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HOW TO CREATE TASKS FROM MATHEMATICAL LITERACY

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ABSTRACT. *In our article we try to present the tasks of mathematical literacy for teachers and students, because we believe that everyone of us should be mathematically literate. We are focused on developing students' competencies to apply basic mathematical thinking and basic skills explore in science and technology. We use The National Educational Program ISCED 3a Mathematics. Tasks are ready for students in grade 13, for high school graduates. These students should already be able to use mathematical knowledge in many different situations in various ways. The tasks are inspired by microbiological knowledge, which can be found in many commercial magazines or in the website.*

KEY WORDS: *mathematical literacy, science literacy, microbiological tasks*

CLASSIFICATION: *D34, D84, M24*

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Introduction

The growing role of science, mathematics and technology in modern life requires that all adults, not just those who aspire to scientific careers, become mathematically, science and technology literate [5]. Research points to the urgency of connecting school mathematics to the outside world [4]. One thing is to know how to calculate the math, the second thing is to understand it, or apply it correctly and interpret current real life situations, encountered, for example, while reading a magazine about health or agriculture.

Students learn to calculate mathematics in specific mathematical situations tasks purely of mathematical content, which lacks real context. For example: students will learn what exponential function are, how to calculate and solve a few examples to practice the mathematical content. The result is that the student controls theory and can computes tasks about the exponential function. However, let us to specify the role of the student with a realistic context and we will be surprised how he will deal with the particular role, and we would be happy if he comes up with a solution. For example, a well-known role of water lilies reads as follows: On the lake, every day lily doubles its surface. 48 days to be grown over the entire surface of the lake water lilies. Which day water lilies grown over half of the lake? 9 out of 10 students will answer that for 24 days. Why? Because the math was not seen in real concept ever before. Motivation decreases, because even though they know math content they are not able to use their knowledge in real life situation. They are losing an important usage of mathematics. The error is not in students, but in the lack of practise use and see mathematics in the real problems, for example in the problem with water lilies on the lake. This issue is completely scrutinized in the study/ The Program for International Student Assessment (PISA). It looks at the needs of the individual manage to solve mathematical problems in which mathematics to practical problem represents a real benefit in the search process solutions [3]. Examines how students are mathematically literate. PISA describes mathematical literacy as: “an individual´s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments

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and to use and engage with mathematics in ways that meet the needs of that individual´s current and future life as a constructive, concerned and reflective citizen” [3,8].

Created tasks

In this article we present a preview of the three tasks of mathematical literacy. We use The National Educational Program ISCED 3a Mathematics. Tasks are ready for students in grade 13, for high school graduates, because the time allocated for high school graduates is always bigger and thus are expected to manage the solution in tasks. We deal with cross-curricular microbiology. We can say that we also develop scientific literacy. We start every problem with specific task inspired by literature (textbook, scientific journals). We create new task developing mathematical literacy of students. The tasks are inspired by microbiological knowledge, which can be found in many commercial magazines or in the websites [6,11,14]. It is non-standard task for our students. We are inspired by the PISA.

Problem1

Task from the textbook [10]:

The number of bacteria in a culture is counted as 400 at the start of experiment. If the number of bacteria doubles every 3 hours, the number of individuals can be represented by formula $N(t)=400(2)^{\frac{t}{3}}$. Find the number of bacteria present in the culture after 24 hours.

Our created task:

The number of bacteria *Escherichia coli* in the sample of faecal contamination of water is counted as 1000 at the start of research. The number of bacteria was doubled every 6 hours, because the sample of water was continuously polluted by waste from sewage. Dependence of the number of bacteria over time is expressed in chart shown in Figure 1.

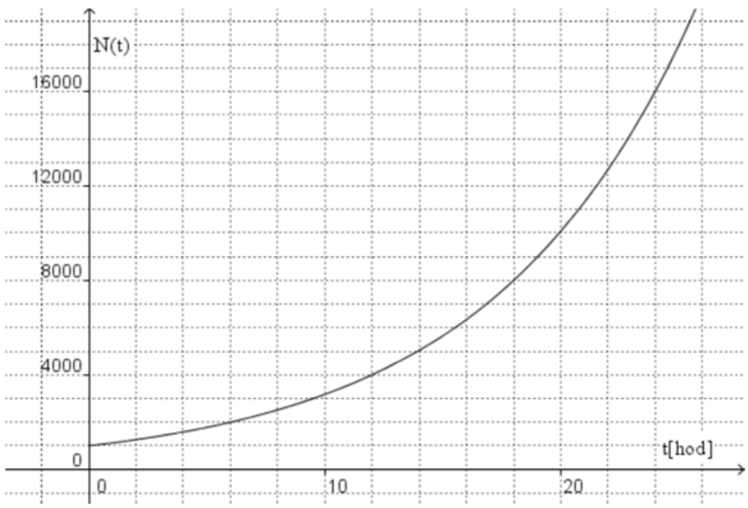

Figure 1: Graph expressing dependence the number of bacteria and the time of growth

Solve the following tasks using the graph shown in Figure 1:

a) Find the number of bacteria $N(t)$ present in culture after 12 hours.

b) Find the time t meanwhile the number of lactic acid bacteria 8-times increased: $N(t) = 8 \cdot N_0$.

c) If a population consisting initially of N_0 individuals also is modeled as growing without limit, the population $N(t)$ at any later time t is given by formula: $N(t) = N_0 \cdot a^{kt}$ (k and a are the constants to be determined). Find the formula for function which graph is shown in Figure 1.

Problem2

We were inspired by the results of the research reported in the scientific journal *Potravinarstvo*. Scientists in the article [11] describe how examining effects of water activity values and incubation temperature on the *Staphylococcus aureus* growth dynamic.

Our created task:

Scientists investigated the effect water activity a_w on the growth dynamic of the bacteria *Staphylococcus aureus*. The values of water activity (the amount of water available for microbial growth) of the tested media were adjusted by *sodium chloride* ($\%NaCl$). The table 1 shows the duration (in hours) of the *lag* phase of growth (where bacteria adapt themselves to growth conditions) and growth rate G_R in the exponential phase (period of growth characterized by cell doubling).

$\%NaCl$	a_w	*lag* [h]	G_R [log KTJ.ml^{-1}.h^{-1}]
0,0	0,999	2	0,320
1,5	0,988	3	0,270
5,0	0,966	6	0,235
8,0	0,955	12	0,230
10,5	0,922	18	0,135
13,0	0,899	36	0,065
15,5	0,877	80	0,040
18,0	0,866	200	0,010

Table 1: Values obtained during experiment (the concentration sodium chloride, the water activity, the duration of lag phase, the growth rate)

Based on the text and the data in table select the incorrect statement:

a) The ability of bacteria to grow at high salt concentrations related to their ability to adapt to osmotic stress during *lag* phase of growth. When the concentration of *sodium chloride* was increased to 5%, there was an extension of the *lag* phase to 6 hours.

b) Water activity a_w is a measurement of the availability of water for biological reactions. It determines the ability of micro-organisms to grow. If water activity a_w decreases, the duration of the *lag* phase to grow will also decrease.

c) Increasing the value of water activity a_w increases the growth rate G_R of the bacteria *Staphylococcus aureus*. Maximum values of the growth rate achieves when water activity is in the range $a_w = 0{,}988$ to $a_w = 0{,}999$.

d) From the data in the table, we can monitor influence of the addition of salt ($\%NaCl$) to the inhibition of bacterial growth. When the *sodium chloride* concentration was increased to 13%, there was the growth rate G_R 5-multiple reduced compared to the growth rate at the beginning of the experiment (0% added salt).

Problem3

We were inspired by the results of the research reported in the scientific journal *Potravinarstvo*. Scientists in the article [6] comparison of occurence lactic acid bacteria in chosen yogurts.

<u>Our created task:</u>

Scientists detected numbers, colony-forming units per milliliter ($CFU.ml^{-1}$), of lactic acid bacteria in yogurts in Slovak markets (creamy yogurts, yogurts with probiotics, non-fat yogurts). In examined yogurts was detected number of lactic acid bacteria ($CFU.ml^{-1}.10^7$) before expiry of the time consumption and after expiry period (see Figure 2). Ratio of the number of bacteria before and after the expiry period was the same for all three types of yogurt.

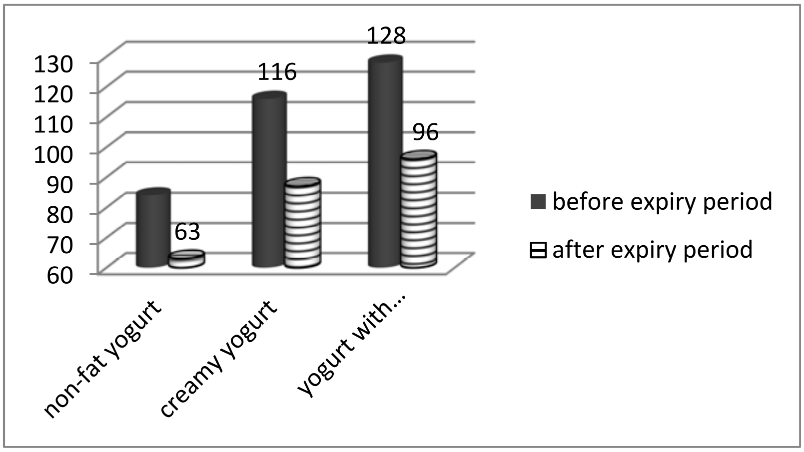

Figure 2: Number of lactic acid bacteria in three types of yogurt, expressed in $CFU.ml^{-1}.10^7$

From the text and data in the Figure 2 solve the following tasks:

a) Calculate the number of lactic acid bacteria in $CFU.ml^{-1}.10^7$ after expiry period in creamy yogurt. Use the data shown in Figure 2.

b) Compare the number of lactic acid bacteria ($CFU.ml^{-1}.10^7$) detected before the expiry period between non-fat yogurt and yogurt with probiotics. How much percent lower was the number of lactic acid bacteria in non-fat yogurt as yogurt with probiotics?

c) Research results were presented on television. The reporter said: "The greatest decrease in the number of lactic acid bacteria was observed in yogurt with probiotics.” Do you consider the reporter's statement satisfactory explanation of the graph? Please give reasons for your answer.

Discussion

The mathematics-education community stresses the importance of real-world connections in teaching [4]. One of the main aims of mathematical education as such is preparing the students for dealing effectively with the real-life situations [12]. Real-world connections are expected to have many benefits, such as enhancing students understanding of mathematical concepts, motivating mathematics learning, and helping students apply mathematics to real problems [4].

In modern educational theories is demand for development of not only pupils' knowledge but all key competencies [13]. Mathematical competence involves, to different degrees, the ability and willingness to use mathematical models of thought and presentations [1]. Mathematical competency is defined as insightful readiness to respond to certain mathematical challenges [2]. Competencies in thinking mathematically means "mastering mathematical modes of thoughts" [7]. A competency in posing and solving mathematical problems is about identifying, posing and specifying such problems and solving different problems [9]. When we will develop mathematical competence, then we will also develop the mathematical literacy students. In creating tasks we are focused on developing competencies to apply basic mathematical thinking and basic skills explore in science and technology [1], so apply mathematical thinking to solve practical problems in everyday, uses mathematical models of logical and spatial thinking and presentation and use basic scientific literacy. Students must to work with various representations of relations within solution of presented tasks. The National Educational Program, ISCED 3a, define what the student have to know [1]:

- use different ways of representing mathematical content: text, table, graph (Problem1, Problem2, Problem3),
- read from the graph of the function with sufficient accuracy the size of the functional value and vice versa noted known size of the functional values on a graph (Problem1),
- differentiate exponential dependence and graph exponential functions used for solving of tasks (Problem1),
- write the simple relationships using variables, constants (Problem1),
- determine the unknown value if the specified table relationships (Problem2),
- based on graphic representation to determine an approximate solution – to estimate a solution (Problem3).

Conclusion

The aim of the paper was to highlight the use of mathematics in real situations. We will be glad if these tasks fall into the teaching process, or at least become an inspiration for mathematics teachers in their lessons. Inclusion of presented tasks in the learning process can improve the quality of education and allow to development of mathematical literacy and interdisciplinary students thinking.

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