Volume 2, Issue 10, October - 2024 **ISSN (E):** 2938-379X

TEACHING OF FUNDAMENTAL SCIENCES IN MEDICAL INSTITUTIONS OF HIGHER EDUCATION

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Abstract
An approach is proposed to the implementation of the problems of teaching clinical subjects with the introduction of the courses "Information Technologies in Medicine" and "Biomedical Engineering" based on the following definitions: reasons for the low level of students' knowledge of the method of forecasting; the main contradictions of teaching students the method of analysis; distinctive features of the methodological system of teaching students the modeling method; ways to implement the basic principles of improving educational technologies involving the use of information and communication technologies (ICT) and biomedical engineering (BME) methods; features of ensuring the professional and clinical orientation of communication and engineering training in the medical specialties of universities; fundamentals for the development of methodological support for information, communication and engineering training of the future doctor.

Keywords: Information and communication technologies, biomedical engineering, scientific discipline, data, information, knowledge, definition, mathematical modeling; biophysical phenomenon; model; medical high school.

Introduction

Modern ways of socio-economic development of the country require improvement of the education system in order to increase the efficiency of knowledge acquisition and strengthen the polytechnic orientation of teaching. Mastering modern information and communication technologies and mathematical methods, general principles and the ability to apply them to solve practical problems contributes to the development of creative and cognitive abilities, the formation of scientific and theoretical thinking, forecasting and decision making. Therefore, for teaching the disciplines of biomedical informatics and engineering in medical universities, the relevance of questions about the role and place of these subjects is increasing.

Information technology and biomedical engineering have been an "emerging field" for decades. The creation of health information and the desire to computerize and robotize healthcare is not new.

Information technology in medicine and biomedical engineering does not have a clear and theoretically based definition, because information technology and robotic assistants are used in all areas as a tool. Many proposed definitions focus on data, information and knowledge, but do not adequately define these terms. Using ideas from the philosophy of information, we

define computer science as the science of information, where information is data plus meaning. Information technology in medicine is the science of information applied or studied in the context of medicine.

Defining the object of study of computer science as data plus value clearly distinguishes the field from related fields such as mathematics, mathematical statistics, mathematical modeling, and biomedical engineering, which have different objects of study. The emphasis on data plus meaning also suggests that information technology problems in medicine and biomedical engineering tend to be complex when they deal with concepts that are difficult to capture through formal computational definitions. In other words, tasks in which it is necessary to take into account meaning, primary data obtained from patients, forecasting, analysis of results and decision-making. Sometimes it is more complex than tasks in which it is enough to manipulate data without taking into account certain criteria and protocols. Additionally, the definition implies that information technology research, teaching, and services should focus on biomedical information as data and meaning.

Therefore, the focus is on mastering modern medical research methodology, integrated with relevant substantive approaches and scientific theories of ICT and biomedical information. Information technology and bioengineering can serve as an effective mechanism for such integration in the process of teaching natural sciences and ICT and biomedical disciplines at a medical university, since the methods of these areas are a form of interdisciplinary activity.

As a result of research and modeling of real medical processes, information technology and bioengineering as a research apparatus are mastered. Thus, the created algorithms, objectively fulfilling an important methodological and research role in scientific knowledge, can also act as one of the teaching tools that contribute to the achievement of a competency level of education for medical students.

The ability to apply in professional activities the method of algorithmization and modeling of medical phenomena and processes, information technology and bioengineering are becoming one of the most important special professional competencies that should be developed in the process of training future medical specialists.

The content of education should be built on the basis of fundamental natural science principles and core ideas. It is necessary to move on to teaching general scientific research methods, in particular, information technology and bioengineering.

Students must: distinguish and be able to build models of medical objects, phenomena and processes; explore these models, transform them into software solutions platforms, technologies and apply them in their scientific and medical activities.

It is known that doctors in their professional activities often solve professional problems using information technology, methods of mathematical statistics, probability theory or ready-made computer software applications. In addition, when students of medical universities study a number of special disciplines, for example, “Management and organization of healthcare”, “Biomedical engineering”, “Medical biology”, “Epidemiology”, etc., not only theoretical knowledge in the field of information technology is required, but also knowledge of the methods of their application.

Tasks of medical and biological content must be included in professionally important sections of information technology and mathematics in order to:

✓ resolve a problematic situation of a medical and biological nature;

✓ show medical students the relationship between information technology and medical practice, information technology and special disciplines in order to speed up the process and obtain results;

✓ promote automation of the process, the formation of primary professional skills of future doctors using information technology and bioengineering, namely the formation of the ability to analyze a process or phenomenon from medical practice and make decisions.

By tasks of medical and biological content we mean text tasks, the plots of which are borrowed from the sphere of professional activity of a doctor, and solutions are found by means of information technology.

The training of a specialist with high creative potential, possessing logical thinking, capable of mastering and creating modern innovative technologies, models of medical processes and phenomena, in our opinion, should be built on the basis of an integrated methodological approach that combines fundamental and general professional education, using various didactic teaching in the educational process principles (interdisciplinary communication, unity of fundamentality and professional orientation, scientific character, etc.), with the use of information technologies, bioengineering and mathematical modeling, enhancing the creative component of learning.

To successfully work in the specialty, a competent medical employee must have deep fundamental knowledge of information technology, biophysics, bioengineering, mathematics and know the areas of their application in professional activities. Without knowledge of their laws, principles, mechanisms, activity in various fields of medicine and biology is impossible. Today, the most important component of a physician's professional activity is the automation of medical and biological processes, mathematical modeling of processes and phenomena underlying technologies and robotization of technological processes in medical and biological research. The visualization method in biomedicine is used to understand biomedical, chemical processes, mechanisms underlying physiological and pathological processes. The main task of such a modeling algorithm is to isolate the phenomenon under study in a "pure" form, an attempt to filter a particular process from disturbing factors and accompanying phenomena in a complex system, to show the essence of the process under study for decision-making. We will consider information technologies within the framework of the variable component when solving medical problems with professional content, using an arsenal of standard biomedical models, phenomena and processes that give correct predictions if they are applicable only within certain boundaries. Information technology in medicine is a tool for solving medical and biological processes with ready-made algorithms, mathematical expressions, logically interconnected, i.e. in the form of differential, integral, algebraic equations, inequalities, etc. As practice shows, the majority of medical university students, demonstrating the ability to work with information technology in clinical classes, experience difficulties in using information and communication technologies when solving medical problems of both abstract and professional content. There is an obvious need to orient students toward educational

activities in clinical subjects that will have a significant impact on their overall professional development.

In this regard, information technology is important as a tool of scientific knowledge in organizing the content of biomedical education, in accordance with which it is possible to implement the educational process and effectively form the natural scientific thinking of medical students.

At the same time, analytical-reflective, constructive-prognostic, evaluative-informational, organizational-activity, correctional-regulatory types of tasks are determined, aimed at developing contextual-environmental, subject-specialized, axiological competencies for the personal and professional development of students. In the process of such work, the selection of integrative educational and professional content of biomedical education is carried out; its structuring is carried out in accordance with the range of designated tasks; methods and organizational forms for students to effectively master this content are determined.

An analysis of the literature and teaching experience shows that medical university students have different levels of knowledge in information technology. They, as a rule, have no interest in studying it. At the same time, for many medical specialties, a number of knowledge on information technologies and methods of activity are of a professionally significant nature. For example, knowledge of the basics of information technology, probability theory, mathematical statistics, and ways to solve problems in these subjects is extremely important for future doctors. Despite the differences in specialties, all doctors need the ability to analyze, filter, focus information, highlight the essence of the issue, master the logic of reasoning, summarize statistical material, and correctly interpret the situation.

Biomedical engineering is information technology oriented and focuses on technology and tools as the defining property of medical information. These definitions typically emphasize hardware and software. Similarly, Berman defines medical information technology as “a branch of medicine that combines biology with information technology.” Clearly, computers and software are very important tools for the biomedical workforce. Many activities related to information technology in medicine, such as data mining or electronic medical records, would not make sense without computers and software. However, by focusing on computers and programs, technology definitions emphasize the tools rather than the work itself. For example, information technology in nursing emphasizes the role of information technology - trained nurse specialists in supporting nursing practice and their knowledge of nursing: a specialty that integrates nursing, information technology and information technology in identifying the causes of disease, collecting and processing data, and in information management to support nursing practice, management, education and research, and to advance nursing knowledge. The software, developed at Stanford University, has been used for a variety of applications, including controlling fans and tuning elevators.

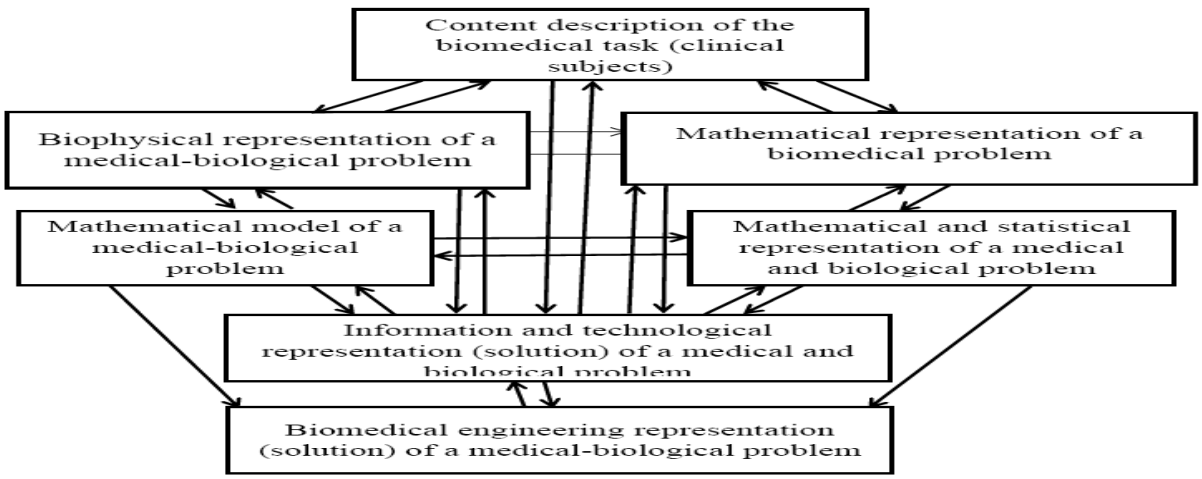
Концептуально-ориентированные определения фокусируются на таких понятиях, как данные, информация и знания. Например, в книге E. Coiera “Guide to health informatics” определяет информационные технологии в медицине как «изучение информационных и коммуникационных систем в здравоохранении». M. Musen фокусируется на онтологиях

и методах решения проблем как на инструментах для организации человеческого знания и, следовательно, имеет фундаментальное значение для биомедицинской инженерии.

Recently, it has become obvious that interdisciplinary integration, coordinated work of teachers of various disciplines to achieve the goals of the learning process is one of the most important factors in optimizing the learning process at a university, including medicine. Interdisciplinary integration is much broader than interdisciplinary connections, since in addition to the purely technical and functional surrounding world, it ensures not only interconnection, but also the interpenetration of individual academic disciplines into each other, increases the cognitive activity of students and promotes a more conscious assimilation of knowledge. Interdisciplinary integration is the mutual complementation of the content of different academic disciplines through the use of various innovative methods, tools and organizational forms of training. In psychology and pedagogy, the conclusion is substantiated that interdisciplinary integration is one of the important psychological and pedagogical conditions, and the principle of interdisciplinarity has recently become one of the leading didactic and methodological principles.

The education system is constantly being updated, new technologies and interdisciplinary integration are being introduced both horizontally and vertically. An important factor determining the nature of changes in the education system is scientific and technological progress, which is inconceivable without information technology. Currently, the goal of developing and improving the medical education system is to train specialists who are ready for independent medical practice and capable of constant self-education in the conditions of the modern level of technical equipment of healthcare and high-tech medical care. At the same time, when solving most biomedical problems, training in the following disciplines is of particular importance: clinical areas, information technologies in medicine, biophysics, biomedical engineering, mathematics, mathematical statistics, mathematical modeling, and especially their integrated training.

As you know, any system has its own methodological basis. In this regard, in general terms, the methodological basis of the information and communication system for integrating the disciplines of information technology in medicine, biophysics, biomedical engineering, mathematics, mathematical statistics, mathematical modeling should be a learning process that includes the following interrelated aspects (see diagram 1.):



Let us note that the solution of any medical and biological problem using biophysical, mathematical methods, biomedical engineering and computer technologies is primarily associated with its formalization, i.e. translation of its content into the language of mathematical symbols and formulas and subsequent interpretation of the resulting mathematical solution, algorithms, programs and platforms with certain functions. Formalization boils down to the following in general terms. Based on the meaningful description, the initial set of system characteristics is determined. To highlight the essential characteristics, at least an approximate analysis of each of them is necessary. When carrying out the analysis, they rely on the statement of the problem and understanding of the nature of the problem under study. After excluding unimportant characteristics, controllable and uncontrollable parameters are identified and symbolized. Then a system of restrictions on the values of controlled parameters is determined. If the restrictions are not fundamental, then they are neglected. Using the obtained research results, the user will be able to draw conclusions and make decisions, and will also speed up the process of solving a given problem.

These interconnected aspects create a natural hierarchy: there will always be more data and knowledge than information. Indeed, much of the knowledge we teach students every day is of true value

To better illustrate the fundamental knowledge between subjects, we need only consider some basic findings from cognitive psychology. The first general result is that with integrated teaching, students tend to remember the meaning of a sentence or picture rather than its exact form. For example, given the sentence “The doctor diagnosed the patient with pneumonia,” participants were more likely to make errors when they were later presented with sentences such as “The doctor decided that the patient had pneumonia” or “The patient was diagnosed with pneumonia” than when they were given “The doctor diagnosed the patient with a brain tumor,” even though the latter is syntactically (but not semantically) more similar to the original sentence. This is the exact opposite of computers, which excel at storing and collating precise syntactic forms but require significant programming to have even a rudimentary ability to equate different forms with the same meaning. Similarly, recent experiments in ecological psychology have shown that many of the psychological biases found in classic studies of human thinking and decision-making can be significantly reduced or eliminated when people are given meaningful problems related to their real-life experiences.

In information technology, the field of artificial intelligence (AI) deserves special attention regarding issues of representation and meaning of any tasks. There are many definitions of AI and significant disagreement regarding its scope, achievements, and corresponding goals of the discipline. John McCarthy, one of the founders of AI, defined the field as “the science and technology of creating intelligent machines, especially intelligent computer programs.” He further defines intelligence as “the computational part of the ability to achieve goals in the world.” Clearly, there can be many goals, some of which are meaning-dependent and difficult to reduce to formal methods (e.g., identifying “sick” patients), and some of which are relatively simple (e.g., 5+2=?). Some AI researchers have spent decades trying to develop machines that can process meaning. Indeed, the (somewhat pejorative) definition of AI is “the study of how to make computers do things that humans are currently better at.”

Note that the above discussion does not mean that medical information technology, mathematics, mathematical statistics, or biomedical engineering are somehow less important than medical information and that they have a different primary focus. In some cases, these fields take different perspectives on the same issue. Clinicians care for patients. Programmers and technologists develop methods to apply and/or extract medical information needed to support effective treatment. Computer scientists are proposing efficient algorithms for manipulating the data underlying medical information.

Finally, we do not mean to imply that these are the only areas that are important to a medical student. Since a medical student must first of all know clinical subjects and their meanings, in which meaning is the central object of study, he must use methods, theories and results from such areas of medicine as therapy, surgery, psychology, healthy nutrition, medical prevention, etc.

Conclusions and offers

A synchronized scheme of differential connections between biomedical problems and practical exercises, respectively, has been compiled between the disciplines of information technology in medicine, biophysics, mathematics, mathematical statistics, mathematical modeling and biomedical engineering.

Program development consists of two different activities - creating an algorithm for its operation and representing this algorithm as a program. Until now, we have only considered the structure of the platform and have not touched upon the question of how, in fact, these algorithms are created. However, creating an algorithm is usually the most difficult stage in the software development process for integrating several educational subjects. After all, creating an algorithm means finding a method for solving the problem that the algorithm is intended to solve.

Consideration of problem-solving methods and their detailed study are not aspects specific to only one subject. On the contrary, it is important for almost any field. The close connection between the process of creating algorithms and the general problem of finding solutions to problems has led to the collaboration of computer information systems specialists and subjects from different fields in the search for better methods for solving problems. Ultimately, it would be desirable to reduce the problem of problem solving to algorithms as such, but this has proven impossible. Thus, the ability to solve problems is, to a large extent, a professional skill that ensures forward and backward synchronicity between interdisciplinary disciplines. It is also necessary to develop, not only in the department, which can be studied, but with all subjects in the medical and biological direction. To create a platform, you can use open access programming languages and their templates.

Information technology in medicine and biomedical engineering is the application of information science and technology as data and tools to problems of interest to biomedicine. These definitions are broad enough to include most activities currently considered to fall within the scope of digital transformation in medical education, while excluding activities traditionally considered outside the scope of our field. Thus, our definition can serve as a guide for students, teachers, practitioners and researchers. Significant work remains to be done to understand and

operationalize the implications of this view. However, we believe that these definitions reflect the intuition behind many definitions of information technology and also open the door to a paradigm shift in how we view and practice information technology in medicine and biomedical engineering.

It should be noted that these disciplines relate to the preparation of a specialist - bachelor - “Medical and Biological Sciences” - 60910600, “Biomedical Engineering” - 60711800 and “Management: Healthcare Management” - 60411200.

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