TQM, as novel computational tools in big data patterns or procedural analysis, in transfusion medicine. Transfusion and Apheresis Science, 59(6), 102985. https://doi.org/10.1016/j.transci.2020.102985

Wu, X., Li, W., & Tu, H. (2024). Big data and artificial intelligence in cancer research. Trends in Cancer, 10(2), 147-160. https://doi.org/10.1016/j.trecan.2023.10.006

Gupta, N. S., & Kumar, P. (2023). Perspective of artificial intelligence in healthcare data management: A journey towards precision medicine. Computers in Biology and Medicine, 162, 107051. https://doi.org/10.1016/j.compbiomed.2023.107051

Biswas, S., & Hasija, Y. (2022). Big data analytics in precision medicine. In Big Data Analytics for Healthcare (pp. 63-72). Academic Press. https://doi.org/10.1016/B978-0-323-91907-4.00005-4

Thirunavukarasu, R., Gnanasambandan, R., Gopikrishnan, M., & Palanisamy, V. (2022). Towards computational solutions for precision medicine based big data healthcare system using deep learning models: A review. Computers in Biology and Medicine, 149, 106020. https://doi.org/10.1016/j.compbiomed.2022.106020

Sen, J., Huynh, Q., & Marwick, T. H. (2023). Prognostic signals from moderate valve disease in big data: an artefact of digital imaging and communications in medicine structured reporting?. Journal of the American Society of Echocardiography, 36(11), 1190-1200. https://doi.org/10.1016/j.echo.2023.05.014

Mathis, M., Janda, A., & Kheterpal, S. (2023). The Promise and Pitfalls of Big Data Studies in Perioperative Medicine. In Perioperative Quality Improvement (pp. 23-28). Elsevier. https://doi.org/10.1016/B978-0-323-83399-8.00005-3

Stengel, D., Augat, P., & Giannoudis, P. V. (2023). Large-scale, pragmatic randomized trials in the era of big data, precision medicine and machine learning. Valid and necessary, or outdated and a waste of resources?. Injury, 54, S2-S9. https://doi.org/10.1016/j.injury.2022.12.016

Gupta, B. B., Gaurav, A., & Panigrahi, P. K. (2023). Analysis of security and privacy issues of information management of big data in B2B based healthcare systems. Journal of Business Research, 162, 113859. https://doi.org/10.1016/j.jbusres.2023.113859

Ellili, N., Nobanee, H., Alsaiari, L., Shanti, H., Hillebrand, B., Hassanain, N., & Elfout, L. (2023). The applications of big data in the insurance industry: A bibliometric and systematic review of relevant literature. The Journal of Finance and Data Science, 100102. https://doi.org/10.1016/j.jfds.2023.100102

Mohammad, H., You, H. W., Umapathi, M., Ravikumar, K. K., & Mishra, S. (2023). Strategies of Artificial intelligence tools in the domain of nanomedicine. Journal of Drug Delivery Science and Technology, 105157. https://doi.org/10.1016/j.jddst.2023.105157

How to Cite: Denisova, O., & Abramishvili, Y. (2024). End-to-End Technologies in Medicine, Pharmacy, and Biology. *Contemporary Education and Teaching Research*. 5(8), 301-310. https://doi.org/10.61360/BoniCETR242016820806