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Developing Mathematical Competencies Through Makeblock mBot Programming in Computer Modelling Education

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***Abstract* – This paper posits that engaging junior high school students in computer modeling through the programming of the educational robot Makeblock mBot improves their mathematical skills by contributing to a deeper understanding of geometric concepts, problem-solving abilities, and data analysis. Additionally, this approach encourages interdisciplinary learning between mathematics, physics, and robotics. Based on the methods of theoretical analysis of various educational standards and synthesis of the necessary competencies, specific projects for mBot programming with the block environment Makeblock are constructed. Each project is described by a technological map containing the main characteristics of the project, the interdisciplinary connections, and the developed competences. The implemented codes are organized and stored in an open access repository. As a result, the opportunity to apply a project-based approach to developing mathematical skills through programming the educational robot mBot is supported.**

***Keywords* – Educational robots, mBot, mathematical competencies, computer modelling competencies.**

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1. Introduction

To navigate unfamiliar and ever-changing circumstances, adolescents need a diverse set of skills. These skills encompass cognitive and meta-cognitive abilities such as critical thinking, creative thinking, adaptability, and self-regulation. Social and emotional skills like empathy, self-confidence, and collaboration are also crucial. Additionally, practical and physical skills, including proficiency in utilizing new information and communication technology devices, play a significant role [22].

The integration of 21st century skills into educational systems has gained global attention. Recognizing this, the OECD (Organisation for Economic Co-operation and Development) has launched a research project called "The Future of Education and Skills: Education 2030", involving 25 countries in a cross-national study, for the development of the educational program for the formation and development of these necessary skills. The project aims to envision the future curriculum, with an initial focus on mathematics. Some key 21st century skills identified by the OECD include critical thinking, creativity, research and inquiry, self-direction, information use, communication, and reflection [27].

Mathematical literacy, as defined by the PISA, is the ability to reason mathematically, apply mathematics to solve real-world problems, and understand the role of mathematics in the world. It involves concepts, procedures, facts, and tools for describing, explaining, and predicting phenomena. Enhancing students' mathematical literacy and transformative competencies can be achieved through the integration of programming into the middle school curriculum.

This article aims to explore how programming the Makeblock mBot can contribute to the development of students' mathematical and computational skills within the domain of computer modelling education.

2. Defining Mathematical Competencies for the Objective of the Research

Strategies, initiatives and educational standards are being developed to overcome the crisis in the field of natural sciences. Reforms are taking place both at the national and international level [6], [8], [11], [19], [27].

The relationship between the concepts of *competence* and *skill* is defined in various scientific sources, and it can be summarized that *skills*, *knowledge* and *attitudes* are integrated in the concept of *competence* [9], [23], [26], [29], [14].

Mathematical competence includes: remembering formulas and procedures, thinking logically, understanding concepts, thinking creatively, knowing how to use mathematics in the real world, justifying decisions, the most important being skills related to the way of thinking [3], [18], [20]. Knowing the degrees of skills development contributes to the correct definition of learning goals and sub-goals, so that an appropriate pedagogical impact is made on all learners; developmental assessment; gradual transition to self-regulation and autonomy [7], [13], [34].

Based on the conducted theoretical research, the following *mathematical skills* were synthesized, which can be divided into two categories (Table 1).

Some modern researches are aimed at establishing and confirming the benefits of using a robot in programming education [21], [35]. The main considered advantages are increasing the efficiency in learning concepts in computer science, computational thinking and motivation of learners.

In addition to mastering concepts and approaches in programming, educational robots can be successfully used to support the development of mathematical competencies. In [17], a survey is made of the tools and materials to be used in integrated teaching of mathematics through computational thinking activities that also include robot programming. Ottenbreit-Leftwich and Kimmons highlight why coding in the K-12 classroom is important [24]. Brender *et al.* investigated and confirmed an increase in motivation and engagement of 15-year-old students during mathematics exercises that involved working with a robot [4].

The educational benefits of the mBot discussed in this paper have been explored in [2], [30], [32]. Kalaitzidou and Pachidis [10] systematize the characteristics of robots that are most effective in STEAM education (mBot included), classify robots used in education in terms of their frequency of use, functionalities, recommended age, price, etc.

According to this research, against the background of other offered educational robots, mBot stands out as a small mobile robot suitable for STEAM education, which offers an acceptable compromise between price and functionalities with many expansion possibilities.

Table 1. Mathematical competences

Competence category	**Description/ definition**
With a wide range	
Mathematical thinking	solve mathematical problems, apply mathematical concepts and procedures to analyse situations and scenarios
Mathematical reasoning	analyse and evaluate mathematical statements, discover patterns and relationships, draw conclusions, and construct reasoned proofs
Mathematical modelling	create and use mathematical models that represent real-life situations and phenomena; analyse and interpret the results of modelling
Mathematical tools	use mathematical tools and techno-logies, such as drawing tools, calculators, computers, mathematical modelling software, for analysis and problem-solving, etc.
Skills to apply mathematics in other fields	the ability to understand and apply mathematical concepts and methods in different contexts, such as physics, economics, information technology, and other scientific and applied fields
Mathematical representation and communication	express mathematical ideas, concepts, and results through various representations – symbolic, verbal, visual, etc.; communicate mathematics in a clear and understandable manner
With a more specific scope	
Numeracy	use different types of numbers, perform basic mathematical operati-ons, and apply mathematical properties and laws
Measurement	use different measurement systems, and convert between them; measure physical quantities
Ratio and proportion	solve problems related to ratios and proportions; apply rules of propor-tionality; create and analyse tables, graphs, and diagrams
Probability and statistics	understand the basic principles of probability, calculate probabilities, and analyse statistical data
Function and graph	understand mathematical and graphed functions, and perform transformations and manipulations with them
Shapes and figures	understand and apply geometric concepts and principles

The RobotiCSS Lab has conducted robotics activities in schools. They conclude that “these activities provide children with an opportunity to develop science skills and competences and a stimulus to reflect metacognitively on the fundamentals of scientific research methodology” [36].

In addition to developing competence in applying mathematics across various domains, the laboratory approach also fosters children's ability to acquire the skill of learning how to learn , plan, communicate and collaborate, act independently and responsibly, solve problems, identify connections and interpret information [36] so these activities also develop the competence of mathematical representation and communication. Students working in groups achieve soft skills like team building, leadership, and peer cooperation [5].

Alberto Parola, Elena Liliana Vitti, Margherita Maria Sacco, and Ilio Trafeli move from “teaching robotics” towards the “teaching with robotics”. They propose robots as a mediation instrument for normal learning and for transversal competencies in the school setting [25].

The primary school students learn mathematical concepts interactively while having fun. Educational robotics enables them to identify constructive procedures to find solutions to concrete problems. It is learner-centered teaching, meaning that, instead of being passive recipients of concepts, learners learn effectively through experience, error, interaction with the environment and with others. This type of learning is particularly productive, since knowledge comes from being active and doing, which begins with curiosity, from a question, and passes through trial and error, hypotheses, in pursuit of suitable solutions [5].

At the moment, training for programming educational robots in Bulgaria is offered episodically in individual schools related to educational projects [33] or in extracurricular activities from specialized courses [31].

Kert *et al*. found experimentally that educational robotics develops computational thinking skills more effectively than block-based programming [12].

Pou *et al*. [28] establish improvement of competences such as communication between classmates, creativity, collaboration, and community building.

3. General Description of Learning Activities

Programming the Makeblock mBot can help enhance mathematical skills through the following activities:

1. Interacting with geometric shapes: programming mBot to perform various movements that represent geometric shapes. Students need to apply mathematical concepts such as vertices, sides, length of sides, angles, right angles, center, and radius to determine the parameters of the shapes.
2. Programming mBot to solve arithmetic problems: Programming mBot to execute a sequence of number operations required by the problems. They are challenged to analyse and break down mathematical problems into executable steps, translating them into code that mBot.
3. Utilizing mBot's sensors for data collection and analysis: Programming mBot to analyse the collected data and perform mathematical operations on them. By leveraging the sensors on mBot, students can explore the practical applications of data collection and analysis. They can design experiments or scenarios where mBot collects data, such as measuring light intensity or distances. Through programming, students can instruct mBot to analyse the collected data and perform mathematical operations, such as calculating averages, median and mode, finding patterns or making comparisons.
4. Mathematical modelling of mBot's motion: Programming mBot to follow specific paths or perform complex movements that are described by mathematical models. Mathematical modelling of mBot's motion involves representation of its trajectory using concepts like speed, direction, and angles. By programming mBot to follow these models, students explore the connection between mathematics, physics and robotics, enhancing their understanding of both.

4. Features of mBot

mBot is an educational robot created by MakeBlock, designed to teach novice programmers and introduce students to the world of robotics and programming [1], [10]. It is affordable, easy to use and offers interesting opportunities for learning and entertainment. Some of the main features of mBot are [16]:

- Motors and wheels: mBot has two wheels that are driven by motors. Through them, he moves forward and backward, as well as turns left and right. Both motors maintain different travel speeds to accomplish the rotation.
- LED lights: They are located on the top of mBot and can be programmed to glow in different colours, allowing the robot to transmit visual signals.
- Buzzer: It can play beeps or tunes. The robot can be programmed to beep for various events as part of interactive projects.

- Ultrasonic distance sensor: It is located on the front of mBot and can measure the distance to objects ranging from a few centimetres to a few meters. It sends ultrasonic waves at objects and measures the time it takes for the signal to return to the sensor after reflecting off the object. With the received information, mBot calculates the distance to the object and can react.
- Light sensor: mBot's light sensor can measure the light intensity in the environment. This allows it to recognize different levels of illumination (the range is 0-1023) and react to changing lighting conditions.
- Line follower: This sensor is located on the bottom of mBot and allows it to follow a pre-drawn straight or curved line.
- Infrared receiver and transmitter: They allow mBot to communicate with other mBot robots by transmitting and receiving signals. This enables cooperation between robots or the creation of interactive scenes and games.
- Block programming: mBot is programmed using block programming, such as in the mBlock environment. This makes programming accessible and easy for beginners.
- Computer connection: mBot can be connected to a computer or other devices via USB, Bluetooth or Wi-Fi. This allows programmers to transmit their programs from a computer or smartphone to the robot and control its movement.

In addition to the basic mBot configuration, a variety of accessories and mBlock modules are available that can be added to expand functionality and perform more complex tasks.

5. Specific Proposals for Developing Projects Together With the Students From the Junior High School Stage

In this section, specific proposals are represented for developing projects together with junior high school students. Tables 2 ÷ 8 describe the projects using technological maps, which include: information about the project name; applied knowledge from specific school disciplines; the competencies in mathematics and computer modelling that are evolved.

Since mBot travels a distance of 35 cm in 1 s at its maximum speed (100%), the resulting equilateral triangle has a side length of 35 cm.

In order for mBot to travel the contour of an equilateral triangle with side a, we need to calculate the time it takes for the mBot to travel a distance a at the same speed ($v = 35\, cm/s$). From the formula for path (s), time (t) and velocity (v), $s = v.t$ we get that $a = 35.t$. Therefore, the time is $t = a/35$.

Figure 1 shows an implementation of the case when the movement time is set to 1 s and depending on the speed of the mBot, the distance travelled is determined, i.e. the length of the side of the equilateral triangle. It was experimentally established that when performing the actions turn `left / turn right` at maximum speed for 1 s, mBot rotates 360^0. For the particular example, a rotation of 120^0 is required, therefore a time of 1/3 of a second is specified.

Table 2. Technology map for description of project 1

Name of the project	mBot motion trajectory – an equilateral triangle
Applied knowledge	*from mathematics:* concepts – equilateral triangle, equality of segments; percentages *from physics:* path, speed, time
Program code for mBot	Figure 1: time and speed of mBot are set Figure 2: the side of an equilateral triangle is given
Developing mathematical competencies	Measurement; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Defining and using variables, computing value by formula, looping algorithm, mBot movement instructions

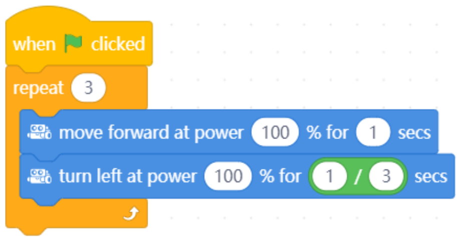


Figure 1. Movement of mBot along an equilateral triangle at a set movement time

If the task is for mBot to move along an equilateral triangle with a given side a, the required time to move should be calculated with the "*set t to* a/v" block. This option is considered in Figure 2.

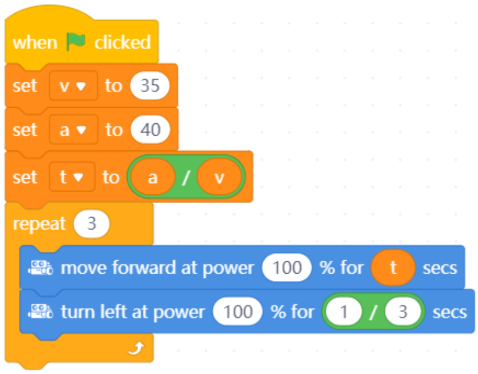


Figure 2. Movement of mBot along an equilateral triangle at a given length of its side a

Table 3. Technology map for description of project 2

Name of the project	**Moving mBot along a rectangle, finding the total length of the path travelled and the area circled**
Applied knowledge	*from mathematics*: concepts – rectangle, right angle, circumference, area, percentages; properties of the rectangle – equality of opposite sides; formulas for perimeter and area of a rectangle *from physics*: path, speed, time, engine power
Program code for mBot	Figure 3: the sides of the rectangle are set; mBot travels a distance and turns; circumference and area are computed using the formulas
Developing mathematical competencies	Measurement; Ratio and proportion; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Defining and using variables, computing value by formula, looping algorithm, mBot movement instructions

Figure 3 contains the sequence of instructions for timing the movement and turning of mBot, to calculate the total distance travelled and the area circled. The lengths of the rectangle sides are set by the variables a and b. Finding the time, it takes mBot to travel a distance corresponding to the lengths of the rectangle sides is done in a manner similar to that described for project 1. In this case, the rotation of mBot is 90^0, therefore the rotation time is $1/4$ of a second.

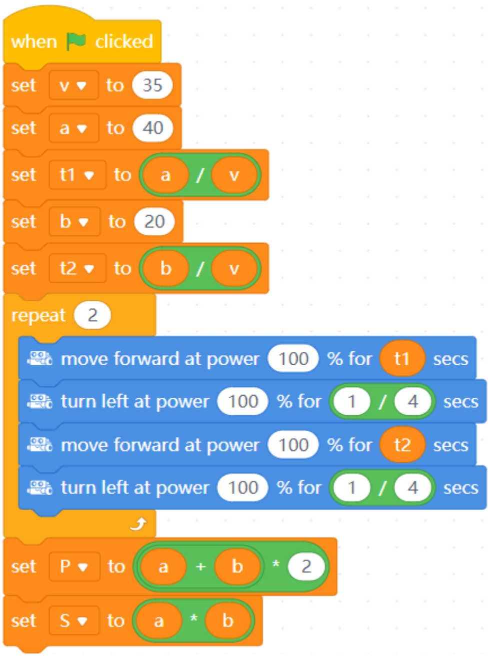
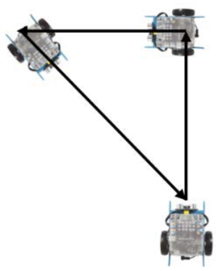


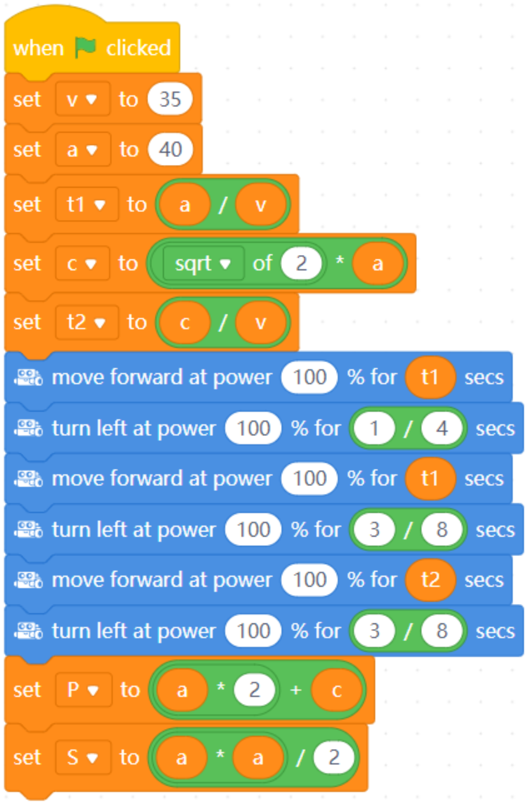
Figure 3. Movement of mBot along a rectangle

The formulas for the rectangle perimeter and area are represented by expressions using the operators corresponding to addition and multiplication operations. Enclosing blocks a and b with an extra ellipsis indicates that the multiplication operation is performed over their sum.

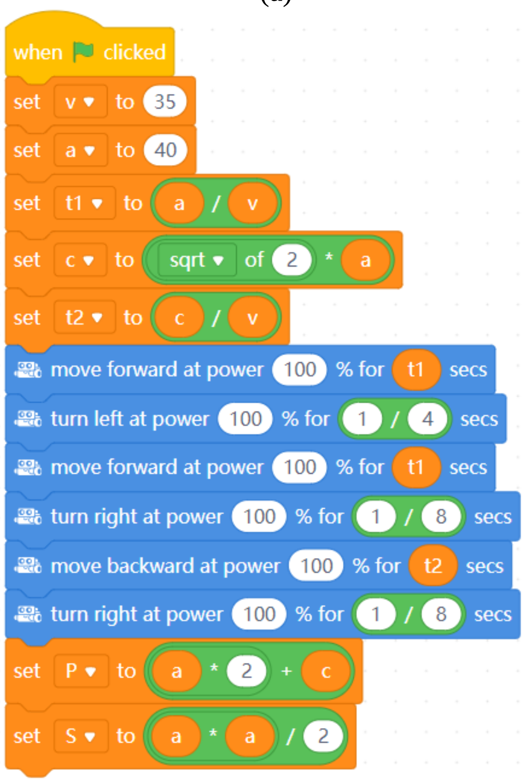
Table 4. Technology map for description of project 3

Name of the project	**Moving mBot along an isosceles right triangle, finding the total length of the path travelled and the area circled**
Applied knowledge	*from mathematics*: concepts – isosceles right triangle, right angle, circumference, area; properties of the isosceles right triangle – equality of the legs and the angles between the leg and the hypotenuse; formulas for perimeter and area of an isosceles right triangle *from physics*: path, speed, time, engine power
Program code for mBot	Two variants are implemented, shown in Figure 4a and 4b. The sequence of mBot movements is illustrated in the figure shown on the right.  In the second variant, the last movement is carried out in reverse.
Developing mathematical competencies	Measurement; Ratio and proportion; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Defining and using variables, computing value by formula, linear algorithm, mBot movement instructions

The Pythagorean theorem is applied to find the hypotenuse; the time required for the mBot to travel a distance corresponding to the legs' and hypotenuse length is calculated in a manner analogous to project 1. Knowledge of the formulas for calculating the perimeter and area of a right triangle is needed



(a)



(b)

Figure 4. Movement of mBot along an isosceles right triangle

Table 5. Technology map for description of project 4

Name of the project	**Movement of mBot in a circle using the ultrasonic distance sensor**
Applied knowledge	*from mathematics*: concepts – circle, length of an arc from the circle, percentage *from physics*: speed, engine power, ultrasonic distance sensor
Program code for mBot	Figure 5: mBot moves with different wheels' speed; the distance to the objects in front of it is measured; if they are less than 30 cm apart, mBot stops moving.
Developing mathematical competencies	Measurement; Ratio and proportion; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Conditional operator, infinite loop, mBot motion instructions, using mBot's ultrasonic sensor for distance

Figure 5 contains the instructions to mBot to move in a circle. The conditional operator if checks whether the objects in front of it are more than 30 cm apart. For this purpose, the data received from the ultrasonic distance sensor is used. Depending on the result of the check, different instructions are indicated – move in a circle or stop moving. The statement forever is intended to define an infinite loop to allow continuous verification of the changing value retrieved by the ultrasonic distance sensor.

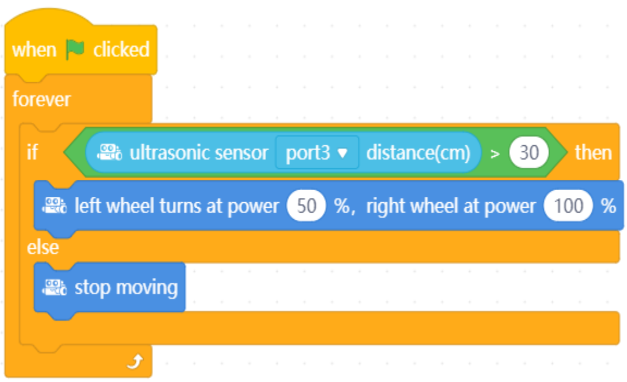


Figure 5. Movement of mBot in a circle using the ultrasonic distance sensor

Since the motor engines of mBot are controlled separately, the speed of both wheels can be different. In this way, mBot is programmed to move in a circle, the radius of which would be useful to calculate.

To do this, let's denote by V_{left} the speed of the left wheel of mBot; with V_{right} the speed of mBot's right wheel, α is the angle of rotation in radians; R_{left} is the radius of the circle on which the left wheel moves; R_{right} is the radius of the circle on which the right wheel moves; W is the distance between the centers of the mBot's left and right motors.

The distance travelled by the inside wheel (the left wheel in a left turn) is equal to the arc length of the circle of radius R_{left}, which can be expressed as:

Left wheel arch length = $\alpha . R_{left}$

Analogously, the distance travelled by the outer wheel (the right wheel) is an arc length of the circle of radius R_{right}, which can be expressed as:

Right wheel arch length = $\alpha . R_{right}$

Then the ratio of the speeds of the two wheels is:

$$\frac{V_{right}}{V_{left}} = \frac{R_{right} . \alpha}{R_{left} . \alpha}$$

After simplifying the expression, we obtain

$$\frac{V_{right}}{V_{left}} = \frac{R_{right}}{R_{left}}$$

Keeping in mind that $R_{left} = R_{right} - W$, it $\frac{V_{right}}{V_{left}} = \frac{R_{right}}{R_{right} - W}$.

Consequently, we can express R_{right} in terms of W and the speeds of both wheels V_{left} and V_{right}:

$$R_{right} = \frac{W . V_{right}}{V_{right} - V_{left}}$$

Therefore, if the left wheel is set to move at half the speed (with 50% power, Figure 5), i.e. $V_{left} = \frac{V_{right}}{2}$, we obtain for the outer radius $R_{right} = 2W$.

Table 6. Technology map for description of project 5

Name of the project	**Movement of mBot in a circle, complete with the use of LED lights and a buzzer**
Applied knowledge	*from mathematics*: concepts – circle, length of an arc from the circle, percentage *from physics*: speed, engine power, ultrasonic distance sensor, LED lights, buzzer
Program code for mBot	Figure 6: mBot moves, under certain conditions the LED lights turn red, mBot makes a sound, mBot stops moving
Developing mathematical competencies	Measurement; Ratio and proportion; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Conditional operator, infinite loop, mBot motion instructions, using mBot's ultrasonic sensor for distance, LED lights and buzzer

Based on the data from the ultrasonic distance sensor (Figure 6), decisions are made about the movement and reactions of mBot. If the objects in front of mBot are less than $50\ cm$ away, the LED lights turn red and mBot makes a sound; if they are less than 30 cm away, mBot stops moving.

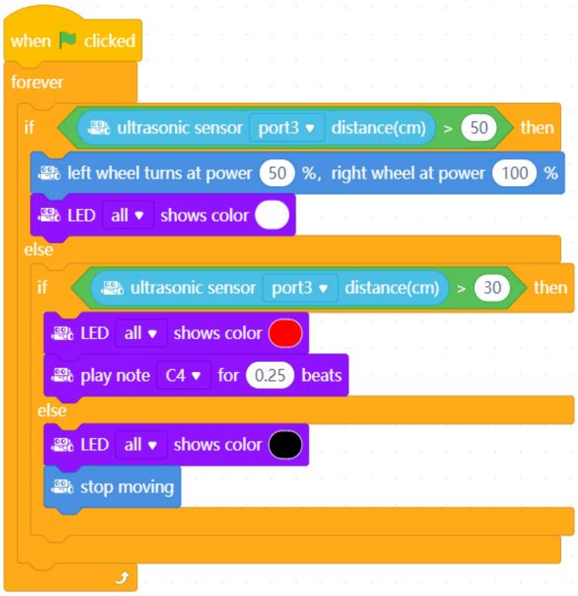


Figure 6. Movement of mBot in a circle, complete with the use of LED lights and a buzzer

Specifically, mBot's movement speed is determined by the distance between it and the object in front of it or the intensity of the light. It is necessary to obtain data in advance and set their relationship with the speed using a functional dependence.

Table 7. Technology map for description of project 6

Name of the project	**Movement of mBot at a speed that varies depending on the data received from its sensors**
Applied knowledge	*from mathematics*: concepts – percentage *from physics*: speed, engine power, ultrasonic distance sensor, light sensor
Program code for mBot	Figure 7: mBot moves, ultrasonic distance sensor result is checked, mBot stops Figure 8: mBot moves, light sensor result is checked, mBot stops
Developing mathematical competencies	Measurement; Ratio and proportion; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Defining and using variables, conditional operator, infinite loop, mBot movement instructions, using mBot's ultrasonic sensor for distance, light sensor

If the distance between mBot and an object in front of it measures less than 30 cm, mBot's movement stops. However, if the distance exceeds 30 cm, it proceeds forward, gradually reducing its speed as the distance to the object decreases. (Figure 7).

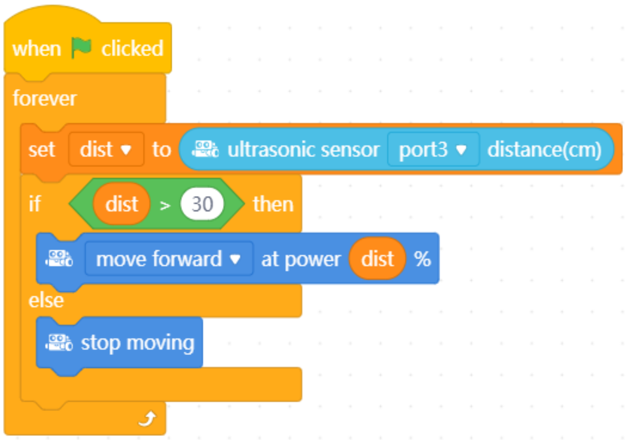


Figure 7. mBot's movement speed is determined by the distance between it and surrounding objects

Using the light sensor, mBot determines the intensity of the light falling on it, and if it is below 500 units, the movement of mBot stops; otherwise, it moves at a speed expressed as a percentage of its maximum speed, 10 times less percentages of the light intensity (Figure 8).

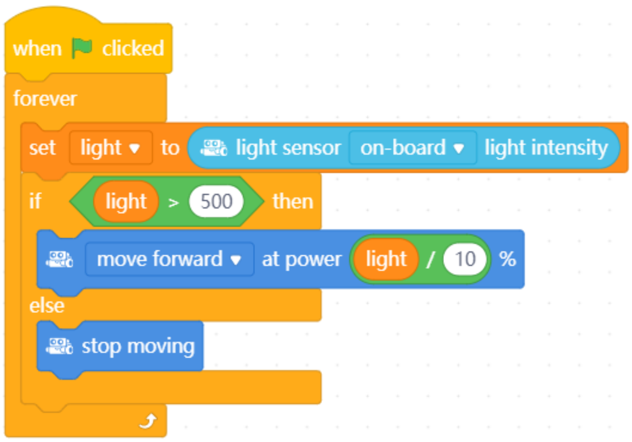


Figure 8. mBot's movement speed is determined by the light intensity

Statistical methods for data analysis are applied; knowledge of the calculation method of an arithmetic mean, median, standard deviation of measurement results and their interpretation is required.

The block *Store* (Figure 9) stores the data received from the mBot's ultrasonic distance sensor. For this purpose, mBot is rotated 10 times, at each position the distance to the nearest object in front of it is found and added to the predefined list *distance_list*.

Table 8. Technology map for description of project 7

Name of the project	**Collecting data from mBot sensors and performing mathematical operations on it**
Applied knowledge	*from mathematics*: concepts – percentages, arithmetic mean, median, standard deviation, arrangement of numbers in ascending order *from physics*: speed, ultrasonic distance sensor
Program code for mBot	Figure 9: mBot measures the distance to various objects and this data is stored in a list; Figure 10: the average value of the distances is computed; Figure 11: saved distances are sorted in ascending order; Figure 12: the standard deviation of the distances is calculated.
Developing mathematical competencies	Measurement; Ratio and proportion; Mathematical thinking; Mathematical reasoning; Mathematical modelling; Mathematical tools; Skills to apply mathematics in other fields
Developing computer modelling competencies	Defining and using variables, creating and manipulation the data structure – list; creating and executing a subprogram, conditional operator, looping algorithm, algorithm for sorting a list of numbers, mBot movement instructions, using mBot's ultrasonic sensor for distance

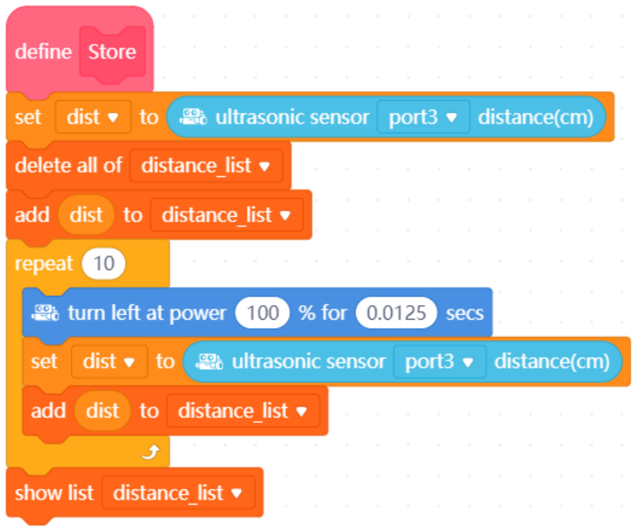


Figure 9. Block for storing measured distances in a list

In the block *Avgof list* (Figure 10), a loop is used to traverse the elements of the list *distance_list*, calculating the sum of the distances stored in it.

The computed sum is divided by the number of elements in the list (length of *distance_list*) in order to find the arithmetic mean of the distances.

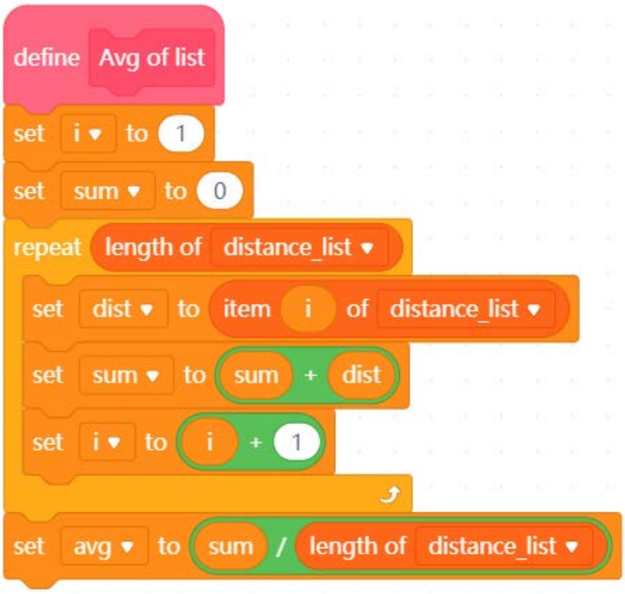


Figure 10. Block for computing the arithmetic mean of the elements of the distances' list

The block *Sort* (Figure 11) implements selection sort algorithm of the list elements (*distance_list*), which consists of the following: the minimum element in the list is found by comparing the first element with all the others; it is exchanged with the item in the first position (via the replace item commands); the above two steps are repeated for each subsequent element.

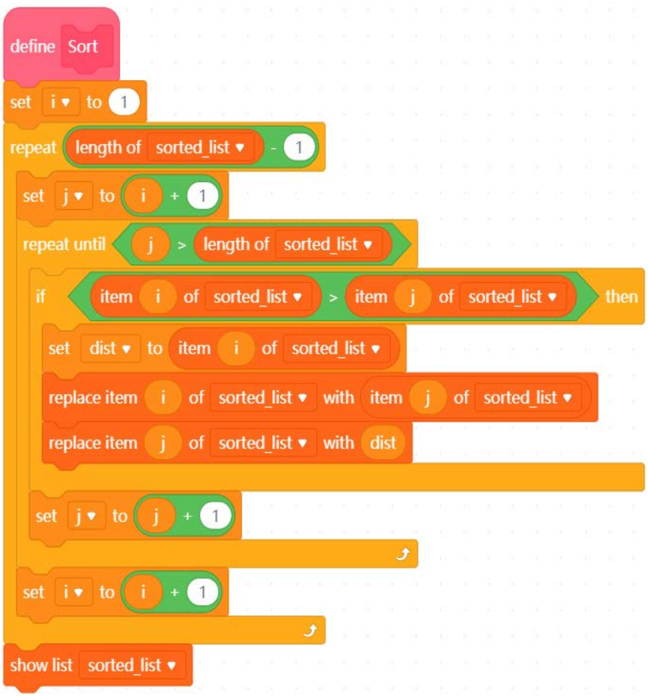


Figure 11. Block for ascending sorting the distances

The block *Compute StDev* (Figure 12) calculates the standard deviation of the distances in the list *distance_list* by finding the sum of the squares of the difference between each value in the list and the average value; this sum is divided by the number of elements in a list reduced by 1; the square root of the obtaining result is computed (the function `sqrt`).

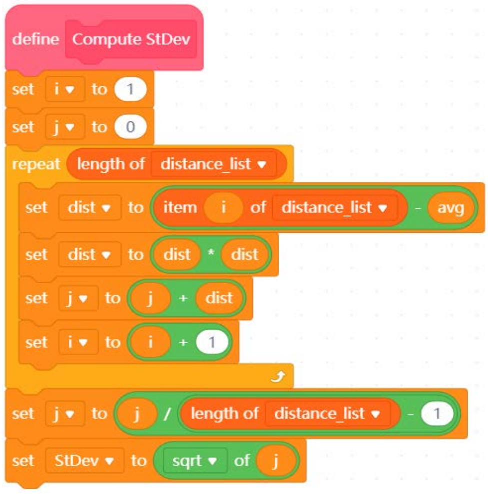


Figure 12. Block for computing the standard deviation of the list distances

The proposed sample projects are published in a git repository and are available at https://github.com/tsvetankageorgieva/mBot to ensure their free future reuse for educational purposes.

When testing the examples, it should be kept in mind that it is necessary to perform measurements of the distance travelled by mBot in 1 s at maximum speed for the particular robot and movement surface. The same applies to the rotation angle from mBot for 1 s. In case of different results, the submitted values should be adjusted to ensure the correct execution of the proposed program implementations.

6. Discussion

The opportunities that information and communication technologies provide are growing and present in all spheres of modern society, reducing the limitations for users in their utilization for learning and development in various fields [39]. Information technology can be successfully applied to support the learning of mathematical concepts even by children in preschool and primary education [37], [38].

In addition, educational robots can stimulate productive, creative, and divergent thinking [36] by building up situations where it is necessary to solve problems; promote creativity, cooperation and communication, learning through experience, application of theoretical knowledge.

The current research is aimed at developing mathematical skills through Makeblock mBot programming for students in junior high school. Furthermore, the proposed projects offer the possibility of advancement for older students, as they can transition from block programming to Arduino C programming.

7. Conclusion

This paper examines Makeblock mBot programming as a possibility to develop students' mathematical skills in the process of learning computer modeling. The proposed projects aim to interact with geometric shapes, solve mathematical problems, collect and analyze data, and mathematically model motion. As a result of performing these activities with mBot, students develop not only programming skills, but also mathematical competences. These skills are critical to their future and success in scientific and technical fields.

In order to support the activity of computer modeling teachers, free access to the implemented projects is provided, as they are published in a git repository. They are limited to the capabilities provided by the base mBot configuration. With additional sensors compatible with mBot, interesting scenarios can be implemented. The subject of future work are the "Meteorological Station" projects to collect meteorological data and analyze this data using a temperature and humidity sensor; "Noise Pollution Monitoring" to measure environmental noise levels and analyze the data collected using a sound sensor.

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