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STEAM EDUCATION THROUGH AND FOR SEARCH MISSIONS

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Summary. The article shows the importance of the role and benefits of the STEAM approach in studying the real sciences through and for solving problem situations in search missions.

Keywords: education, STEAM, drone, TIC, mission, search, probability, optimal procedure, function, minimum.

EDUCAȚIA STEAM PRIN ȘI PENTRU MISIUNI DE CĂUTARE

Rezumat. În articol se arată importanța rolului și beneficiile abordării STEAM în studierea științelor reale prin și pentru soluționarea situațiilor-problemă în misiuni de căutare.

Cuvinte cheie: educație, STEM, drone, TIC, misiune, căutare, probabilitate, procedură optimă, funcție, minim.

1. Introduction

Most European countries face a small number of high school graduates interested in studying or pursuing a career in STEM (science, technology, engineering, mathematics), while the demand for STEM resources is growing rapidly. Consequently, it is important to increase the attractiveness for the exact disciplines, for the STEM / STEAM faculties. In addition, it was found that having STEAM skills increases the employability and entrepreneurial spirit.

Given the rapid evolution of new technologies, we conclude that the use of drones in education has a major impact, especially in the fields of training science, technology, engineering and mathematics. The use of these devices in teaching activities can be an opportunity to make the courses more attractive and useful for students. Working with a real tool in an academic environment will help students to acquire new skills needed for professional activities in the fields of STEAM.

Drone technology helps students better perceive and memorize mathematical and physical concepts, allowing them to use the information they acquire on a daily basis. Applying mathematical concepts and relationships in the real world makes students not only understand the enormous potential of mathematics, but also see the real result of their work.

In mathematic classes, exercises can be formulated to calculate the distance travelled by a drone from one point to another, time, speed and acceleration of movement, etc. The results obtained can be verified through practical exercises with the use of drones.

Drone education contributes to a better understanding and awareness of abstract notions. For example, when studying the laws of physics, students can use drones to determine the time needed to cross a certain distance, the influence of the wind, etc. [1, p. 21; 3].

The use of drones by professionals involves the emergence of new scenarios, problem situations that require theoretical knowledge and practical skills at a level that goes beyond the simple management and maintenance of drones [1, p. 23].

A STEAM scenario proposed to students for research may be the involvement of drones in search missions.

Statistics show that hundreds of thousands of people disappear every year. For example, according to the Ministry of Internal Affairs, more than 120,000 people disappear each year in Russia [4]. The reasons are not only accidents and violence, but also the loss of people in the forests. At present, the most effective way to find a person in the forest is considered the systematic linear search of the territory accompanied by loud sounds meant to attract the attention of the lost. In most cases, the search staff is made up of volunteers.

It is very difficult to form rescue teams remotely and in sparsely populated areas. In addition, searching in forests with search teams is a long and intensive process in limited areas of application, especially in remote areas, large regions and in difficult weather conditions. The average walking speed of a person on the road is 4 – 6 km / h, and in case of passing through forest areas and searching for missing persons, the real value of the speed can decrease to 2 – 4 km / h. The width of the line cannot exceed the line of sight – on average, 15 – 20 meters.

Sometimes rescue services use helicopters, but in the case of a search in the woods, it is quite difficult to see someone under the treetops. A lost person must be in an open space and make loud noises to be identified. However, when using the helicopter, the success of the rescue operation is not yet guaranteed, and this method also requires large resources. For these reasons it is used only in exceptional cases.

The search for the lost is an operation that requires a large number of specially trained people, patience, skills, as well as a sufficient material and technical basis: water, food, clothing for various weather conditions, etc. Therefore, it is necessary to develop a new solution based on modern technologies. One of these solutions could be the use of unmanned aerial vehicles (UAVs) that are capable of flying over and under the crowns of trees. UAVs are much cheaper to use than helicopters or search and rescue planes. The advantages of a UAV over other solutions are high permeability and optimum speed.

2. Formulation of the problem and its mathematical solution

A helicopter crashed in some area. According to the first information received, it was found that the helicopter could have crashed near locality ***A*** or near locality ***B***, both in the given region.


The probability that the helicopter crashed near locality ***B*** is 0.8, and near locality ***A*** – 0.2. Eight drones were made available for helicopter searches.

It is considered that each drone can detect the helicopter with a probability of 0.7 and searches are performed independently of each drone.

a) How should drones be distributed so that the probability of detecting the helicopter is maximum?

b) What is the probability of detecting the helicopter for the optimal search procedure?

Solution:

According to the hypothesis, the number of drones is 8, ie $n = 8$. The probability of detecting the helicopter near locality B is $p(B) = 0.8$, and near locality A is $p(A) = 0.2$. Obviously $p(B) = 1 - p(A)$.

The probability of detecting the helicopter by each drone (near the locality where the helicopter is located) is denoted by $p = 0.7$. Then $q = 0.3$ is the probability of not detecting the crashed helicopter.

We admit that near the locality ***B*** participates in the detection of k drones. Then $n – k$ drones will participate near locality ***A***. The probability that the helicopter, being near locality ***B*** will not be detected by any drone, according to the theorem about the product of probabilities, is equal to q^k. Then the probability that the helicopter, being near locality ***B***, will be detected at least by a drone will be $1 – q^k$. For the area near locality ***A*** the probability of detection is $1 – q^{n – k}$. According to the total probability formula, the size

$$p(B)(1 – q^k) + p(A)(1 – q^{n – k})$$

will be the probability of detecting the helicopter. This probability will be equal to

$$p(B)(1 – q^k) + p(A)(1 – q^{n – k}) = p(B)(1 – q^k) + (1 – p(B)) (1 – q^{n – k}) =$$
$$= p(B) – p(B) \cdot q^k + 1 – q^{n – k} – p(B) + p(B) \cdot q^{n – k}) =$$
$$= 1 – (p(B) \cdot q^k + (1 – p(B)) \cdot q^{n – k}).$$

As the drones must be distributed so that the probability of detecting the helicopter is maximum, the expression

$$p(B) \cdot q^k + (1 – p(B)) \cdot q^{n – k}$$

to receive the lowest value.

We make the notation $q^k = t$. The fact that the expression

$$p(B) \cdot q^k + (1 – p(B)) \cdot q^{n – k}$$

must receive the lowest value means we must research the function to a minimum

$$f(t) = p(B) \cdot t + \frac{(1-p(B))q^n}{t}, \text{ where } t \in (0; 1).$$

The values of t are within the indicated range, because the probability of an event cannot be less than zero and cannot exceed the value 1.

The derivative of this function is $f^{/}(t) = p(B) - \frac{(1-p(B))q^n}{t^2}$. We equal the derivative obtained with zero: $p(B) - \frac{(1-p(B))q^n}{t^2} = 0$ or $p(H) = \frac{(1-p(B))q^n}{t^2}$, where do we get:

$$t = \pm\sqrt{\frac{(1-p(B))q^n}{p(B)}}.$$

When passing through the point $t = \sqrt{\frac{(1-p(B))q^n}{p(B)}}$ the function $f(t)$ changes its sign from „–” to „+” and therefore the point $t = \sqrt{\frac{(1-p(B))q^n}{p(B)}}$ is a minimum point for $f(t)$.

Function graph $f(t) = p(B) \cdot t + \frac{(1-p(B))q^n}{t}$ is in the class of graphs of type functions $f(t) = at + \frac{b}{t}$. Schematically, such a graph is drawn in Figure 1 showing the minimum value of the function and the point at which it receives this value.

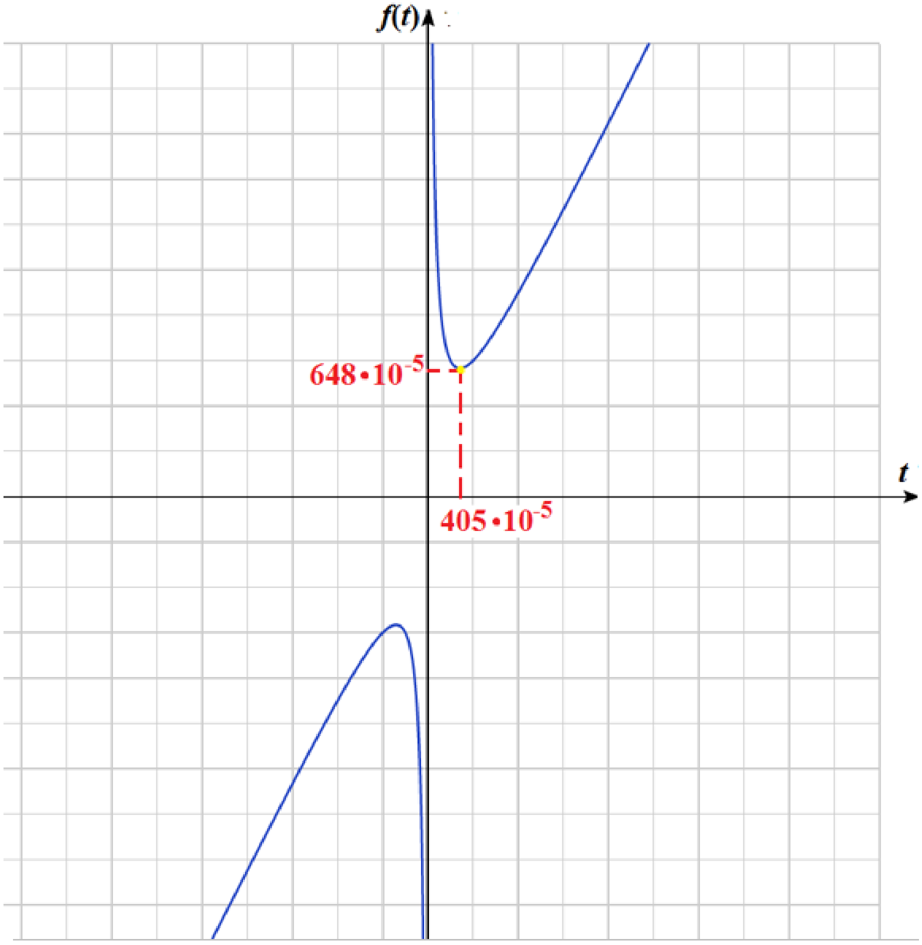

Figure 1.

Thus,

$$q^{2k} = \frac{(1-p(B))q^n}{p(B)} \text{ or } q^{2k-n} = \frac{1-p(B)}{p(B)},$$

$$2k - n = \log_q \frac{1-p(B)}{p(B)}, \qquad 2k - n = \frac{\ln(p(B)^{-1} - 1)}{\ln q}.$$

The last formula allows us to determine the number k:

$$2k - n = \frac{\ln(1{,}25 - 1)}{\ln 0{,}3} = \frac{\ln 0{,}25}{\ln 0{,}3} \approx 1{,}2.$$

But then $2k - n = 1{,}2$; $2k - 8 = 1{,}2$; $k - 4 = 0{,}6$; $k = 4{,}6$.

Since we cannot provide a fractional number of drones, it results that 5 drones will be made available for searching for the crashed helicopter near locality ***B*** and for searching for the crashed helicopter near locality ***A*** – 3 drones. At such a distribution of drones, the probability that the helicopter will be found is 99.75% and is maximum.

Answer:

a) Five drones will be made available near locality ***B***, and three drones will be available near the locality ***A*** for the search for the crashed helicopter.

b) The probability that the helicopter will be found is 99,75%.

3. STEM approach: Information analysis, data processing and taking decisions using Informatics and Information Technologies

For a better understanding of the solution, the calculations and the result, a series of problems can be formulated, different scenarios can be created that will involve knowledge and skills in the field of Informatics.

Examples:

a) To elaborate an algorithm that will construct / represent the graph of the function:

$$f(t) = p(B) \cdot t + \frac{(1-p(B))q^n}{t}, \text{ were } t \in (0; 1).$$

b) To verify the existence of the critical points of the function *f*(*t*).

c) To automate (program) the solution of the problem for the given values *P*(*A*), *P*(*B*), *n* and *q*.

The proposed tasks seem simple, but when testing the algorithm for different values, problems may arise in representing the graph, determining the critical points, etc. These are related to:

– the computer coordinate system, which by default is expressed in whole coordinates (number of horizontal and vertical screen points);
– scaling points with very low coordinates-values;
– determination of the critical point (with a good approximation);
– variation of value ranges according to initial data;
– the correct choice of the step of building the points of the graph, etc.

Students must critically analyse each situation and be able to represent appropriate graphs for each situation.

Some students will suggest using a table processor to generalize the solution using the formula: $k = \frac{n}{2} + \frac{\ln(p(B)^{-1}-1)}{2\ln q}$

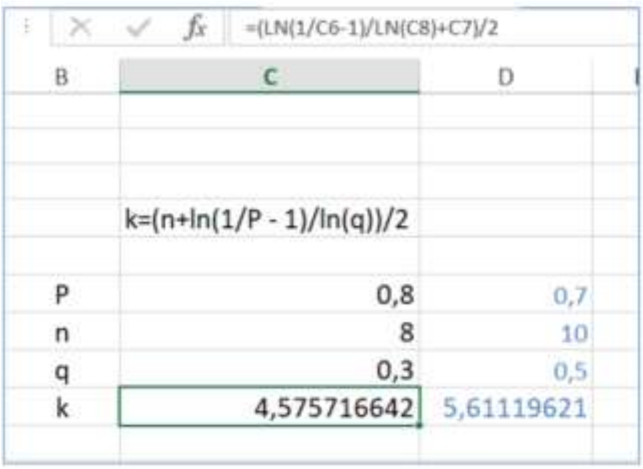

Figure 2.

This choice (fig. 2) involves studying the tools, the syntax of spreadsheets (writing formulas, relative addresses, absolute addresses, cell formatting) allows us to obtain the result-numerical value, but does not give us the possibility to represent the graph of a function and critical points with high accuracy if the definition and value ranges are too large.

A more successful solution may be to use an integrated development environment with a high-level programming language, such as Lazarus, which is open-source and uses Object Pascal (fig. 3).

Figure 3.

We notice that the coordinate system was presented on a scale of 1: 10000. For other values it may be necessary to change the scale.

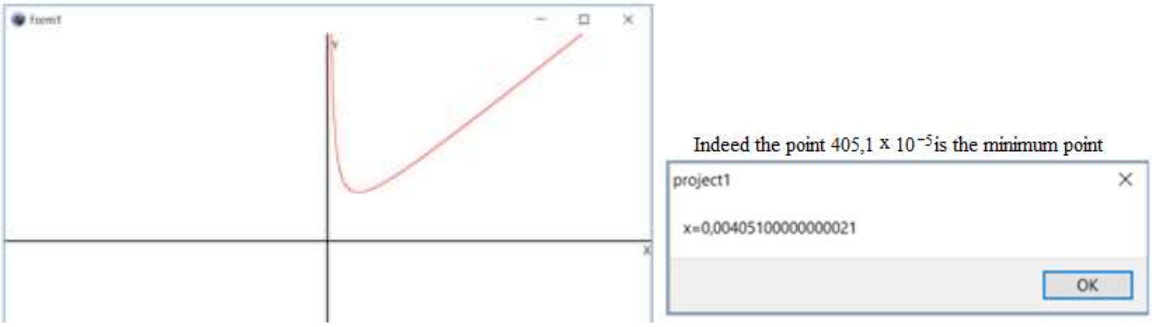

Figure 4.

In order to determine the critical points, numerical calculation methods can be applied (for the students from the 12th grade) or the consecutive values of the ordinate can be analysed. As a minimum point is sought, the first ordinate value greater than the previous one was determined. In order not to display the other similar values (ordinate value higher than the previous one) a Boolean variable (*f*) was used as a switch.

Thus, from figure 4 it can be seen that for the data in the problem the same critical point was obtained with a pretty good accuracy.

To capitalize on IDE Lazarus students and students in grades 9 – 12 are motivated to research (recap) and apply data structures and programming language control elements, computer-aided graphics, coordinate transformations, ratios and proportions, calculation errors, etc.

The research at the mathematics lessons of the problem presented in the presented way led to a good mobilization and motivation of the pupils / students and, consequently, to the obtaining of the quality academic performances. We worked collaboratively for 2 weeks, in teams of 4 – 5 members, with synchronous and asynchronous assistance by the teacher.

Conclusions

In the concept of those presented, we can say that:

1. The proposed activities can develop such qualities of character indispensable to the postmodernist era, such as the spirit of initiative, constructivism, creativity, etc.
2. Continuous learning skills can be formed, capacities to adapt to new situations, learning situations can be created in which pupils / students are aware of learning approaches, results, shortcomings, etc.
3. Possessing them, the student can collaborate, compete and make independent correct decisions, to accept and promote innovations, to resist, but also to get out of stressful situations, so that later the pupil / student is young, mature able to prepare, design and direct its work [2].
4. The STEM / STEAM approach in combination with the case study method based on the real problem is effective, especially if Information Technologies and modern digital devices are used: drone, tablet, smartphone, etc.
5. These devices must be used as educational tools that contribute to the efficiency of the process of studying the exact sciences and nature: mathematics, computer science, physics, chemistry, biology, geography.
6. However, the real problems must be chosen carefully, to be connected to the learning objectives, especially if they are researched within a single discipline.

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