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METHOD OF THEOREMS IN PHYSICS CLASSES

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ABOUT ARTICLE

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Abstract: The article shows that everyday, pre-scientific ideas of students about the physical world is a pedagogically significant value, which is advisable to use in the process of teaching mathematics.

INTRODUCTION

The physical origin of the conditions of some mathematical theorems is revealed. Elements of the methodology for presenting the main theorems of differential calculus based on their relationship with physics are proposed. The article was written within the framework of the author's concept of modeling the basic properties of scientific research in the educational process.

About the level of physical intuition of students:

To determine the level of physical intuition of students, the author set up an experiment that was conducted in 1987-88 on the basis of the Yaroslavl State Pedagogical University (YaSPU) and the Yaroslavl State University (YarSU).

The experiment was based on the following considerations. First, it is natural to consider mathematics as an integral part of natural science. On this occasion, the famous mathematician of our century J. von Neumann writes the following: “Some of the brightest ideas of modern mathematics (I am convinced that these are its best ideas) can be clearly traced back to their origins in the natural sciences”. Narrowing the object of consideration and speaking of mathematical analysis, we can say that it was created to describe the mechanical movements of bodies. The well-known Russian mathematician A.N. Krylov writes: "Newton discovered and gave the foundations of the infinitesimal calculus, based on the concepts of mechanical and geometric." (Quoted from A.N. Kolmogorov's book [1, p. 95].) Secondly, the creators of mathematical analysis—Newton, Euler, the Bernoulli brothers, and others—were not "pure" mathematicians, but had serious works in the field of mechanics, physics, astronomy, and other sciences. Naturally, there was no partition in their minds separating mathematics from physics. The study of the movements of bodies provided material for the introduction of mathematical concepts, and mathematical theorems made it possible to describe the movements of bodies and find physical laws. A teacher starting to present differential calculus can try to organize its study in such a way that students receive and assimilate information approximately in the same way as the creators of mathematical analysis learned it.

Referring to the experience of children, it should be said that they observe the movements of bodies from a very early age. They can easily compare the speed of the swing at the top and bottom points, describe the movement of the train quite well at the moment of changing the direction of movement, etc. The teacher who starts the presentation of differential calculus should be able to activate children's ideas about the physical world and direct them in the right direction.

All of the above led to the conjecture that is stated in the summary as a statement. To test it, an experiment was conducted with students of the first two courses of the mentioned universities. It was attended by 374 people studying at different faculties and acquiring different specialties.

An important characteristic of the experiment is the moment of its implementation: the first week of training, i.e. the moment when mathematical analysis has not yet developed into any coherent theory.

The experiment proceeded as follows. It was explained to the audience that the goal of the experimenters was to find out how well first-year students know school physics, and then several questions were asked regarding the motion of bodies. The students answered the first two questions as they saw fit. For the other two, a priori answers were given, from which the student was asked to choose one.

Question I. A body moves in a straight line for a certain period of time. Compare

minimum speed vmin , maximum speed Vmax and average speed Vav.

Question II. The body moves in a straight line for a certain period of time. Compare minimum speed vmin , maximum speed arbitrary time Vmax and instantaneous speed v(t) in

Question III. The body moves in a straight line for a certain period of time. Is the following statement true: there is a moment in time such that the speed of the body at this moment is equal to the average speed of the body?

Answers: 1) Yes. 2) No. 3) I don't know.

Question IV. The body moves in a straight line for a certain period of time, and at the final moment of time it returns to its original position. What is the speed of the body at its greatest distance?

Answers: 1) Greater than zero. 2) Less than zero. 3) Equal to zero. 4) I don't know. The results of the answers to the first two questions are contained in the following table.

To clarify the essence of question IV, we use the same notation. The correct answer is that the speed of the body at the moment of greatest distance is zero. EU-

whether t0 is the moment of greatest removal, then

v(t) = 0 , or s(t) 0 . It turns out that if s(b) =s(a)

(the body returns to its original position), then there is a moment in time

t0 , such that s(t0) 0 . This statement is Rolle's theorem.

The results of the experiment show that on an intuitive, physical level, 77% of respondents can independently formulate Rolle's theorem, which is one of the main theorems of differential calculus (the last column of the table, the line with the answer v=0).

The last two cells of the last column of the table deserve special attention. The point is that the theorems of Rolle and Lagrange occupy a central place in the course of differential calculus, since it is from them that the main statements used in the study of functions and constructing their graphs are deduced: a criterion for the constancy of a function, a sufficient condition for monotonicity, a sufficient condition for an extremum. The fact that 57% of respondents are able to independently formulate two serious mathematical theorems on an intuitive level indicates that students have a fairly good physical intuition and that this intuition should be actively used in teaching differential calculus. Rolle's and Lagrange's theorems are derived purely logically from one another, so it turns out to be very important that 94%

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of respondents can intuitively formulate at least one of them on their own. He says that the stimulation of physical intuition in the study of mathematics will meet with a fairly adequate response from almost the entire student audience.

The experimental data show that there is no direct relationship between the orientation towards physical and mathematical sciences and physical intuition in the area under study and at the level under study. Thus, the data for economists (specialty “accounting”) show that they are comparable with the results of mathematicians and even physicists (see lines with correct answers and the last two lines).

It is interesting that the respondents did not connect the physical questions they were asked with the mathematical material, as evidenced by the interviews conducted with the audience.

The reliability of the results obtained was assessed using the chi-square test. The calculation showed the following: the probability that these figures were obtained as a result of a random (equiprobable) choice of one of the possible a priori answers is much less than 0.001.

So, the experimental data show that the physical intuition of students is a significant value, the active use of which in the teaching process is quite natural. Below we will show that its use is not only natural, but also very effective.

2. The logic of proofs and the physical origin of the conditions of some mathematical theorems

Let us derive from physical considerations some restrictions on a function that can serve as a law of motion of a macroscopic body, and then compare them with the conditions of the main theorems of differential calculus.

Similar reasoning could be carried out with regard to other theorems of the differential calculus. Multiple checks have shown that students can easily cope with the task of extending the properties of motions to a wider class of functions and independently obtain all the main theorems of differential calculus in the form of hypotheses.

CONCLUSION

In conclusion, we note that the emergence of mathematical statements in the form of hypotheses by no means replaces their strict logical proof, even if in the process of independent derivation of these statements, students demonstrated the ability for mathematical creativity. At the same time, this creative act should not be underestimated. Even from a utilitarian point of view, it gives the teacher great freedom in relation to further mathematical and pedagogical actions. Hypothesis testing can be made immediate or delayed, you can do this test yourself or send students to textbooks, apply these hypotheses in physics or mathematics, and so on. The teacher's choice of one or another method of action depends on the specific situation.

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