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Biomathematical Culture and Peculiarities of Its Formation of Students of Biological Specialties

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Abstract. Despite the needs of the labor market in biologists who know mathematical methods at a high level, the current system of mathematical training of students of biological specialties does not meet these requirements. The article discusses the concept of biomathematical culture of the students as the main indicator of the effectiveness of the educational process in mathematics. The author's definition of student biomathematical culture is presented, its component composition and levels of formation are defined. The results of experimental work are presented, what allowed to identify the existing problems in the mathematical training of students of biological specialties. The directions of students' biomathematical culture formation are suggested and their effectiveness is evaluated.

1. Introduction

Prospectiveness and productivity of development of any industry hinge on highly educated and highly qualified personnel. Furthermore, specialists with a good level of intellectual and practical training in several non-allied areas of knowledge simultaneous are increasingly required. Analysis of the labor market, the requirements for applicants put forward by companies with a worldwide reputation, demonstrates the rapid growth of demand for biomathematics – specialists competent in both biological and mathematical areas of knowledge. At first glance such different scientific areas as mathematics and biology, in the XXI century are in close cooperation. This is due to the accuracy, rigor and universality of mathematical methods that allow to solve urgent problems of genetics, immunology, zoology, molecular biology, and other areas. Development of approaches to the creation of vaccines, mapping on the human genome, prediction of mutational changes, modeling of the dynamics of infectious diseases, population dynamics analysis, modeling of fishing activity and biodiversity, etc. – problems, the solution of which became possible thanks to a rich arsenal of mathematical methods.

At the end of the last century scientists (Bailey N T J [1], Riznichenko G Yu [2], Kepchik N V [3], Murray J [4], Gilderman Yu I [5], Lahos-Beltra R [6]) came to the conclusion that a specialist biologist needs a "mathematical way of thinking in solving a biological problem" [5]. In the modern world, this need is felt very urgent - the insufficient level of mathematical training of a specialist seriously narrows the space of professional tasks within its competence. In this regard, the relevance of the mathematical training of students-biologists, an indicator of the effectiveness of which is the level of their mathematical culture.

The concept of mathematical culture has a large number of definitions, due to differences in approaches to the study of this concept, the complexity and breadth of its scope. Each author considers the concept of mathematical culture from the perspective of the problem area in which the research work is carried out. Sushkova S N [7], Khudyakov V N [8] considers mathematical culture as the integrated education of f specialist personality, which includes thought, language and cognition, the unity of which ensures the success of professional activity. Ikramov J [9], Okuneva O A [10], Rozanova S A [11] define mathematical culture as a system of mathematical knowledge, skills and the possibility of their application in practice. According to Bishop A J [12], Pakhomova A P [13], Yuzi J [14] mathematical culture is a part of human culture. As the quality of personality determines the ability to receive, apply and improve knowledge, skills and abilities in mathematics determine the mathematical culture of Akmanova Z S [15], Rassokha E N [16].

The pedagogical theory and practice analysis demonstrates the attention of scientists to the formation of mathematical culture of students in various fields of training: economical (Buldyk G M, Okuneva O A, Pustobayeva O N, Shatrova Yu S, etc.), engineering (Zaripova Z F, Kuleshova I I, Rassokha E N., etc.), pedagogical (Artebyakina O V, Kuzmin S Yu, Mirzoev M S, Putilova E V, etc.). At the same time, currently available research works do not affect the of students' mathematical culture concept of biological areas of training. For brevity, we will call her biomathematical culture of the students.

Due to the fact that this concept has not been previously considered, the purpose of the study is to determine the essence and component composition of the biomathematical culture of a biologist student, to determine the ways of its formation in the process of studying mathematics at the University.

2. Biomathematics culture of a student

2.1. Definition

The student's biomathematical culture is an integral system of mathematical knowledge, the ability to apply them to the solution of biological problems, carrying out the necessary mental operations, search and research, analysis, interpretation and competent presentation of the results.

Biomathematical culture – is not just the presence of the future specialist deep knowledge and skills in mathematics and biology, it is the ability to identify in a variety of educational and professional tasks ways to solve them on an abstract mathematical level and to translate the results into biological language.

2.2. The structure of biomathematical culture

Development of biomathematical students culture structure is carried out on the basis of analysis of the scientists' ideas about the component composition of the mathematical culture (Khudyakov V N, Akmanova Z S, Artebyakina O V, Ikramov J, Kuleshova I I, Zakharova T G). Based on the presented ideas of teachers in the biomathematical culture structure was divided into five components: cognitive, activity-related, axiological, motivational, reflexive.

The cognitive component is characterized by the student's mathematical knowledge and skills, as well as an understanding of the biological meaning of the studied mathematical concepts (for example, derivative – productivity of the population, a definite integral – population growth over a certain period of time).

The activity component is determined by the ability to apply the knowledge and skills in the sphere of mathematics to the problems of biological content, as well as the ability to predict, analyze and competently present the results. This component demonstrates the degree of biomathematical culture formation at the level of the cognitive component.

Motivational component is characterized by the presence of students ' positive attitude to mathematics, awareness of the importance of studying mathematics, both for personal development and for future profession, the desire for self-education.

Axiological component is determined by the presence of students-biologists value orientations and motives of educational and cognitive activity. This component provides orientation of students, future specialists of biological branch, on fruitful professional activity, understanding of a place and value of mathematical knowledge in the chosen speciality, induces to personal growth and self-education.

The reflexive component is characterized by the ability of the student-biologist to give an objective assessment of the results of their activities, as well as the entire process aimed at solving the problem. The work of a biologist is intimately connected with the solution of serious ethical problems (experimentation on animals, transplantology, cloning, etc.), often putting the scientist before a difficult moral choice. The ability to monitor and evaluate the process and results of professional activity is an integral component of the biologist's biomathematical culture.

2.3. Levels of formation biomathematical culture

The formation of a biomathematical culture is a process of qualitative and quantitative changes of its structural components during the educational process in mathematics. In accordance with the allocated components were identified four levels of biomathematical culture of student – future specialist biological discipline:

- The low level is characterized by the presence of the student's basic knowledge of mathematics in the amount sufficient to solve typical problems, as well as the possession of the necessary mental operations. Biomathematics culture formed at the level of the cognitive component.
- The intermediate level is characterized by the presence of mathematical knowledge and skills that allow to solve problems not only algorithmic, but also non-standard type; the ability to conduct educational dialogue; the ability to carry out educational and research activities to solve biological problems. Biomathematics culture at this level is characterized by the formation of cognitive and activity-related components.
- The upper-intermediate level involves the possession of a student strong mathematical knowledge that allows to solve problems of biological content, carrying out the necessary mental activity, predicting and evaluating the possible results; awareness of the importance of acquired mathematical knowledge, skills in future professional activities. Biomathematics culture at this level is determined by the presence of cognitive, activity-related, reflexive and axiological components.
- High level of biomathematical culture of the student means possession of integral system of mathematical knowledge and ability to apply it to the analysis, the decision and interpretation of biological processes; conscious aspiration to personal growth, self-education, self-improvement; free knowledge of mathematical language; studying of problem questions of biological science and aspiration to search of their permission by means of mathematical methods; valuable attitude to the studied discipline. In this case, all structural components of biomathematical culture are fully formed.

The task of the teacher is to form a biomathematical culture at the last two levels during the training of biology students, which will allow us to talk about the preparation of competent and highly qualified biological specialists.

3. Ways of biomathematical culture formation

The analysis of the domestic practice of teaching higher mathematics to students-biologists revealed the main problem that determines the low level of biomathematical culture of graduates. The study of mathematics is carried out in isolation from other disciplines, interdisciplinary connections are absent, which makes such an important for the future profession discipline into a set of abstract formulas and theorems. To solve this problem, and as a consequence, to increase the level biomathematical culture of the students allows the orientation of the educational process in mathematics towards the biological specialization of the students.

3.1. Bio-oriented discipline content

The content of the discipline should reflect the relationship of mathematics and biology, the basic mathematical concepts to find a biological interpretation. The studied formulas will cease to be difficult and incomprehensible for students, if they can be used to describe the real processes of wildlife.

3.2. Mathematical tasks of biological content

Mathematical tasks focused on the biological specialization of students is a basis for biomathematical culture of the students. The use of mathematical problems of biological content allows:

- demonstrate the relationship between mathematics and biology;
- master the mathematical tools;
- to form research skills (problem analysis, translation of the problem from biological into mathematical language, search for the optimal solution method, directly solution, interpretation of the result);
- to increase the level of students' motivation to study mathematics.

3.2.1. Examples of tasks. Matrix modeling. Suppose that one of three different alleles x, y, z is present in each member of the population. Moreover, the carriers of allele x there is a mutation and in 5 % of cases they become carriers of y allele, and in 3 % of cases are carriers of z alleles. 0.1% of the carriers of alleles y be carriers of z alleles, 90% of the carriers of z alleles become carriers of x alleles. Create a matrix model of mutations and predict the number of individuals who are carriers of each of the three alleles, after 3 years, if at the time of observation was recorded 120 carriers of alleles x, 150 carriers of alleles y and 200 carriers of alleles z.

Derivative of a function. Colon bacillus 5 microns long has the shape of a cylinder. Its diameter is continuously increasing. Determine the rate of change in the volume of colon bacillus with a diameter of 2 microns, if its radius is currently increasing at a rate of 0.02 microns/s.

Problems of biological content are widely presented in the works of Stewart J & Day T [17], Neuhauser C [18], Larson R [19], Kepchik N V [20], Chasnov J R [21], Ledder G[22].

4. Research methods

The research involved students of Ryazan State University, Ryazan State Radio Engineering University, Ryazan State Agrotechnological University, Vyatka State University.

The first stage was carried out ascertaining experiment to determine the level of biomathematical culture of biology students who fully mastered the course of higher mathematics and completed its study. Determination of the level of students' biomathematical culture was carried out on the basis of questionnaires and review work, containing tasks to check the availability of basic knowledge and skills in mathematics and tasks requiring the ability to apply mathematical methods to problems of a biological nature. Analysis of the results of the ascertaining experiment, which was attended by 389 students, confirmed the existence of problems in the mathematical training of students-biologists: weak motivation to study mathematics, superficial mathematical knowledge, lack of value attitude to mathematics, lack of understanding of its place in the work of a biologist, lack of desire for self-education. In accordance with the received data, 67% of students have low and intermediate level biomathematical culture. High level biomathematical culture showed only 5% of students.

At the second stage, experimental and control groups were formed. The study of the fundamental sections of higher mathematics in the control group was carried out according to the traditional system, and in the experimental group – by filling the studied abstract mathematical concepts with biological meaning and solving problems of biological content.

5. Results

The students included in the experimental group showed higher results compared to the students of the control group in the following indicators: knowledge and skills in mathematics, the ability to solve problems of biological content by the instrumentality of mathematical tools, mathematical thinking, the ability to reflect, motivation and value attitude to the study of mathematics, the desire for self-education. As a percentage, the results are presented in the table 1.

Table 1. The results of empirical research.

Level of biomathematical culture	Control group (%)	Experimental group (%)
Low	38	11
Intermediate	36	28
Upper-intermediate	19	42
High	7	19

Comparative analysis of the results received in control and experimental group allows to make a conclusion about the effectiveness of the proposed ways of forming biomathematical culture of the students. The students of experimental group showed higher rates of formation of each of the components biomathematical culture.

6. Conclusions

As a result of the study, the following conclusions were made:

- Indicator of the effectiveness of mathematical training of students of biological areas of training is the level of their biomathematical culture.
- Structure biomathematical culture can be represented by five components, a qualitative change which determines the level biomathematical culture of the student.
- The formation biomathematical culture within the educational process can be done by filling the studied material with professionally significant material, as well as by solving biological problems by mathematical methods.

It should be emphasized that the high level of biomathematical culture will allow graduates of biological specialties to withstand serious competition in the labor market and achieve better results in their professional activities.

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