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Образователни технологии

STEM ROBOTICS IN PRIMARY SCHOOL

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Abstract. Robotics has a significant role in modern life. Complex programmable devices are used in high-tech manufactures as well as in many households. More and more people encounter the need to control and program robotic devices. For this reason, STEM education aims to develop such digital competencies in modern students. This article represents the results from a questionnaire held for students from the primary school stage who participate in a STEM education in robotics and assess the activities positively. We suggest three variants of tasks with solutions suitable for the students and for the working process with the robot Edison and programming environment of EdBlocks.

Keywords: STEM; digital competencies; Edison; EdBlocks; primary school

Introduction

Digital competencies are among the eight key competencies recommended for inclusion in modern education by the European Commission's science and knowledge service; they have to be included into the curricula from the earliest age. One of the subjects that develop these competencies is computer modelling. Among the expected results at the end of third and fourth grade are acquisition of knowledge, skills and attitude, associated with algorithms. Such study curriculum usually requires knowledge about a specific block programming environment, digital content creation, analytical thinking development and creativity.

Nowadays robot block programming is an actual solution. The use of such approach in out-of-class activities ensures extra affirmation of the digital competencies, included in study curricula and linked to digital content creation and problem solving in this field. The observation of robot behaviour favours the realization of the steps of an embedded algorithm, the analysis and removal of possible algorithmic errors. Additionally, block programming ensures the familiarization with new environments for programming and digital content creation, as well as the team work development.

Students learn to code in gaming environment by giving various missions to the educational robots, which helps the formation of digital competencies for working with programmable devices. Such devices can be controlled manually or programmatically.

One of the schools that introduced such education for its students is primary school "Hristo Botev" in the city of Plovdiv, Bulgaria. Its realization is happening due to the project of Ministry of Education and Science "Interesting activities". A club named "Little programmers" was created. During the education period of 2018/2019 study year, the students became familiar with the components of the computer system and the application of block programming (Code.org) (Garov & Peykova 2019). Since the 2019/2020 school year the club started with the education with programmable robots, which happens in informal environment and ensures comfort and relaxation to the students. The tasks are usually realized by groups consisting of three students. The used programmable robots are Edison and Bluebot. Each of them has different features and program languages. Since the beginning of 2020/2021 school year the education with Arduino UNO R3 was introduced at the school. During this education the students become familiar with the world of electronics and the possibilities it offers. The participants work in groups and construct different devices according to the tasks given by their teacher.

The club participants fill in a questionnaire that aims to check the level of their motivation and quality of conducted education. The questions associated with the student motivation and their answers are presented below.

Questions: These are not questions, but let us assume they are.

1. I like to visit the club, because the study material is interesting to me.
2. It is a pleasure for me to solve tasks, linked to robot programming.
3. I like the fact that I can understand immediately what I have done when I test the robot behaviour.
4. I like the possibility for sharing ideas associated with the robot programming with my teammates.
5. I feel well when my ideas help the team to solve a given task associated with the robot programming.

The questions included in the surveys cover the pupils' internal and external motivation and refer to the following groups:

For internal motivation

– Cognitive – diagnostics of the desire to learn the new subject matter, stimulated by pleasure and interest in knowledge (Question 1);

– Achievement – measures the pursuit of maximum high result, the pleasure of solving difficult tasks (Question 2, Question 3);

– Self-development – measures the motivation to develop personal abilities and potential within the learning activity, reaching a sense of competence (Question 4).

For internal and external motivation

– Self-esteem – measures the desire for learning, for self-importance and increased self-esteem in learning achievement. Need for respect and self-esteem (Question 5).

The answers of the presented questions for the students' motivation

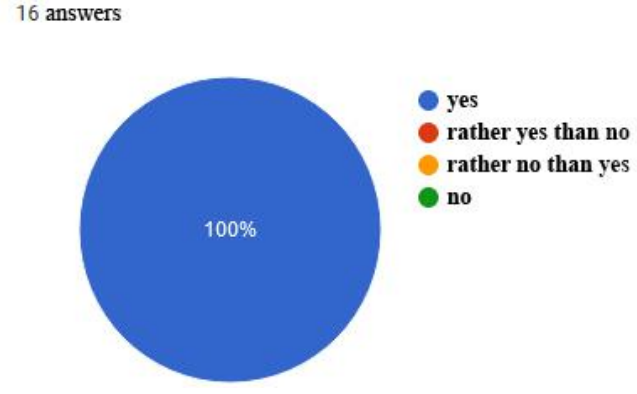

Figure 1. Diagram, presenting the answers of the questions №1, 2, 5

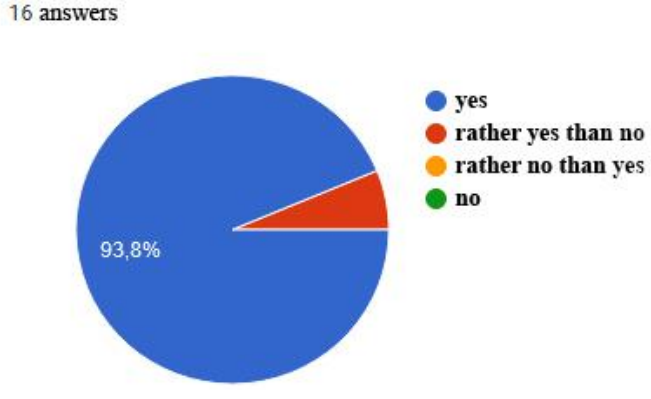

Figure 2. Diagram, presenting the answers of the questions №3, 4

The results show the positive motivation of the students from primary stage of the school "Hristo Botev" participating in the club for education with programmable robots.

The analysis of another part of the questions from the questionnaire shows that the participants are content with the education and highly appreciate the teacher's work and the existing material base of the club.

Programming with robot Edison

The robot Edison[1)] is suitable for teaching students (at the age between 4 and 16 years) in coding and robotics. It possesses sensors, which helps the execution of many specific operations (Todorova – Lazarova 2019).

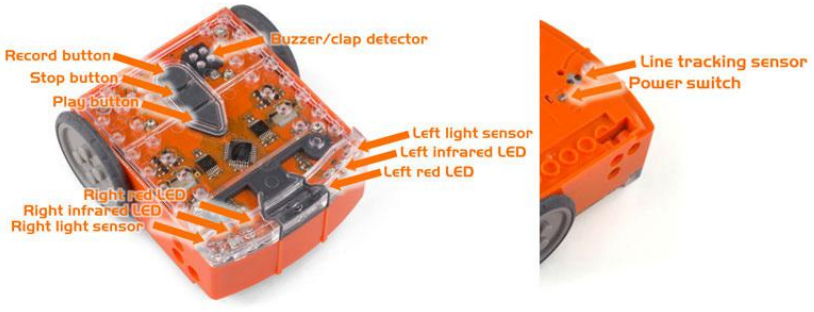

Figure 3. The sensors of the robot Edison

Edison can be programmed to detect and react to IR commands sent from a remote control by pairing the robot to a remote using special barcodes.

Different configurations of the robot can be obtained by connecting separate Lego elements. It can be programmed by several free applications, suitable for different age groups, and barcodes with built-in programs:

– EdScratch – vertical block language for visual programming, based on Scratch. It is suitable for the age group of 10-11 years. EdScratch combines the easiness of "drag and drop" programming with powerful functionality and flexibility. The result is easy-for-learning programming language, which suggests stable platform for education in Computer Science.

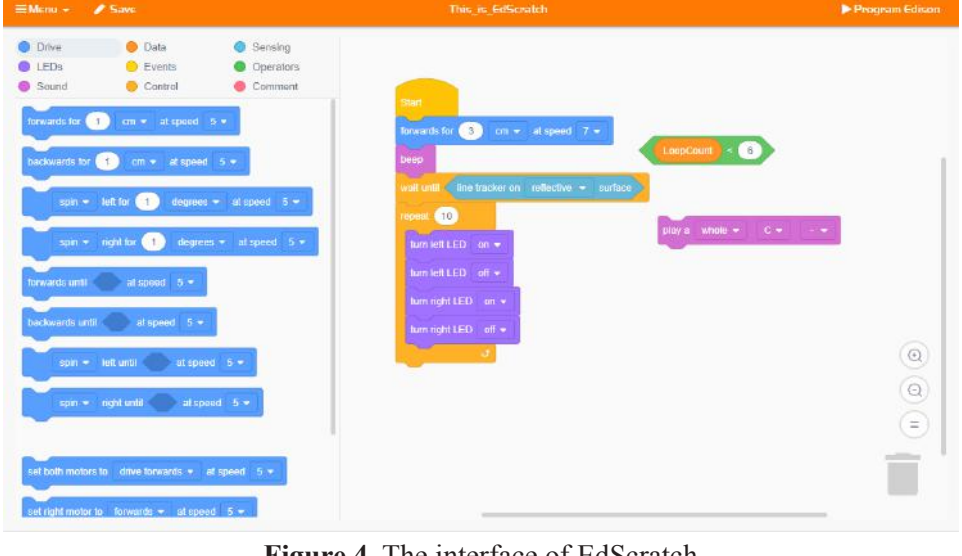

Figure 4. The interface of EdScratch

– **EdPy** – very flexible text-based language for programming of Edison, suitable for the age of 13 years. EdPy is based on Python and makes text-based programming entertaining, while it allows the students to see how the written code comes to life through Edison. With EdPy the students are able to study the core of a real programming language which can help them to raise the level of their study in coding and robotics. The online programming environment of EdPy has a range of functions for helping students to learn text-based programming: Line Help, Autocomplete, Popup help, Help text and examples.

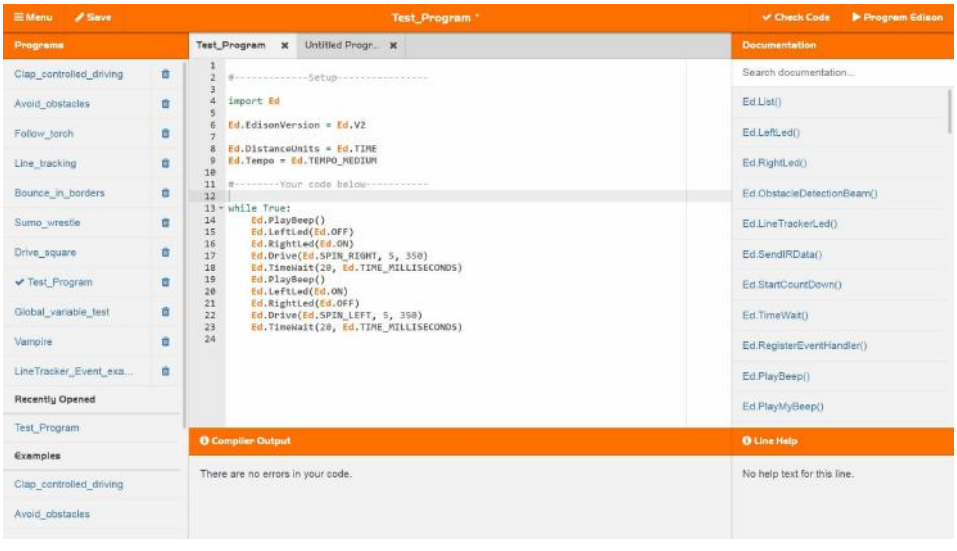

Figure 5. The interface of the programming environment of EdPy

– **EdBlocks** – graphic language used for programming of the robot Edison. EdBlocks is "drag and drop" based system, which is intuitive and entertaining for younger users. EdBlocks is suitable for students in the age gap between 8 and 12 years.

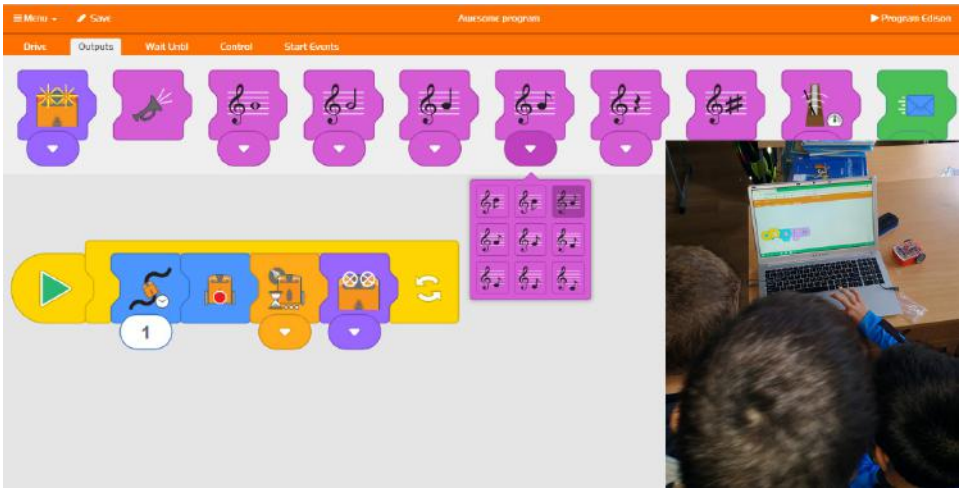

Figure 6. Interface and working with EdBlocks

The online programming environment of EdBlocks is easily used on computers as well as on tablets. It contains more than 150 blocks. All blocks are accessible through the main menu, which is organized in five different categories:

– Drive menu with blocks for motion;
– Outputs – menu with blocks for sound and programming of light signals;
– Wait Unit – menu with waiting blocks;
– Control – menu with blocks for repetition;
– Start Events – menu with blocks for starting.

Each of the blocks is suitable for students from certain age group. There are materials for each application developed specifically for teachers or students. They are accessible at the address https://meetedison.com/robot-programming-software/edblocks/, where the materials for each programming language can be found in section "Lessons". Of course, during the writing of a given code, the teacher helps the students to finish successfully a given task.

The tasks as a part of the used methodical tools

The possibilities which the chosen robot suggests allow the development of tasks, originally categorized by us in the following directions:

– Motion – free motion; limited motion – line, boundary, light, clapping; obstacle avoidance; with the usage of signal devices.

– Sensor devices usage – sound sensor; tracking sensor, IR sensor, reflected light sensor. This type of devices can be combined with motion, signal devices or with the both simultaneously.

– Signal devices usage – sound, lights.
– Communication between robots.

Tasks with different difficulty can be developed in the each of the groups. The tasks presented below are with low difficulty aiming to familiarize the students with some of the main blocks which the programming environment suggests and with a simple behaviour of the robot for an easy error detection and analysis. The application of more complicated robot constructions from the beginning can lead to their misunderstanding and student demotivation.

The coding tasks given to the students include movement, control and interaction with environment. The tasks are suitable for students' analytical and algorithmic thinking development by analysis of a given problem, building logical chains and organizing the logical sequence in the chains for suggesting a final solution of a problem. Additionally, the students develop digital competencies associated with the knowledge about data processing and extraction from different information sources.

The examples are shown below.

Task 1 is a part of a group consisted of easy tasks for free motion and related to the development of competencies in digital device control: defining of accurate and clear commands for sequential moves in a chosen direction, speed control, realization of linear algorithm steps which guarantees the knowledge gain about some blocks and the use of these blocks. For effective differentiation of the speed degree (slow, normal, fast) the task can be preceded with two simpler block variants – one for speed (three possibilities) and one for motion.

Task 1. Find the right block by which you can move the robot Edison ahead for a definite time. Let this time be approximately 30 seconds and the movement speed change at every 10 seconds.

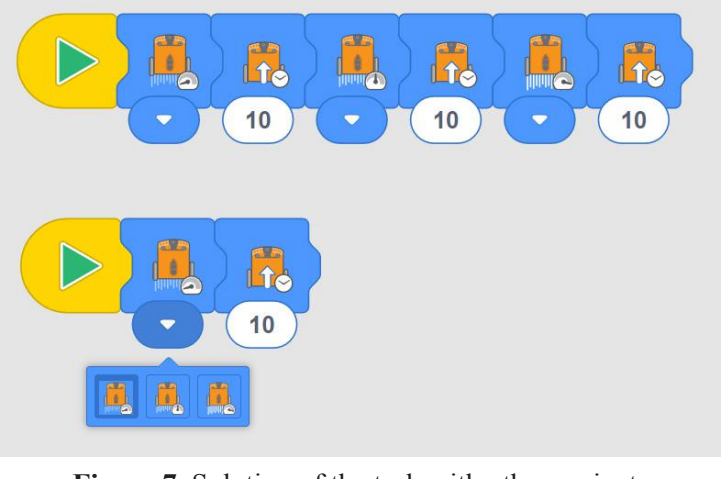

Figure 7. Solution of the task with other variants

Task 2 is a representative of a group consisted of low difficulty tasks for limited motion. This task is a modification of Task 1. It ensures constant linear motion for 30 s and serves as a base for comparison and analysis of the variable speed from Task 1. As a modification, the three blocks can be replaced with one block with duration 30 s or they can be removed, after which an analysis and comments can be made about the robot motion – does it change the speed, can it miss the stop line (bad positioning prediction) and in which cases. The task improves the logical and algorithmic thinking of the students as well as their skills for right dimensional orientation and robot positioning.

Task 2 Create a program in which you include the sensor-tracking block in order to make Edison stop at the black line on the floor of the classroom.

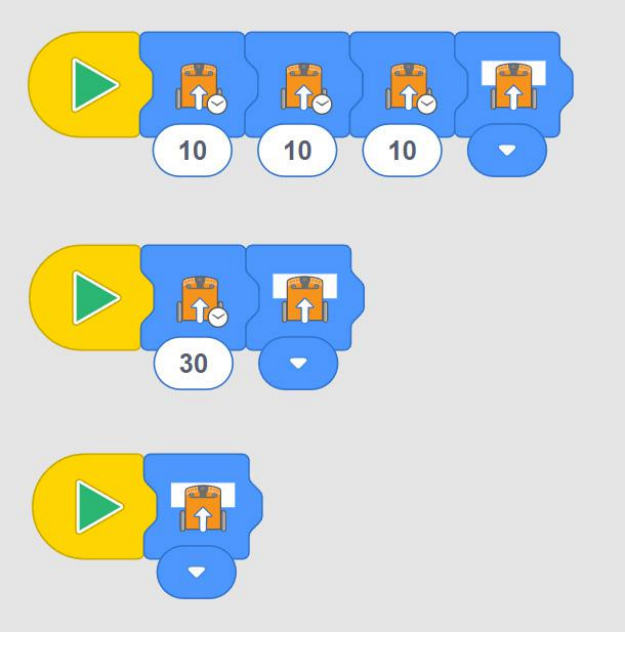

Figure 8. Solution of the task with other variants

Task 3 is a representative of a group consisted of easy tasks for processing of input data obtained from sensor devices and their combination with signal devices. In this case the signal devices detect light. The task doesn't include robot motion. This simplifies the algorithm and the robot behaviour. The aims of the task are the formation of positive attitude to robot reactions and the enhancement of interest for event combination – the use of left and/or right lights, music play and their combination.

Task 3. Create a code to turn on/off the lights of the robot in response to a hand-clap.

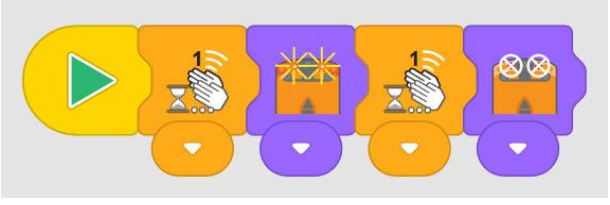

Figure 9. Solution of the task

Learning outcomes

The types of tasks that include a visible response of the robot are suitable for students from third grade at primary school. The immediate feedback from the actions of the robot in a response to the execution of a written code allows the students to analyze the robot behaviour and make corrections if necessary. As a result the students can enhance their dimensional and algorithmic way of thinking in the real environment. The students like this type of practical sessions, which enhance their interest and motivation and make participants to finish practical tasks successfully. Finally, the developed program is uploaded to the robot by using a special cable connected to the sound card of a computer.

Working with robot Blue-Bot

The robot[2)] is developed by TTS Group Company with an educational goal. Looking like a bee, it gives students the opportunity to acquire skills for spatial orientation and programming by using applications in real environment. The robot can be controlled by using its buttons or by an application installed on a computer or a start device with Bluetooth connection. Educational materials, a guidance book for working with the robot, developed applications for OC Windows and Mac can be found at the webpage https://www.tts-international.com/blue-bot-bluetooth-programmable-floor-robot/1015269.html.

The students manage to finish all tasks successfully and if it is needed, they receive a help from a teacher. During the development of a code, the length of the robot step (15 cm) and the ability of the robot to remember to do up to 40 steps must be taken into account. After finishing each step the robot stops and gives a signal light.

Expected results

Our focus is directed to the development of a suitable methodical tool associated with the choice of instrumental means (robot), block environment for its programming and the development of a range of tasks for digital content creation by the realization of algorithms, which encompass and affirm the shown competencies for com-

puter modelling in third and fourth grade. Additionally, one of the aims is upgrading the developed algorithms by the acquisition of specific knowledge for the chosen robot (sensors, possibilities) and skills for their use (turning on/off, data access and processing), which suggests an upgrade with the help of specific digital competencies.

A pedagogical study about finding the benefits for the computer modelling class education from the conducted club education will be made at a later stage.

Conclusion

Working with programmable robots is entertaining and interesting activity for students from the primary school stage, especially if it is a part from the educational process and aims the acquisition of knowledge, skills and competencies in the field of technologies and robotics.

Edison is chosen according to students' age. It can be programmed by barcode and several free applications like EdBlocks, EdScratch and EdPy. In contrast with Bluebot, Edison possesses sensor and signal devices, which help the development of additional specific digital competencies, related to digital data processing and solving problems with the used digital technology. These digital competencies can be viewed as an extension of the learning outcomes from the computer modelling curriculum in third and fourth grade. EdBlocks is a block orientated environment similar to Scratch, suitable for students aged from 8 to 12. This makes students' adaptation to the use of this programme easier. The presented examples are with low difficulty and simple algorithms which makes them suitable for initial familiarization of students with the robot abilities and the access to them, provided by the specific environment blocks. After the acquisition of the main competencies in control and behaviour recognition of the robot the focus can be changed to more complicated algorithms.

The results from the questionnaire, conducted at the end of each study year, show an enhancement of the student interest towards the new technologies and the motivation for learning (Tuparova & Kaseva 2016; Radev 2016).

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NOTES

1. Edison, https://meetedison.com/, last visited on 26.08.2021.
2. Blue-Bot Bluetooth Programmable Floor Robot, https://www.tts-international.com/blue-bot-bluetooth-programmable-floor-robot/1015269.html, last visited on 26.08.2021.

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