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ACTION-STRATEGIC COMPETENCE IN STEAM CONCEPT

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Rezumat. Aparatele de zbor fără pilot la bord pot reprezenta pentru Republica Moldova o unealtă extrem de importantă provocărilor secolului XXI. Realitatea actuală indică o tendinţă ascendentă şi accelerată în acest domeniu, iar cererea unor astfel de unelte este limitată doar de creativitatea şi imaginaţia utilizatorilor. Putem afirma cu certitudine că progresul tehnologic al senzorilor şi apariţia unui număr tot mai mare de soluţii fără pilot vor putea satisface necesitățile învățământului STEAM din Republica Moldova de a obţine performanțe calitative prin astfel de aparate de zbor ghidate la distanță.
Cuvinte cheie: STEAM, modelare, traiectorie, dronă, programare, scratch.

Abstract. Unmanned aerial vehicles can be an extremely important tool for the challenges of the 21st century for the Republic of Moldova. The current reality indicates an upward and accelerated trend in this field, and the demand for such tools is limited only by the creativity and imagination of users. We can say with certainty that the technological progress of sensors and the emergence of an increasing number of unmanned solutions will be able to meet the needs of STEAM education in the Republic of Moldova to achieve qualitative performance through such remote-guided aircraft.
Keywords: STEAM, modeling, trajectory, drone, programming, scratch.

1. Introduction

STEAM is an educational approach to learning, which uses Science, Technology, Engineering, Art and Mathematics as access points for instruction, education, survey guidance, dialogue and critical thinking of pupils/students.

The end result is students who take risks, get involved in experiential learning, persist in problem solving, embrace collaboration and work through the creative process.

At present, the scenario of humanity in the offer of educational curricula/study and training programs shows an essential difference: on the one hand, the strong pressure of the labor market, which is constantly looking for and growing profiles with strong STEAM skills, and on the other hand, there is an inadequate level of STEAM competencies both among high school students and among college students [2, 3].

Therefore, the existing reality requires the creation of means to improve STEAM skills in pupils and students in order to develop their technical and professional skills that prepare them to access the labor market more easily, by strengthening their employment capacity. One such means could be the adoption of harmless drone technology, which can be combined with many aspects of the European STEAM curriculum, which is easy to exploit and transfer in terms of building teacher-led educational programs, invested with a new role as a learning facilitator, bringing theory to laboratory practice. Applying the STEAM concept to a real object will help teachers to involve and motivate students. In fact, it is believed that pupils / students are more inclined to learn theoretical concepts through practical activities than through traditional teaching methods in which the teacher only explains concepts and assigns tasks and exercises.

Based on STEAM educational programs developed by teachers in a teacher-led perspective, pupils/students will cooperate in a community of practices inserted in a learning context that simulates the workplace, to study, disassemble and build harmless drones or parts thereof, in accordance with a learning logic.

Thus, according to the concepts presented, both teachers in general and mathematics teachers in particular are forced to create a product of the imagination of pupils / students, designed to allow the free use of knowledge, in a new and relevant context, answering a key question: *What can i do with what i have learned* ?

Below we present an example of a problem in the STEAM concept that exemplifies the applications of mathematics in describing the trajectory of a drone and perfectly fits into the curriculum in the specialty of Mathematics and Computer Science.

2. Problem model solved

Problem. Functional dependence $T(x) = \sqrt{x^2 + 1600}$ characterizes the mathematical trajectory of a drone between points *O* and *A*, $T(y) = \sqrt{y^2 + 6400}$ – between points *A* and *B*, and $T(z) = \sqrt{z^2 + 14400}$ – between points *B* and *C*.

Determine:

a) the shortest trajectory between points *O* and *C*, if the variables *x*, *y* and *z* must satisfy the equation of the plane $x + y + z = 180$;
b) the analytical expression in Cartesian rectangular coordinates of the shortest trajectory of the drone in a plane parallel to the plane (*xOy*);
c) the parametric expressions of the shortest trajectory of the drone;
d) the values of the parameter *t* for each of the points *O*, *A*, *B* and *C*.

After obtaining the mathematical results:

e) program in the Scratch language with the help of blocks the drone's trajectory;
f) perform the flight at a specialized simulator according to the programmed trajectory;
g) make a real flight with a inoffensive drone according to the programmed trajectory.

Solution. From the conditions of the problem it results that the shortest trajectory between points *O* and *C* will be equal to the sum of the lengths of the trajectories *OA*, *AB* and *BC*, i. e. $OC = OA + AB + BC$. To determine the shortest trajectory of the drone between points *O* and *C* we will present two methods [1].

<u>Method 1.</u> This method can be presented to students who are familiar with the theory of functions of several variables and their extremes.

To determine the shortest trajectory we must fully investigate the function of three variables $f(x; y; z) = \sqrt{x^2 + 1600} + \sqrt{y^2 + 6400} + \sqrt{z^2 + 14400}$, where $x + y + z = 180$, that is, we must determine its minimum. This method leads us to quite voluminous calculations which are reflected below.

Since $z = 180 - x - y$, then we obtain the function of two variables:

$$f(x; y) = \sqrt{x^2 + 1600} + \sqrt{y^2 + 6400} + \sqrt{(180 - x - y)^2 + 14400}.$$

The first order partial derivatives of this function are:

$$f_x^{/}(x; y) = \frac{x}{\sqrt{x^2 + 1600}} - \frac{180 - x - y}{\sqrt{(180 - x - y)^2 + 14400}},$$

$$f_y^{/}(x; y) = \frac{y}{\sqrt{y^2 + 6400}} - \frac{180 - x - y}{\sqrt{(180 - x - y)^2 + 14400}}.$$

Equating these derivatives with zero: $f_x^{/}(x; y) = f_y^{/}(x; y) = 0$, we will receive

$x\sqrt{y^2 + 6400} = y\sqrt{x^2 + 1600}$, $x^2y^2 + 6400x^2 = x^2y^2 + 1600y^2$, $y^2 = 4x^2$, $y = \pm 2x$.

We admit that $y = 2x$. Then we get the equation

$$\frac{x}{\sqrt{x^2 + 1600}} - \frac{180 - 3x}{\sqrt{(180 - 3x)^2 + 14400}} = 0,$$

which admits the only solution $x = 30$. But then $y = 60$ and $z = 90$. So a stationary point has the coordinates: (30; 60; 90).

We admit now $y = -2x$. Then we get the equation:

$$\frac{x}{\sqrt{x^2 + 1600}} - \frac{180 + x}{\sqrt{(180 + x)^2 + 14400}} = 0,$$

where does the square equation result from:

$$x^2 - 45x - 4050 = 0,$$

which admits the solutions: $x_1 = -45$ and $x_2 = 90$. But then

$$y_1 = 90,\ y_2 = -180 \text{ and } z_1 = 135,\ z_2 = 270.$$

Thus, we obtained three stationary points:

(30; 60; 90), (–45; 90; 135) şi (90; – 180; 270).

We find the values of the function $f(x; y; z)$ in the stationary points:

$$f(30; 60; 90) = \sqrt{900 + 1600} + \sqrt{3600 + 6400} + \sqrt{8100 + 14400} =$$
$$\sqrt{2500} + \sqrt{10000} + \sqrt{22500} = 50 + 100 + 150 = 300;$$
$$f(-45; 90; 135) = \sqrt{2025 + 1600} + \sqrt{8100 + 6400} + \sqrt{18225 + 14400} =$$
$$= \sqrt{3625} + \sqrt{14500} + \sqrt{32625} = 30\sqrt{145} \approx 361{,}25;$$
$$f(90; -180; 270) = \sqrt{8100 + 1600} + \sqrt{32400 + 6400} + \sqrt{72900 + 14400} =$$
$$= \sqrt{9700} + \sqrt{38800} + \sqrt{87300} = 60\sqrt{97} \approx 590{,}93.$$

Thus, the students come to the conclusion that the shortest trajectory between points *O* and *C* will be equal to 300, because the lowest value of the researched function is equal to 300.

To determine the shortest trajectory of the drone between points *O* and *C* we can indicate another method that does not require knowledge in higher mathematics and therefore such a problem can be solved with pupils in gymnasium.

Method 2. This method is based on geometric illustrations, the rectangular triangle and Pythagoras theorem.

We are looking at figure 1. The trajectory of the drone will be the shortest when the length of the line broken *OABCD* will have the shortest length. This is possible only when the points *O*, *A*, *B* and *C* will be located on one and the same line, ie the smallest length must be the length of the segment *OC*, which is the hypotenuse of the rectangular triangle *OFC*. Since the legs of the right triangle are 180 and 240, it follows that *OC* = 300.

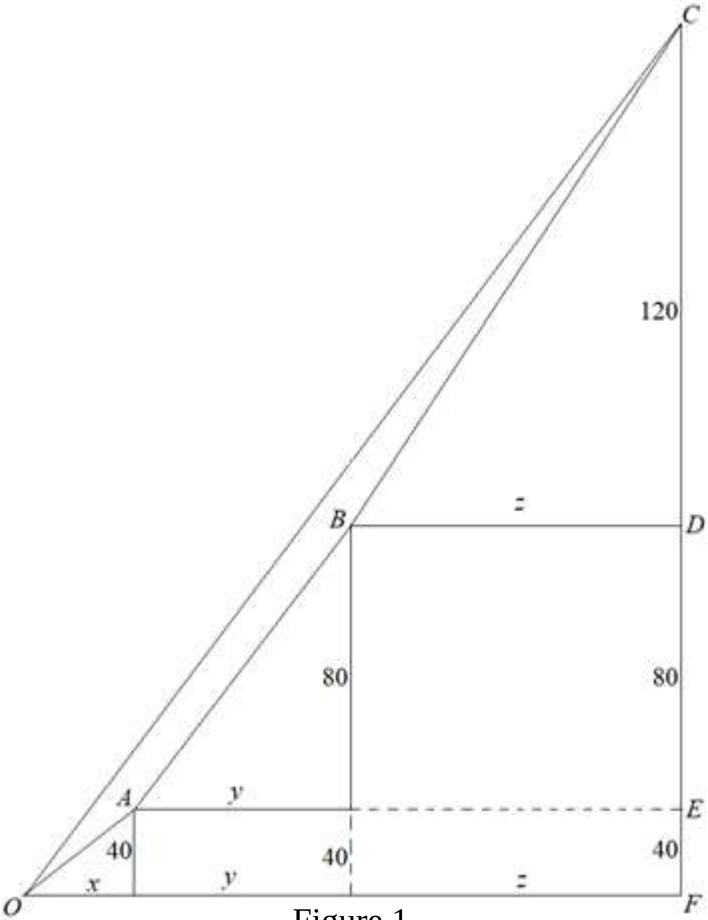


Figure 1.

b) To determine the analytical expression in Cartesian rectangular coordinates of the drone's trajectory we fix a rectangular Cartesian coordinate system with origin at point O (see fig. 2). We choose the positive directions of the axes (*Ox*) and (*Oy*) as indicated in figure 2. We denote $O(x_0; y_0)$ $A(x_A; y_A)$, $B(x_B; y_B)$ and $C(x_C; y_C)$. Since point *O* is the origin of the Cartesian rectangular coordinate system, it follows that *O*(0; 0). According to the results obtained above, it follows that the first coordinate of point *A* is 30. Out of equality $AB = \sqrt{x^2 + 1600}$, distance formula

$$OA = \sqrt{(x_A - x_0)^2 + (y_A - y_0)^2} = \sqrt{(30-0)^2 + (40-0)^2},$$

the way we chose the Cartesian rectangular coordinate system, for practical and security reasons of making a drone flight, respecting the legislation of the Republic of Moldova in force, we conclude that the second coordinate of point A is 40.

So, point *A* has the coordinates (30; 40). Analogously we obtain: *B*(90; 120) and *C*(180; 240).

Since the trajectory of the drone is a line, and the line is determined uniquely by any two distinct points of it, we choose, for example, points *O* and *A* with which we determine its equation in Cartesian rectangular coordinates:

$$\frac{x - x_0}{x_A - x_0} = \frac{y - y_0}{y_A - y_0}, \qquad \frac{x}{30} = \frac{y}{40}, \qquad 4x - 3y = 0.$$

If we substitute the coordinates of points B and C in the equation of the obtained line, then we can be convinced that they also belong to the line $4x - 3y = 0$.

Therefore, the equation of the drone's trajectory has the form: $4x - 3y = 0$.

c) The expressions or parametric equations of the drone's trajectory containing points O, A, B and C will have the form:

$$\frac{x}{30} = \frac{y}{40} = t,$$

where from

$$\begin{cases} x = 3t, \\ y = 4t. \end{cases}$$

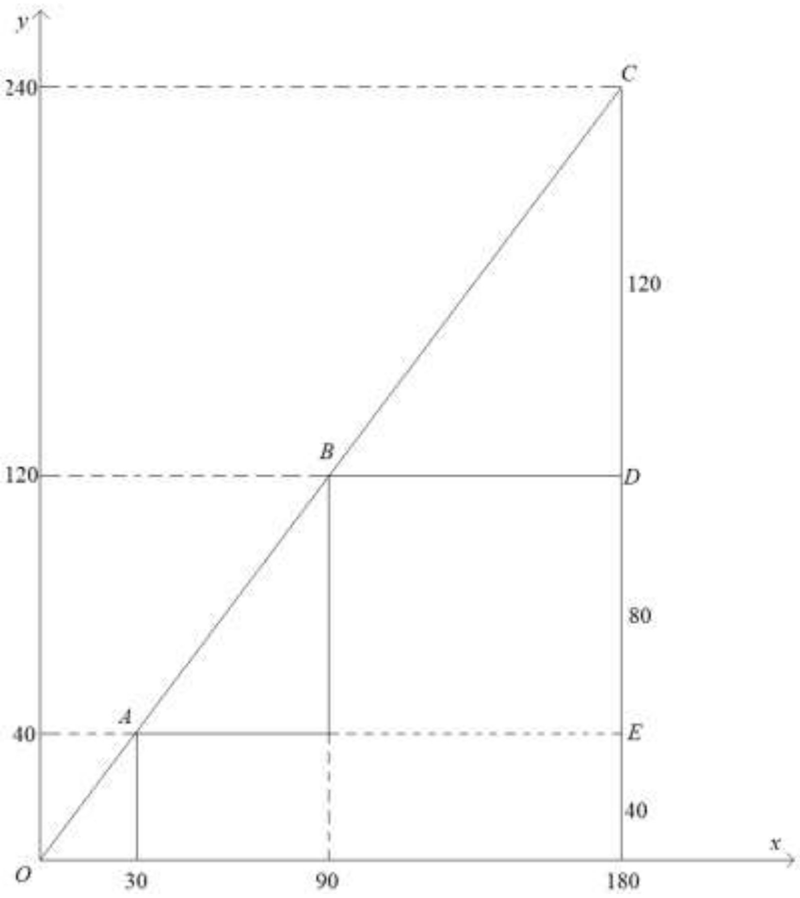


Figure 2.

d) The values of the parameter t for each of the points O, A, B and C are found by substituting the coordinates of the respective points in the parametric equations of the trajectory. Thus, for point $O(0; 0)$ we have $t = 0$, for point $A(30; 40)$ the value of the parameter $t = 10$, for point $B(90; 120)$ we obtain $t = 30$ and for point $C(180; 240)$ the parameter $t = 60$.

After obtaining the mathematical results, we move on to the flight scheduling.

e) The program for making the drone flight in the Scratch language through the blocks is presented in fig. 3.

For safety and convenience reasons, the flight will be performed in the plane determined by the equation $4x - 3y + z = 90$. The flight in this plane does not require the consent of the respective authorities.

After the drone's trajectory has been programmed, students will be able to make a flight both to a specialized simulator and with a real drone by a single press of the respective button.

Obviously, the teacher can change this problem by asking, for example, to determine all possible trajectories of the drone related to the stationary points of the function of three variables $f(x; y; z) = \sqrt{x^2 + 1600} + \sqrt{y^2 + 6400} + \sqrt{z^2 + 14400}$, where $x + y + z = 180$ and for the trajectories obtained the students to:

f) write the program in the Scratch language with the help of blocks;

g) realize the flight at a specialized simulator;

h) perform the flight with an inoffensive drone.

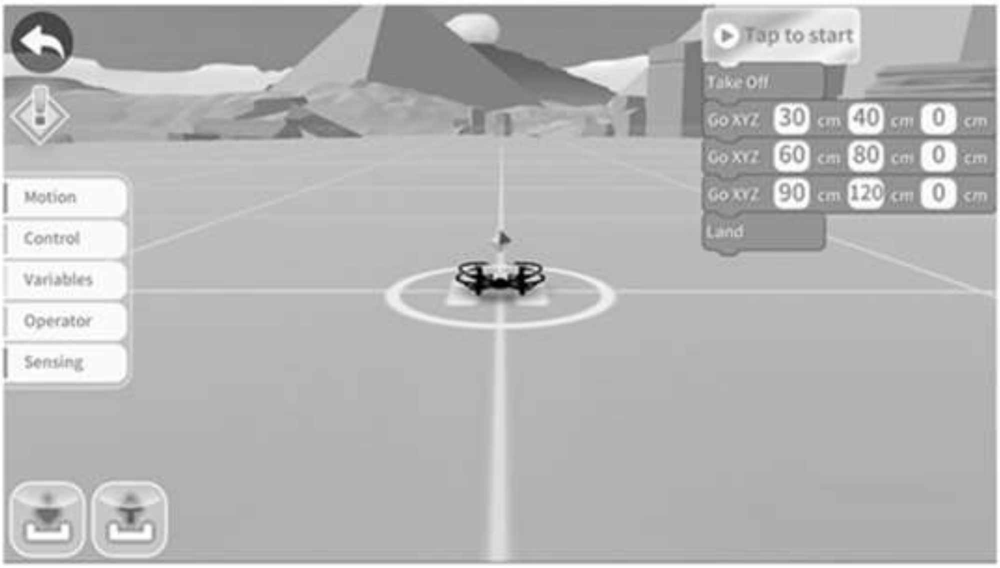


Figure 3. The program for the flight

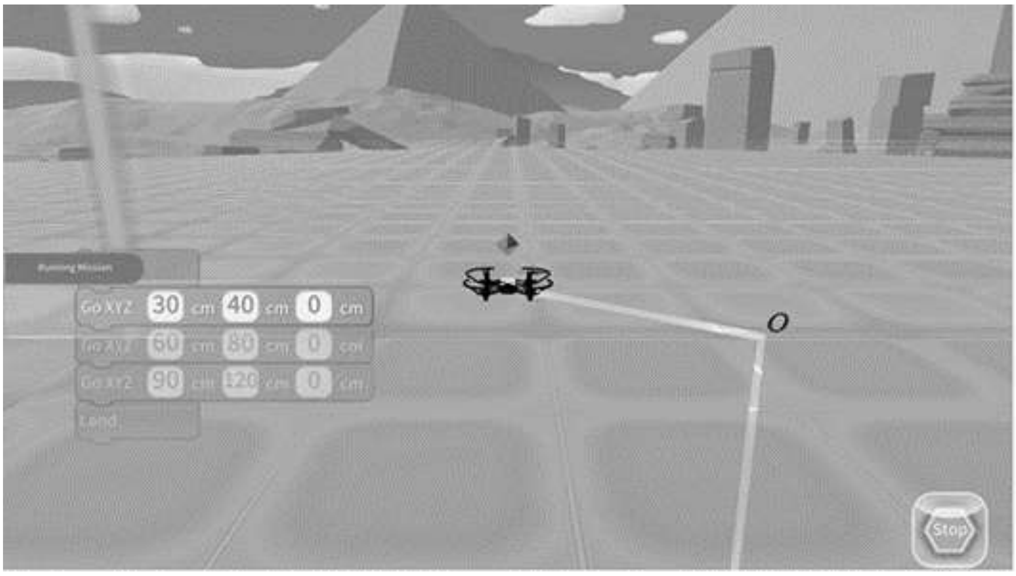


Figure 4. The trajectory of the drone from point *O* to point *A*

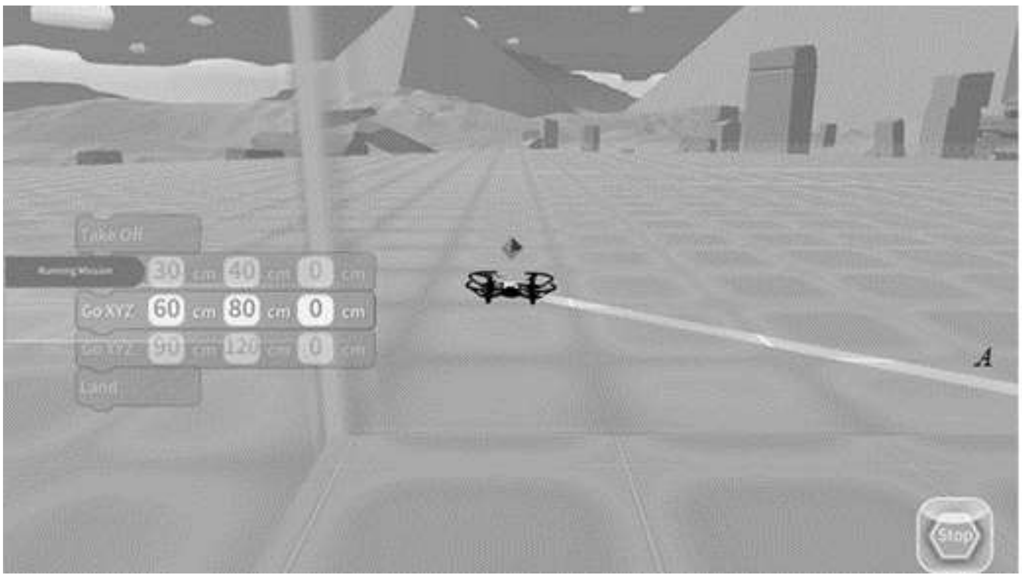


Figure 5. The trajectory of the drone from point *A* to point *B*

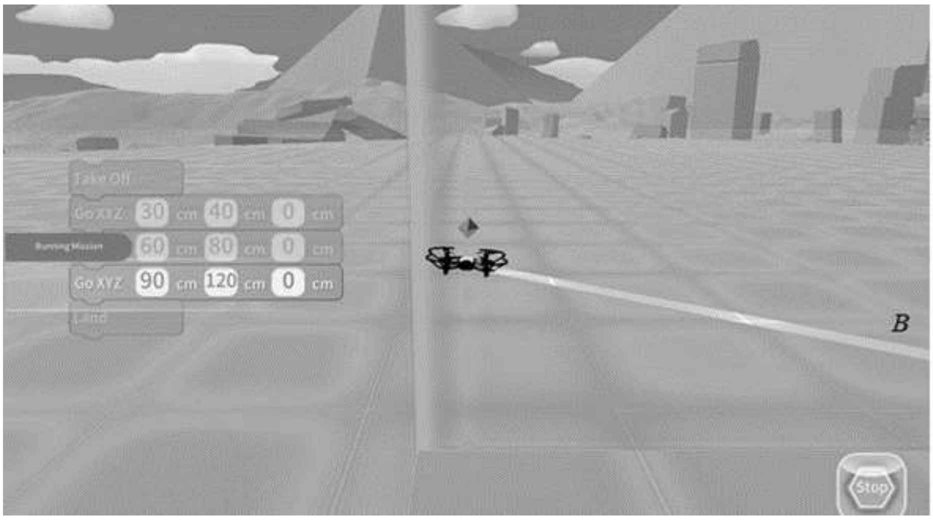


Figure 6. The trajectory of the drone from point *B* to point *C*

In such a case for the stationary point with the coordinates (–45; 90; 135) by modeling we will obtain that the trajectory of the drone passes through of the points $O(0; 0)$, $A_1(-45; 40)$, $B_1(90; 80)$ and $C_1(135; 120)$. We observe that points O, B_1 and C_1 belong to the line $8x - 9y = 0$, and point A_1 does not belong to the given line. But the points $O(0; 0; 90)$, $A_1(-45; 40; 90)$, $B_1(90; 80; 90)$ and $C_1(135; 120; 90)$ belong to the plane $z = 90$. The trajectory of the drone is shown in figure 7.

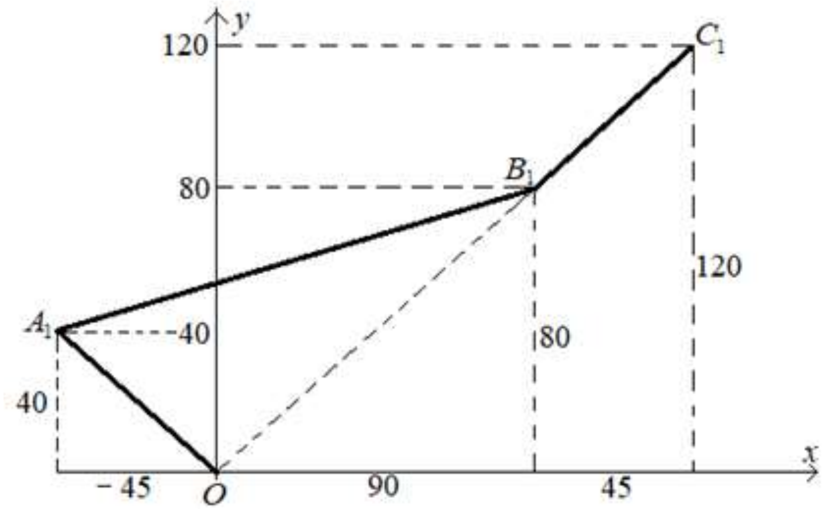


Figure 7. The trajectory of the drone for the stationary point (-45; 90; 135)

The program for performing the drone flight in the Scratch language by means of blocks is shown in figure 8.

For the stationary point with the coordinates (90; –180; 270) – the trajectory of the drone is also a broken line and passes through the points: $O(0; 0)$, $A_2(90; 40)$, $B_2(-180; 80)$ and $C_2(270; 120)$. We observe that points O, A_2 and C_2 belong to the line $4x - 9y = 0$, and point B_2 does not belong to the given line. But the points $O(0; 0; 90)$, $A_2(90; 40; 90)$, $B_2(-180; 80; 90)$ and $C_2(270; 120; 90)$ belong to the plane $z = 90$. Therefore, we can also perform the flight in the plane determined by the equation $z = 90$. The trajectory of the drone is shown in figure 9.

Figura 8.

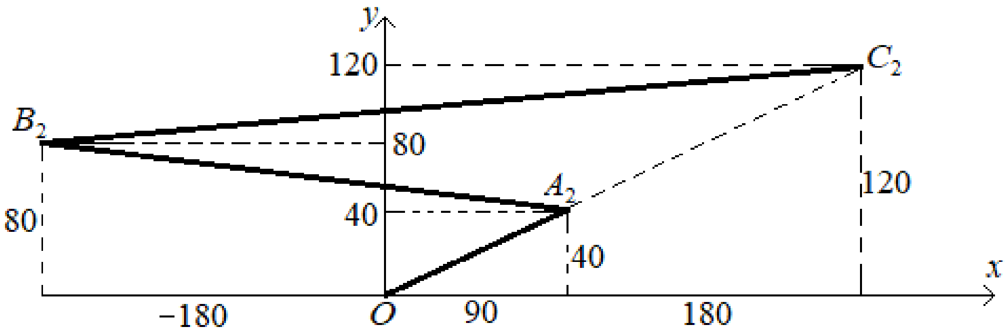


Figura 9. The trajectory of the drone for the stationary point (90; -180; 270)

The program for performing the drone flight in the Scratch language by means of blocks is shown in figure 10.

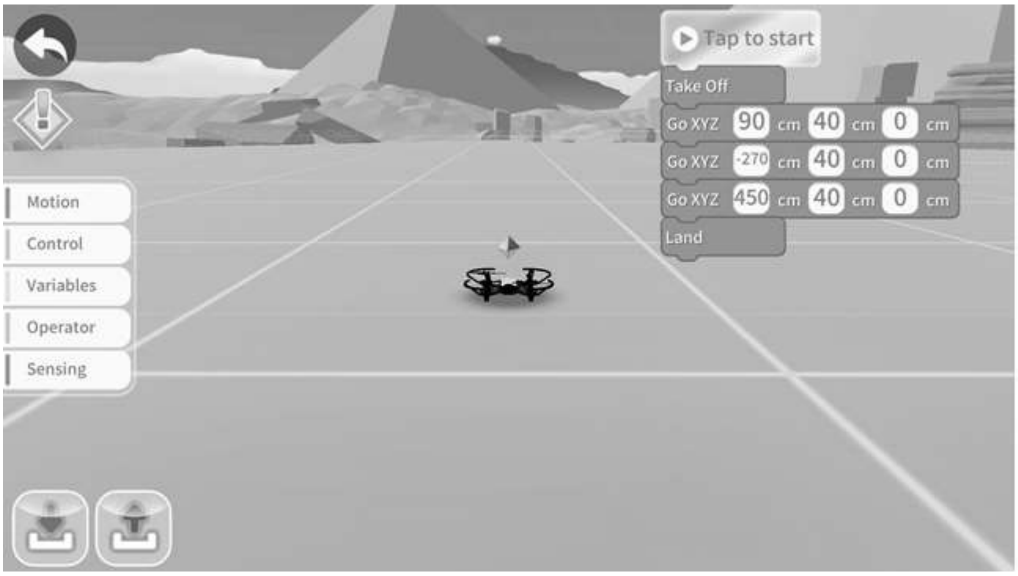


Figura 10.

3. Conclusions

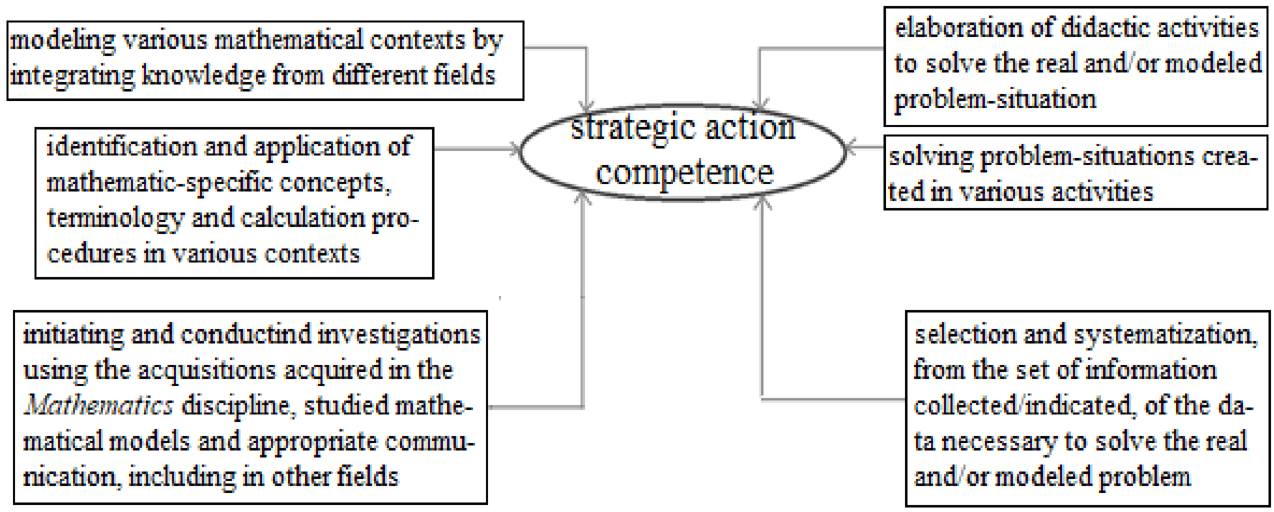
In the concept of those presented, we can say that the proposed activities can develop such qualities of character indispensable to the postmodernist era, such as the spirit of initiative, constructivism, creativity, etc.

By owning them, the pupil/student can collaborate, compete and therefore they offer the possibility to independently make correct decisions, to accept and promote innovations, to resist, but also to get out of stressful situations, so that later the student can either the young, the adult able to take care of the preparation, design and direction of his / her activity, because the school, then life is the battlefield where the pupil/student is the commander of his own decision.

Based on the activities presented above, lifelong 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.

Such activities can create favorable conditions for the transfer of mathematical knowledge acquired and realized in various fields, including everyday life and in the field determined by the curricular area. In this regard, we must use every opportunity to exemplify the applications of mathematics in physics, computer science, biology, chemistry, in everyday life and in other fields.

Therefore, as a result of the activities performed, the teacher can establish a link between the specific competences of mathematics and the action-strategic competence in the process of studying mathematics, a link that is shown in the diagram below.



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