EDUCATIONAL ROBOTICS FOR STEM EDUCATION

Deyana Peykova, Kosta Garov

Abstract. *Robotics is increasingly entering all spheres of modern life. Complex programmable devices are available in both high-tech industries and households. Modern people face more and more often the need to know how to control and program robotic equipment. Algorithmic and spatial thinking have to be develop from an early age. The use of programmable toys end robots is particularly effective way for this purpose. Learning robots aims to form digital competence for working with programmable devices. The following work describes good practice in using educational robots at Hristo Smirnenski Primary School, Rakovski and how they help students learn to code in a play environment.*

Key words: educational robots, programming, programmable toys.

1. Introduction

Today, there are many digital tools that help teachers to transform their daily teaching, but there are also new tools and devices that allow them to approach the most complex aspects of existing technologies in the educational field, such as robotics.

The use of robotics in education can be considered from two well-distinguished perspectives. On the one hand, the perspective related to the programming of devices or software and, on the other, that which is associated to the assembly and operation of devices or hardware. Though most robotics educational applications focus exclusively on programming or in subjects directly related to technology, the truth is that they can be applied to a much wider range of subjects, such as mathematics, languages, music, or art. [1]. Robots have the potential to be the next effective add-on to traditional education. The tangibility of robots and he excitement they bring into the classroom environment is considered conducive for learning [2].

Educational robotics is a discipline designed to introduce students to Robotics and Programming interactively from a very early age. It provides

students with everything they need to build and program a robot capable of performing various tasks. The complexity of the discipline is always adapted to the students' age. Educational robotics is included within the STEM (Science, Technology, Engineering and Mathematics) education, a teaching model designed to teach science mathematics and technology together and one in which practice takes precedence over theory [3].

Today there are many educational robots for children and young people. Among the most popular are Photon Edu, Botley, Marti, Artie, Finch, Ozo Bot, Blue Bot, Bee Bot, Edison, Codey Rockey, Lego education. In the case of secondary and higher education, more advanced educational robots help students deepen their knowledge of robotics and programming. Furthermore, high-cost humanoid robots, programmed to teach any subject, are also useful in classrooms because of their ability to capture students' attention and, in robotics and programming classes, they act as the perfect link between theory and practice.

Through play, educational robots help children develop one of the basic cognitive skills of mathematical thinking at an early age: computational thinking. They help develop the mental process we use to solve problems of various kinds through an orderly sequence of actions [4].

As well as developing computational thinking, educational robots promote the development of other cognitive skills among children and young people as:

- learning from mistakes;
- teamwork when they work on group challenge, adaptation;
- creativity – the search for solutions and the freedom to assign new functions to these robots stimulates imagination and creativity;
- self-assessment: by being able to see the results of their actions instantly, without the need for an adult to tell them whether they have done well or badly, students learn to assess their own performance;
- practical applications: applying the mathematical or physical knowledge learned in school motivates children and young people to continue studying these subjects;
- other cognitive skills that are positively influenced by educational robots are responsibility, order and a more optimal development

of spatial perception and relationships between objects.

Another important benefit of educational robots is that they teach children to become familiar with and learn basic programming concepts, a skill that is becoming more and more important every year. According to the European Commission, by 2020 there will be 825,000 unfilled jobs in Europe due to a lack of computer science and ICT professionals [4].

From the academic year 2018–2019, in Bulgaria the third grade students were introduced "Computer modelling" as a compulsory subject in the curriculum. The initial program for this subject is aimed students to gain basic knowledge, skills and attitudes regarding coding. They create computer models of familiar objects, processes and phenomena and experiment with them. The emphasis on third grade students is mastering digital skills, working with files, creating animated projects using condition algorithms and repetitions through a visual block programming environment. The implementation of computer models in a visual environment is prepared with visual materials in a familiar environment for students and the implementation of algorithms with the means of this environment [5]. During the next academic year /2019–2020/ when students were in the fourth grade they learnt as a part of the subject about programmable toys and robots. From the academic 2021–2022 computer modelling is introduced in 5th grade.

In Computer modeling lessons most schools in Bulgaria use Scratch in the regular class but some teachers use different platforms as www.code.org. The website offers a lot of Computer Science lessons for both teachers and students, different labs where students can create apps and courses designed for students in different ages. Each year there is an Hour of code and a lot of schools create their own hack-a-thons [6].

Hristo Smirnenski Primary School in Rakovski, Bulgaria has started implementing Robotics and programming since 2017 when the teachers won Lego Mindstorms EV3 and set the first Robotics club. The same year students won the third place at the annual competition Robo Cup. Then the second club has started in 2020 and the school management board supplies the clubs with another types of robots. This paper describes two programmable robots that are used at the school in order to make coding more interesting for young students – Ozobot and Lego Mindstorms EV3.

2. Use of educational robots

Ozobot

Ozobot is a programmable robot that helps students' computational skills, programming skills, analytical and logical thinking to be developed. It is a small interactive toy that by their sensors recognize the different colored lines. Ozobot is a small robot weighing 17 g, but the robot offers users many options. The first is the use of commands that are a combination of lines of color (color code language). It uses the color black, green, red and blue (Figure 1). Just paper and markers and children can create lines along which the robot runs. Another way to control a robot is to use the website `http://ozoblockly.com/`. The site offers editor commands, which is a bit like Scratch tools, for example. Commands are divided into five groups according to their difficulty. Users can easily compile program monitor and record using light sensors directly into the robot [7].

There are resources and printable worksheets on Internet that can be useful for teachers. The following examples give ideas to teachers how to use Ozobot both with paper and markers and how to program it on Ozoblocky. Some of them are simple and aim to provoke students interest to robotics.

Ozobot Easter egg hunt – the little bot had to collect as many eggs as possible with the help of ozocodes and when it pauses for a few seconds, thars when the Ozobot has collected one egg (Figure 2).

Figure 1. Ozobot

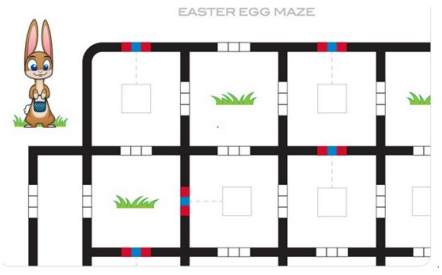

Figure 2. Ozobot Easter egg hunt

Alphabet Practice with Ozobot Codes – students practice writing the letters of the alphabet – with Ozobot codes.

Mapping the ocean floors – students create models of the ocean floor with QR codes associated with each feature. Students then switch maps of the ocean floor and use Ozoblockly to code the path drawn by

another group.

Vasko Da Gama's Route – students create a map of the southern part of Europe, India, and all of Africa. They label the three main countries in this area, and label the two oceans surrounding Africa. They create the route that De Gama used to go from Portugal to India, add a speed color code to signify the length of time this journey took.

More lessons and ideas can be found the the Ozobot classroom online [8].

Treasure hunting

Students have a treasure map and they find a treasure using their own programme (Figure 3). They have a list with instructions saying where the Ozobot stands in the beginning – "Stand backward to the biggest tree and face south". Then there are instructions about movements of the little robot "Go 4 steps forward", "Beware, moving sands! You will overcome them by very fast jumping from the left to the right – zigzag". In order to fulfill the last instructions students program the robot with the code that Ozobot makes this movement. The final instruction says to robot to start digging the treasure by spinning around.

Before using Ozobot on paper, it is necessary to calibrate Ozobot for play on paper.

Another activity than can be done with students is explaining is how the Moon rotates around the Earth. Students choose Moon position and draw the expected trajectory, then they put Ozobot on trajectory and it shows how the Moon is moving around the Earth. Students mark place where the Lunar eclipse, Solar eclipse and Earth eclipse happen (Figure 4).

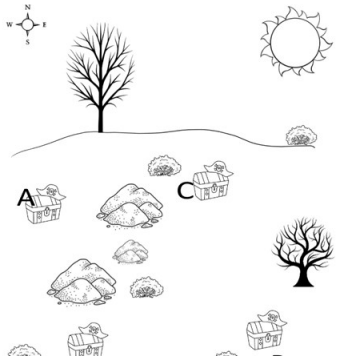

Figure 3. Treasure hunt map

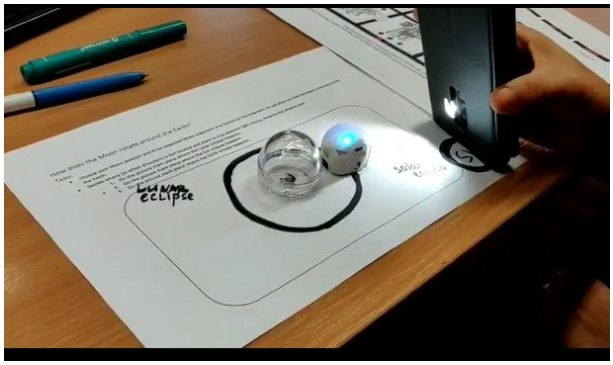

Figure 4. Ozobot shows how the Moon is moving around the Earth

LEGO Mindstorms EV3

This robot is recommended for children over 10 years old. It is a robotics set that includes several sensors, three servomotors and over 500 LEGO Technic components (Figure 5). Using them students can create different robots that can move, shoot, crawl, etc. (Figure 6). It is controlled via a simple and intuitive programming interface [9].

Figure 5. Lego Mindstorms EV3 set

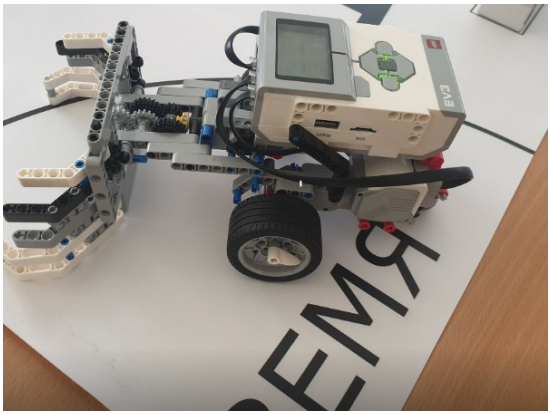

Figure 6. Lego Mindstorms EV3 robot

LEGO robotics allows students to design and control robots by LEGO constructors – a favorite game of many children. This is an effective and fun way for students to learn and apply knowledge in the fields of physics, mathematics, computer science, information technology and even English. With several motors, sensors for light, sound, distance, touch, a powerful "thinking part" and a little imagination from a LEGO constructor, students build a LEGO robot that can do (almost) everything.

LEGO Mindstorms EV3 allows to reach key ideas of STEM disciplines using an easy programming platform. Students are given the opportunity to build design thinking in practice and generate ideas. They easily use LEGO components, designing, testing and building models and solving specific problems in teams.

Students work with hardware and software. They get the chance to experience both the design process and debugging. By working with classmates and teachers, they are encouraged to ask questions and try more advanced programming concepts, such as loops, conditional processes, and variables from different types of data that are appropriate for the more advanced.

They design models as solutions to complex industrial problems with

multiple criteria and constraints. They plan, conduct and share research to analyze scientific principles in various fields of physics and apply science and mathematical concepts to make their ideas work [10].

"Mission on Mars" project

This is a project with Lego Mindstorms EV3 that is held with seventh grade students in Hristo Smirnenski Primary School in Rakovski. The robot performs various missions on Mars: "Saving Martians", "Delivering fuel and water". The goal is to write code to perform as many missions at once!

A working field is designed and printed where the starting point is the Earth. The following materials are needed to build the field: Empty box of Orbit chewing gum; two type D 1.5V batteries; mpty box of Mentos chewing gum, one block for aromatization of toilet; pine – both parts are used; color staples – 15 pcs.; three cut plastic straws; one chocolate dessert Barney; one chocolate dessert Mars – 51 g.; one can of sweet corn – 212 ml; three packs of broth; one insulating tape – 10 m / 15 mm; one ping-pong ball; two lollipops; two plastic caps of non-alcoholic drink 2 l.; one disposable plastic fork; two cans of pate by 100 g; cardboard cup [11].

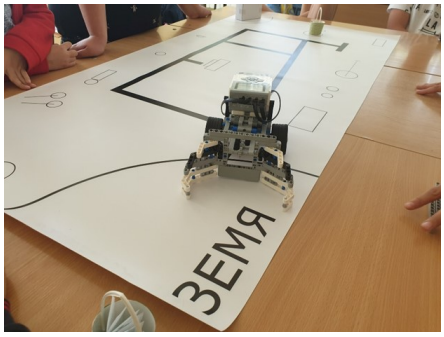

Figure 7. Lego Mindstorms EV3 robot and field

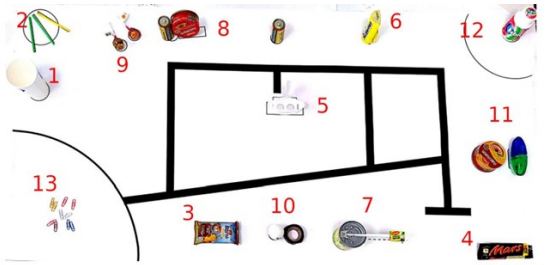

Figure 8. "Mission on Mars" field

Asteroid cloud is the cup, which is located in the field under number 1. The sun's rays are in the field under number 2. The Martian bear is in the field under number 3. Mars must be moved from its original position, number 4, in the enclosure, which is in position number 12, without knocking Orbit off the table and without passed through the base. Transport ship is in the field under number 5. For this mission of the ground (in the base, number 13) are placed 15 paper clips. The points that will be awarded to the team are determined by the number of staples that are inside the

ship after successfully reaching the original position on Mars, located at position number 4. The Pluto caterpillar (located at position number 6) must be rescued, such as remove from the throat and the valuable cosmic materials with which she choked.

Intergalactic station generator is located at number 8. The acting judge will count in the process of complete the mission the number of iterations you make with the pate between the batteries. For one iteration we consider the transfer/rolling of the paste from one battery to its opposite, requiring the pate to touch the surfaces of the respective batteries, without demolishing them. If the battery is out of its original shape, the points made on this mission are still saved, but the mission can no longer to be implemented. Lost Martians are located at number 9.

Through LEGO robotics, children enter the world of programming in an innovative and accessible way. They see the practical application of mathematics and science. They explore how the world around works and get to know the world of new technologies. They develop their thinking, experiment, learn to solve problems and work in a team. They get a better idea of how robots complement workers [11].

3. Criteria to choose the right robot

Here are a few factors teachers to consider for choosing the most suitable programmable robots for the students.

- Educational robots for the right age
  - for students in early age;
  - for upper primary and middle students;
  - for high school students and those who are engaged in Robotics club.
- Type of the robot
  - physically coded robots;
  - introductory programmable robots;
  - computer-programmable robots;
  - kit-based robots.
- Coding language
  - block-based programming language;

  - other programming languages.

- Other

  - Price.

For very young students the most suitable choice is a physically coded robot e.g. BeeBot, These robots are made up of hardware (the physical robot) and software, which is what is used to program the robots. Unlike other educational robots, physically coded robots "hide" the software aspect of themselves from the end user. Rather than using screens and code to program these robots, students use a "physical" means of coding instead [12].

Introductory programmable robots are suitable for primary students. They use some form of programming device separate from the robot itself. This might be an included remote control, but is most commonly a programming application run through either a tablet or a smartphone. An example of this kind of robots is Botley [12].

Computer-programmable robots like Sphero come fully assembled, just like physically coded robots and introductory robots do, but also include more sensors and a more comprehensive range of coding possibilities. This additional capacity makes computer-programmable robots perfect for explicit coding instruction. They are perfect for upper primary and middle school students.

Kit-based robots like LEGO Mindstorms AV3 arrive unassembled. Students need to both build and program the robots themselves. They are ideal for students who already have an interest in robotics and some basic experience using robots and coding and high school students [12].

4. Conclusion

The innovative transformation of the modern technical environment and the updating of the technical activities of the society must be reflected in the content of school education. Teaching should focus on the development of knowledge, abilities and competencies that allow the young generation to be successfully integrated into modern socio-technical systems.

This paper shows the potential for integrating educational robotics into the teaching and learning in the primary school. These good practices are initial steps toward a development of educational STEM programme

at school that can be implemented.

Unfortunately, robotics has been working in the education system for the last few years, but in the form of academies, clubs and other extracurricular activities. It is necessary educational robotics to be included in the curriculum not only as a part of Computer modelling subject but to be integrated into the all subject at school.

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