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Developing Students' Critical Thinking Through Biological Problem Modeling Technologies in Medical Education

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Abstract: This article analyzes the role of modeling technologies for biological problems in developing students' critical thinking skills in medical education. Modeling technologies provide an opportunity to understand complex biological processes, analyze problems, and develop alternative solutions. The article also examines the main types of modeling, their advantages in forming critical thinking, and their effectiveness in the medical education process. The results of the study show that the use of modeling technologies serves to deepen students' knowledge, develop analytical thinking, and increase their independent decision-making skills.

Keywords: Medical education, biological problems, modeling technologies, critical thinking, mathematical models, computer simulations, virtual laboratories, analysis, problem solving, innovative education.

Introduction: In the process of modern medical education, one of the important tasks is to develop students' independent and critical thinking skills. Medical science requires an understanding of complex biological processes, which cannot be fully achieved by traditional teaching methods. Therefore, technologies for modeling biological problems are being introduced into the educational process. This article analyzes the impact of modeling technologies on the development of critical thinking in medical education. Medical education is the process of training qualified specialists for the healthcare sector, which includes teaching the basics of medical science, developing clinical skills, and increasing practical experience. The main goal of medical education is to train highly qualified doctors, nurses, and other medical specialists to provide quality medical services to society.

Important aspects of medical education:

- Interdisciplinary approach - related to biology, chemistry, physics, pharmacology, anatomy, and other sciences.

- Practical training - Simulation laboratories, hospital practices.

- Innovative technologies - Use of simulations, virtual reality, artificial intelligence and medical modeling.

- Critical and clinical thinking - Doctors must have the ability to think critically in order to make accurate diagnoses and develop effective treatment plans for patients.

Modern trends in medical education

- Online and hybrid education - the possibility of learning through distance learning platforms.

- Virtual and augmented reality (VR/AR) - used to study anatomical and surgical procedures.

- Person-centered education - educational programs tailored to the interests and needs of the student.

- Medical simulations - gaining realistic experience through modeling clinical cases.

Medical education is a constantly evolving field, becoming more efficient with the help of modern

technologies and innovations. Modeling is the representation of real-world processes using mathematical, graphical, or computer technologies. Mathematical models represent physiological and biochemical processes of the organism;

Computer simulations predict the organism's response to various situations.

Virtual laboratories are a way to express the possibility of conducting experiments in safe conditions, allowing for a deeper understanding of complex biological processes. Modeling of biological processes in medicine is used in the following areas.

The role of critical thinking in the development of critical thinking

Critical thinking is a special type of thinking that draws conclusions by analyzing facts. It is the ability to analyze problems, draw conclusions based on evidence, and evaluate alternative solutions. Modeling biological problems develops students' critical thinking through the following aspects. This concept has complex and diverse definitions, including rationality, skepticism, objective analysis, and fact-checking. Its prerequisite is to agree to strict standards of mental development and apply them with vigilance. Critical thinking requires the acquisition of effective communication and problem-solving skills, as well as overcoming our natural egocentrism and sociocentrism.

Visualizing complex biological processes

By creating models of processes occurring in the body, students understand their dynamics and have the opportunity to analyze problems in depth.

Opportunity to experiment

By simulating processes that are difficult to implement in real life, students analyze how specific medical conditions develop in different scenarios.

Development of problem-solving skills

Through modeling, students develop the skills to study variable data, make assumptions, and test them.

Teamwork and discussions

Students have the opportunity to justify their own ideas and analyze the ideas of other group members while working on a specific biological model.

Advantages of using in medical education

Biological process modeling technologies have the following advantages:

- Clarity and clarity - students consolidate theoretical knowledge using visual and interactive methods;

- Real-time error analysis - based on models, students have the opportunity to quickly review their mistakes and correct them;

- Independent formation of ideas - students try to solve problems based on their own ideas.

- In the modern medical education system, it is not enough to provide students with theoretical knowledge alone. It is also important to develop their independent and critical thinking skills. The use of modeling technologies is one of the important tools for analyzing and understanding various complex processes, especially in the field of biological and medical sciences.

The essence of biological modeling technologies

Biological modeling is the process of describing the processes occurring inside an organism using various models (mathematical, computer, graphical, physical) to understand and analyze them. With the help of these technologies, students can gain a deeper understanding of complex biological phenomena and independently formulate their own ideas.

The main types of modeling technologies:

- Mathematical models - describing the activities of cells and organs using mathematical equations.

- Computer modeling - simulating how the organism responds to various diseases.

- Virtual laboratories - interactive systems that allow you to conduct experiments in a safe environment.

- 3D visualization - analysis of biological structures in three dimensions.

The role in the development of critical thinking

Critical thinking is the ability to analyze information, draw evidence-based conclusions, and make independent decisions based on existing theories or evidence. Modeling biological problems develops critical thinking through the following aspects:

Deep analysis of complex biological processes

Students can understand the mechanisms of disease development using various models and isolate important parts of them by visualizing processes. Students safely conduct expensive and dangerous experiments in the real world in virtual laboratories and draw conclusions based on their results.

Study and evaluate alternative solutions

Modeling technologies encourage students to test different scenarios. For example, the effect of a drug on the body is analyzed using different models, which allows them to compare alternative treatment methods. By working together on specific models, students develop the skills of expressing their opinions, discussing with other group members, and justifying arguments.

Advantages of modeling technologies in medical education

- Practical application of theoretical knowledge - students have the opportunity to apply the theoretical knowledge they have learned to real life.

- Expressing complex information in an understandable form - through visualization, students can more easily understand complex processes.

- Real-time error analysis - through modeling, students have the opportunity to identify and correct their own errors.

- Developing decision-making and reasoning skills - students learn to find the most optimal solution by testing different scenarios.

Modeling

When we talk about medical and biological tasks, we mean understanding the text, finding solutions using mathematical methods. Aspects of mathematical education in a medical university can be considered on the basis of a universal multiplicative model of the quality of education. It is necessary to move from classical methods in teaching mathematics to the method of applying mathematical methods in medical practice.

The reasons for the low level of students in modeling are:

- insufficient use of this method;

- mainly explanatory and illustrative methods are used in the educational process;

- the conflict between the scientifically based methodology of teaching and existing methods, which does not allow to fully reveal the diversity of the application of the modeling method to the educational process.

Thus, the current methods of teaching students using the modeling method are not enough to ensure the required level of education and professional skills of graduates. Analysis of the state of problems of student learning in medical universities revealed the following contradictions. Scientific information in the field of medicine has increased. This information cannot be delivered to students without modeling and other modern methods. Between the increasing role of the modeling method in scientific research and education and the existing theoretical research in the field of teaching methods of scientific disciplines, there were no conceptual rules that would allow creating a teaching methodology for students using the modeling method. The requirements for the quality of personnel training are increasing. But the level of training is not significant. The methodological system for training students in modeling has its own characteristics. The unification of natural scientific knowledge within the framework of various scientific disciplines based on the modeling method, i.e. systematic reflection, experimental planning, construction of scientific theories, the educational role of the modeling method in scientific research. The following stages of targeted selection of educational material and training students in the modeling method are the provision of new theoretical materials to familiarize them with the modeling method. Development of general approaches to the application of the modeling method. Using the natural scientific content of specially developed creative tasks aimed at using the modeling method in the formation of special professional competencies in the process of teaching subjects. The use of this method increases competence in the field of modeling, develops theoretical thinking. The main principles of improving educational technologies using mathematical modeling methods are implemented. A higher educational institution with a medical specialty as its professional direction should provide mathematical training: mastering the mathematical apparatus that allows students to model, analyze and solve important problems related to simple mathematics encountered in medical science and practice; explaining the need to improve knowledge in the field of mathematics and its application. The implementation of the professional direction of teaching mathematics for a given specialty includes: firstly, maintaining mathematics within the framework of a single invariant course; secondly, ensuring the use of mathematics in other disciplines, thirdly, using mathematical models used in various branches of medical science and practice.

When choosing a mathematical content for training medical students, the following principles should be followed: a phased approach, personal and professional significance and adaptation. Together, these principles allow you to adjust the nature and depth of the studied mathematical material to the mathematical and propaedeutic-professional study. They contribute to the development of methodological support for the mathematical preparation of the future doctor. The mathematical preparation of a doctor should be carried out in the following areas: integrativeness, connection between elementary and senior courses, compatibility of students' future professional elements with mathematical activities, the preparation of professionally oriented tasks is achieved through the use of activities; renewal of professional motivation, which is carried out on the basis of involving situations that are significant from the point of view of medical practice; creative approach to issues. The creation of training materials and systems of professionally oriented tasks in various mathematical sections, as well as topics for practical work, their

implementation involves the involvement of a very serious mathematical apparatus. From the point of view of the problems under study, mathematical problems are considered, first of all, as a means of developing professionally important intellectual qualities necessary for a future doctor ("unusual" problems play an important role here), and secondly, as a carrier of mathematical content of professional importance. The formation of skills necessary for the formulation and solution of problems of a medical nature, their components are highlighted, an algorithm of the corresponding work is formulated, various methods of such work are indicated (including the introduction of professional information into the conditions of a mathematical problem; "framing" the condition with a purely medical plot, etc.), and a typology of tasks of this type is presented. When developing methodological support for the mathematical training of a future doctor, it is recommended to adhere to the following basic rules.

Modeling and modeling classification

Each model is created for a specific purpose and is therefore unique. However, the presence of common features allows us to group all their diversity into separate classes, which facilitates their development and study. In theory, there are many signs of classification, and their number is not determined.

- However, the following classification criteria are most suitable:

- The nature of the simulated side of the object;

- The nature of the processes occurring in the object;

- The method of implementing the model.

Classification and modeling of models based on the "nature of the simulated side of the object".

Functional models demonstrate only the behavior, the function of the modeled object. In this case, the simulated object is considered a "black box" with inputs and outputs. The physical nature of the object, the nature of the processes occurring in it, the structure of the object, since they are unknown, are ignored by the researcher. In functional modeling, the experiment consists of observing the output of a simulated object with artificial or natural changes in input effects. Based on this data, a behavioral model is built in the form of some mathematical functions. A computer chess program is a functional model of the human brain when playing chess. Structural modeling is the creation and study of a model whose structure (elements and connections) is similar to the structure of the simulated object. As we learned earlier, the similarity is not established at all, but is established relative to the research goal. Therefore, it can be described at different levels of consideration. The most general description of the structure is a topological description using graph theory. For example, military exercises are a structural model of a type of military action. Classification of models and modeling based on the "nature of the processes occurring in the object". According to this criterion, models can be deterministic or stochastic, static or dynamic, discrete or continuous or discrete-continuous. Deterministic models represent processes that do not have random effects.

To develop critical thinking, you need to do the following:

Step One. First, you need to analyze the information, interpret it, and if necessary, evaluate it. This is the most important competency in working with information. What is primary and secondary information? What is primary and secondary? Cause and effect? How is one piece of information related to another?

Step Two. It is very difficult to confuse the thoughts of a critical thinker, because he can easily identify all logical errors and any inconsistencies in thinking. Use a simple algorithm of critical questions. Is the topic of discussion clear? Can all arguments be called true? Are all arguments disclosed and proven? Are there no contradictions?

Step Three. Finding logical errors is one thing, explaining them and substantiating them to your opponent is another. The skill of argumentation and convincing reasoning is the main aspect of critical thinking. Persuasion should not be based on a beautiful presentation or form, but on comprehensively proven and disclosed evidence. The fourth step. And finally, the main point. A person can theoretically analyze information perfectly, find logical errors in exercises in a logic textbook, build arguments in the format of an artificial “debate”, but if he cannot apply all this knowledge and skills to business practice and solve real practical cases, this method will not give any results. Therefore, the fourth component of critical thinking is the ability to apply the results to solve problems. Critical thinking can and is very necessary to develop. It requires constant development. Critical thinking is not about criticism. It is about how to navigate in a huge flow of information, how to analyze incoming information. You need to doubt and ask different questions. The more complex the idea, the statement, the more questions you should have. It is important not to be afraid to check the information several times and look for primary sources, compare several sources. Most importantly, you need to learn to look at everything critically and not just believe any information.

CONCLUSION

The use of biological modeling technologies in medical education is an effective tool for teaching students critical thinking. Through these technologies, students visually analyze complex biological processes and develop scientific thinking and problem-solving skills. Therefore, the widespread introduction of modeling technologies in medical education is of great importance. Critical thinking plays an important role for doctors.

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