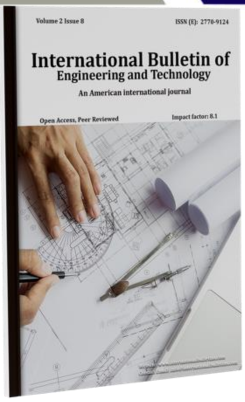

STRENGTHENING THE TEACHING OF MATHEMATICAL MODELING AND PREDICTION IN INFECTIOUS DISEASE EPIDEMIOLOGY USING INTERACTIVE METHODS

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Abstract: The article describes the use of the method of teaching the topic "mathematical modeling and prediction in the epidemiology of infectious diseases" using the interactive method "Problem situation". The results of scientific research conducted using this interactive method show its significant effect in the lesson process, the formation of independent, free and creative thinking skills in students, the establishment of interaction between teachers and students.

Keywords: Problematic educational technology, pedagogical technology, problem situation, student criteria, methods and tools, disease prognosis, epidemiological models, Reed-Frost model, dispersion, epidemiological assumptions.

Introduction. One of the important requirements for the organization of modern education is to achieve high results in a short time without excessive mental and physical effort. The formation of certain skills and abilities based on the delivery of certain theoretical knowledge to students in a short time, monitoring their activities, and assessing the level of theoretical and practical knowledge acquired by them requires modern pedagogical skills from the teacher, a comprehensive new approach to the educational process. Today, in developed countries, extensive experience has been accumulated in the use of pedagogical technologies that increase the creative activity of students and guarantee the effectiveness of the educational process, and interactive methods form the basis of this experience [6]. The advantages of the “Problem Situation” method in conveying medical topics to students are significantly higher than other methods. The “Problem Situation” method is a method based on the formation of students' skills in analyzing the causes and consequences of various problem situations and finding solutions to them as far as possible. The complexity of the problem selected for the “problem situation” method should correspond to the level of knowledge of medical students. They must be able to find a solution to the problem, otherwise, when they cannot find a solution, it will lead to the fading of the interest of the listeners and a loss of self-confidence. When using the “problem situation” method, listeners in the medical field learn to think independently, individually analyze the problem and its consequences, and find a solution to it. [6,7]

The difference between the mathematical modeling method and other innovative methods is that the object or process is described mathematically, that is, various formulas, equations, functions, etc. The study of models is carried out using mathematical methods, solving the equations that form the basis of the model. Sometimes, qualitative analysis of the model itself, without solving the equations, provides valuable information about the object or process [11]. Today, it is difficult to name a research area where mathematical modeling methods are not used. In many areas, such as physics (of course, first of all), biology, chemistry, medicine, economics, ecology, social sciences, extremely wide-ranging results with high efficiency are obtained on the basis of mathematical modeling methods. Mathematical modeling methods are of invaluable importance in the analysis of various technological processes. Therefore, it is important to widely implement the use of these methods in technical sciences [12].

Research methodology. Mathematical modeling of diseases is an urgent problem, and this topic is devoted to studying the possibilities of using mathematical modeling in medicine.

Today, more and more researchers are turning to mathematical models to predict a particular disease, as they help to accurately and accurately study the changes in certain processes occurring in society. Mathematical modeling is indispensable in some areas of medicine where real experiments are impossible or difficult, for example, in epidemiology.

The principles of mathematical models in disease epidemiology are very different from those used in the natural sciences, since there are no invariant relationships confirmed by experience. The concept of forecasting is presented as modelers understand it and can be based on some classic examples. A prerequisite for providing reliable forecasts is that most of the parameters underlying it correspond to reality, but such correspondence is often limited, since all models are simplifications of reality. The main principle of mathematical modeling is what we call the "reliability thesis": a model whose values approximately correspond to reality gives an approximately reliable forecast. It is important to study the results of different models in different ways to determine which forecasts can be trusted. Mathematical modeling in predicting the spread of a disease can provide global assistance in making decisions about prevention, treatment, and financing. It should be noted that a mathematical model is a system presented in the form of mathematical symbols, formulas, and equations. Mathematics provides us with algorithms for formulating rules of behavior in a concise and precise form, which forces and helps to express our assumptions clearly. When a mathematical model is built, mathematical analysis, often combined with computer simulation, helps us to study the global behavior of the model by determining the consequences of the assumptions we have made.

Mathematical modeling is an important tool for studying the anatomy underlying the functioning of complex systems of a voluntary nature, including biomedical systems. The main principle of mathematical modeling of complex systems is the principle of optimality. This means that the model should be as simple as possible, that is, it should contain a minimum number of variables (and therefore equations), and should also have relatively simple relationships between variables. However, it can be a difficult question to decide which predictions of a simple model can be reliably applied to reality. An important procedure used by modelers to check the reliability of predictions made by a mathematical model is to compare different models. Thus, if a very simple model makes a prediction and the same or very similar prediction is made by a slightly more complex model that includes some mechanisms or details that are not in the first model, then the prediction can be assumed to be reliable.

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A mathematical model of the spread of an infectious disease in a population describes the transmission of a pathogen between patients depending on the nature of the contact between sick and susceptible people, the latent period from infection to transmission, the duration of the disease, the level of immunity acquired after infection, etc. After modeling all these factors, the number of infected people, the peak level of the disease, that is, the prediction of the entire epidemic, and the number of cases expected for each time point are given by the model. In 1760, D. Bernoulli (1700-1782) first applied mathematical analysis to the study of infectious diseases, thereby assessing the effectiveness of various methods of vaccination against smallpox. His analysis was first presented at the Royal Academy of Sciences in Paris in 1760 and published in 1766. In 1840, W. Farr used the normal distribution curve to describe data on smallpox deaths in England and Wales from 1837 to 1839. In 1906, John Brownlee continued his work on this method and adapted a series of epidemiological data based on the Pearson distribution, which he described in his article "Statistical Approach to Immunity Protection: Epidemic Theory". The most famous and paradigmatic model in mathematical epidemiology is the simple SIR model, described in 1927 by W. O. Kermack and A. G. McKendrick. It is adopted using systems of differential equations (continuous time) or difference equations (discrete time), describing the dynamics of groups of infected and recovered individuals.[15] In this model, the population is divided into infectious and recovered individuals, and the functions s(t), I(t) and R(T) denote their respective proportions in the population at time t. The aforementioned work first applied the "law of active masses" to epidemiology tasks, according to which the number of new infections in a population is directly proportional to the product of the current number of infected individuals. With such mathematical modeling, it is possible to draw conclusions about the epidemic threshold, the size of an epidemic when it occurs. The epidemic threshold means that an epidemic can be prevented if a portion of the population is vaccinated before the pathogen arrives to reduce its initial incidence. This result is central to the concept of herd immunity, which states that an epidemic can be prevented if a sufficiently large portion of the population is vaccinated. If the vaccination rate is not high enough, then the epidemic rate can only be reduced, but not prevented. There are many assumptions in the models that are not clear, for example, in a well-mixed population, each person is assumed to have an equal chance of coming into contact with every other person in the population. This ignores the fact that people who are geographically and socially closer are more likely to be infected. This model does not take into account that individuals may differ in the ways they are likely to be infected. There are people who are more susceptible to infection or contagious than others; and there are people who have more contact with more people than others. The duration of infection is exponentially distributed—this model means that the probability of a person becoming infected immediately after contact and recovering over time does not depend on the time since infection. Neither assumption is true.

In addition, a large population model, constructed in terms of constant quantities (population fractions), assumes that the population is large (strictly speaking, infinite). In small populations (e.g., a village or a school), stochastic effects are more important, and modeling using the mean-field approximation (i.e., differential equations) becomes problematic. The main approach that modelers can take to address this issue is to make some unrealistic assumptions. Even for a realistic model, the unchanged or slightly modified predictions are considered reliable and can be applied to the real world.

Much of the literature on mathematical modeling of infectious disease transmission includes the aforementioned disease epidemiology assumptions, which can be used to build appropriate models in this area and describe how the behavior of the models changes when the model assumptions change. Returning to the predictions made with the above simple SIR model (the Kermack-McKedrick model is one of the simplest compartmental models, in which the dynamics of groups of susceptible, infected and recovered individuals are described using systems of differential equations), we can note that the boundary property predicted by this model is realized for almost all epidemiological models [14]. In Russia, in 1889, the epidemiologist P. D. Ann developed and published a model of the spread of an infectious disease in discrete time, the equations of which describe the average values of the number of groups obtained in the Reed-Frost model. This became known only thanks to the review of the history of the application of mathematical models in epidemiology by Klaus Dietz and Dieter Schönzl. In their works, scientists discussed methods for generalizing the IC model based on the use of various laws of distribution for the number of contacts. P. D. Ozko's work was republished in English in 1989, and the Russian scientist himself is recognized as the first specialist in epidemic modeling in history. Works by M. S. Bartlett began to develop stochastic models of epidemiological processes by continuously studying the stochastic SIR model, published in 1949. In addition, the works of N. Baily (1970) made a significant contribution to the application of the theory of random processes in epidemic modeling. One of the first spatial models of epidemic spread was described by D. G. Kendall in 1957 on the basis of partial differential equations. At the same time, M. S. Bartlett models the spread of epidemics at the nodes of a spatial structure on the basis of simulation. This was a new direction in science based on computer simulation. J. Fox and L. Elveback in 1971 described a simulated, person-oriented model of infection transmission, which was not immediately recognized by the world scientific community, since there was not enough data to configure person-oriented models and the low performance of computers at that time. Since the 80s of the last century, mathematical models for assessing the effectiveness of various methods of diagnosing and treating various diseases, including oncological diseases, began to appear. These models were developed based on deterministic and probabilistic approaches.

Conclusions. Thus, the mathematical representation of biological processes provides transparency and accuracy in relation to epidemiological assumptions, which allows us to test our understanding of disease epidemiology by comparing model results and observed results. An important role of mathematical models is that they alert us to shortcomings in our current understanding of the epidemiology of various infectious diseases and set goals and objectives for further research.

Analysis and results. The scientific novelty of the results in these processes is that in order to increase the effectiveness of the independent learning process of students of the professional education system, we conducted empirical research to determine the results of an organized training session with students studying in groups MB-302, MB-303 of the 3rd year of the Medical Biology - 60910600 educational direction in the discipline "Mathematical modeling in Biology and Medicine" in order to form the competencies of students in teaching the topic of mathematical modeling and prediction in the epidemiology of infectious diseases. The students of the group were divided into two groups:

The first experimental group (12 students) received traditional teaching.

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The second control group (14 students) received e-learning resources and interactive methods.

The proportion method was used to determine the effectiveness of the results obtained in the above empirical studies.

Results: In the first group, the topic of "mathematical modeling and prediction in the epidemiology of infectious diseases" was presented in the traditional way, and the positive results were as follows.

Proportion method.

12 - 100

1 - x ,

X=100/12=8,33

8.33%*12=99.96% matching

(3 students 5th grade, 4 students 4th grade, 6 students 3rd grade, 1 student 2nd grade) with the result.

8.33 %*3 students =24.99 %

8.33%*4 students =33.32 %

8.33% *6 students =49.98 %

8.33%*1 student =8.33%

We achieved a positive indicator of 58.31% through 99.96% matching

The positive results obtained by using interactive teaching methods - Problem situation method - for students of the second group were as follows.

Proportion

14 - 100

1 - x ,

X=100/14=7,14

7.14%*14=99.96% mastery

(6 students 5th grade, 5 students 4th grade, 3 students 3rd grade,) with the result .

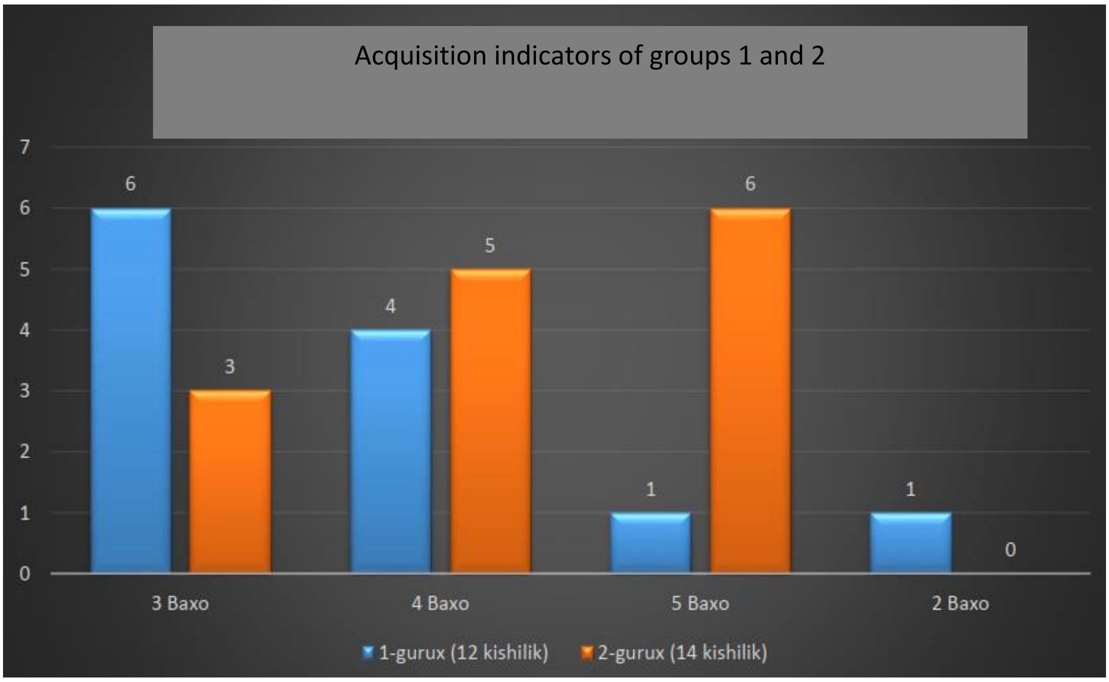
7.14 %*6 students =42.84 %

7.14%*4 students =28.56 %

7.14% *3 students =21.42 %

With 99.96% mastery, we achieved a positive indicator of 71.40%.

The chosen method gave good results, because the topic "Mathematical modeling and prediction in the epidemiology of infectious diseases" is rich in concepts and the "Problematic situation" method leads to a complete mastery of the topic as a result of students' discussion on the topic. At the same time, the correct answers to the test questions given to the students after the presentation of the topic are a vivid example of this



- Conclusions and suggestions. It can be said that when experimental testing was conducted in two groups at the Department of Informatics and Information Technologies of Samarkand State Medical University, the effectiveness of the practical training conducted using the "Problem Situation" method in student learning was 13.09% higher than that of the traditional method.

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