

Maja P. Nikolova  
Museum of Pedagogy  
Belgrade

УДК 371.39:007.52  
Примљен: 9. септембар 2019.  
Прихваћен: 15. новембар 2019.

## ROBOT EDUCATION

*Abstract:* The development of modern technology and its application in everyday life point to the need to prepare young generations for a new era in which robotics will play an important role. Therefore, as part of the teaching process, robotics is increasingly present in our primary and secondary schools. Namely, the use of robots in teaching allows us to acquire new knowledge through the game, breaks the fear of the unknown in new technologies, develops imagination and creativity and to acquire new knowledge and skills in programming, mechanics and electronics. In addition, the construction and programming of robots represents a motive for further advancement in work as well as in school and out-of-school activities.

The aim of this paper is to point out the need for teacher education to use educational robots in their work. The methodology is based on the previously published experience in this field, as well as on the analysis of the collected data. The results obtained by the qualitative analysis will point out the important place for robotic education in the new system of education.

Therefore, the author of the paper considers that professional development and professional competence of teachers in the field of robotics would have far-reaching influence on the development of the curriculum for teacher education.

*Keywords:* robot, programming languages, imagination and creativity, teachers' competencies.

## INTRODUCTION

Many centuries ago, a learned rabbi made from clay an artificial creature who looked like a man, which was expected to do hard work instead of him and defend him from the enemy. Thus, on the banks of the Vltava, in the 17<sup>th</sup> century, a bulky creature was created, which, after the sacred word *Emet* was imprinted on his forehead, revived. It was named GOLEM. Golem worked amenable hard jobs and became larger and bigger every day. The rabbi was scared that it was going to become as big as universe and wiped the sacred word from his forehead, after which Golem turned into a handful of clay.<sup>1</sup> The moment Golem's behavior

---

<sup>1</sup>In some stories about Golem, at some point it turns against its creator.

went out of control, the rabbi destroyed it, realizing that the adventure of making an artificial being was a mistake. The story of Golem came from the Bible, Psalm 139:16, and symbolizes an unshaped form, while in Hebrew the word indicates a stupid and hopeless creature. In any case, this is one of the first preserved stories of the creation of an artificial being.<sup>2</sup>

During the 19<sup>th</sup> century, with the progress of science and technology, stories about artificial beings appear in literature. The readers were fascinated by a character from Mary Shelley's novel – the artificial being Frankenstein, which became a symbol of contemporary culture and initiated the appearance of a number of novels and stories about artificially created beings that are aggressive, dangerous and evil. At the beginning of the 20<sup>th</sup> century these creatures got their own name – *robots*. In his play “R.U.R.” (“Rossum's universal robots”), performed in 1921, Czech writer Karel Chapek first introduced the word *robot* to describe a creature that does the hard work.<sup>3</sup> With the appearance of Isaac Asimov, before the Second World War, robots got a new dimension – they became gentle guardians of the child in the novel *I robot*. In the decades that followed, since imagination and technology became closely linked, robots became main characters in many films.

A robot is a machine that can move and perform various tasks without human help. The basic characteristics of a robot are movement, perception and intelligence. They are mostly powered by electric motors, equipped with cameras for monitoring the environment; there are ones that are operated wirelessly. Robot movements are complex, and in most cases the mechanical arms and legs are driven by electric motors controlled by computer.<sup>4</sup> The development of computer technology affected the construction of devices as well, hence robots eventually transformed into intelligent robots that can work independently. Electronic brains of modern robots work on the principle of brains of simple animals, and their *mind* is contained in microprocessors on the motherboard. Some robots possess various sensors that simulate human senses – the sense of smell, vision, hearing and touch. There are specialized multipurpose robots, they come in different sizes and with various accessories, allowing them to be used in various spheres of life. The part of the robotics that develops androids, human-like robots, has progressed so much in the past 30 years that in some cases the similarity is quite high.

---

<sup>2</sup>Most ancient mythologies contain mechanical servants or artificial people such as clay Golem from the Jewish legend, a clay giant from the Norwegian legend, Galatea – mythical statue carved by Pigmalion that revived, or Tal – a man of bronze. Greek engineer Ctesibius constructed the first water clocks with movable figures, and in the 4<sup>th</sup> century BC Greek mathematician Archytas constructed a moving bird on a mechanical steam.

<sup>3</sup>In the drama, we follow the rebellion of robots and the disappearance of the human species that is replaced by their conscious products.

<sup>4</sup>There are robots that can simulate human movements, such as the movement of a human hand.

The first mass-produced robots are industrial robots of modest features that performed simple tasks. Initially, their purpose was to assist human beings; today there are stand-alone production machines that are set up in places where people cannot or must not be, due to harmful environment.<sup>5</sup> In 1961, a robot called Unimate, the first industrial robot that was used on a production line, was constructed in the United States. It was set up at the General Motors Company to pour red hot metal needed for the production of cars; it was the first machine that completely replaced an employee.

Robots move on the ground or on the water, cruise through the sky and collect data, explore the universe. Some of them possess artificial intelligence that allows them to navigate independently on remote planets. A robotic vehicle, called the *Mars rover*, and a space robot *Curiosity* were sent to the nearby planet to explore the ground and answer the most important question – is there life on Mars. When they complete their mission, they will be destroyed and will remain on Mars as a testament of a civilization.

Robots are used to help in the home as well – to do vacuum cleaning, mow the grass, cook tea or imitate a pet. Some of Serbian scientists have participated in the worldwide design of a man-like robot that can move, help people in daily activities, and maintain interactions with people in a way that is similar to human.

Unmanned vehicles and drones have found their application in military research, and robotized piano in music. Robots are a popular theme in fine art as well as in the film industry; they are the main characters in many science-fiction films.

Robots are used in laboratories – they can easily repeat the same action countless times, which contributes to scientific research. They are applied in medicine – some specialized robots perform surgical operations and some are used as artificial limbs.

In the domain of using robots for medical purposes, the Institute “Mihailo Pupin” from Belgrade occupies a special place. Immediately after the end of the Second World War, professor Rajko Tomović (1919–2001) began his research in the laboratory for automatic control at the Institute. Together with professor Miodrag Rakić (1923–1998), in 1964, he designed the first prosthetic robotic hand, that is, a prosthesis with external power supply that could squeeze a fist and collect items with outstretched fingers. Although this *Belgrade hand* was never used for medical purposes, it served as a basis for future research.

Professor Miomir Vukobratovic (1931–2012), who left a great mark in the field of humanoid robotics, joined the Institute “Mihajlo Pupin” in 1966. Working at the Laboratory for Robotics, founded in 1967, he studied the stability of bipedal anthropomorphic motion, and the results of his research contributed to the solution of the problem of the movement of humanoid robots. In 1972, professor

---

<sup>5</sup>In 1978, an industrial robot with anthropomorphic figure was made; it is used in our country as well.

Vukobratovic and his team constructed the first active exoskeleton in the world, a kind of a robotic suit, an active mechanical device which served to trigger the limbs of paraplegic and dystrophic patients. The research in the field of robotics brought world fame to professor Vukobratovic.<sup>6</sup>

New scientific achievements find use in everyday life. Being able to create a *new life* or take the role of the creator, men gave robots their role in the society. Robots are expected to be as close to human as possible, so humanoid robots become reality. One of the most famous is ASIMO (Advanced Step and Innovative Mobility), which was made in Japan at Honda Motor Company in 2000. This robot, which is about 130 cm tall and weighs 54 kg, can walk, run, identify objects that move, speak, communicate and answer questions, help sick people, climb stairs, follow the man and welcomes him. It responds to its name and recognizes obstacles.<sup>7</sup>

## ROBOTS TOYS

Mechanical toys that were created during the 17<sup>th</sup> century were the forerunner of today's robots; the first toy robots were winding toys that appeared in the 1930s. These toys were made of metal with painted eyes and mouth and contained pieces of plastic with blinking light. In the 1950s, elements of toy robots were connected by wire to produce certain tones, and in the 1970s battery powered robots appeared, whose legs were driven by an electric motor.

In pre-school institutions in America, children play with robots that move around the room and give dynamics to many games. In this way, the children become familiar with the functioning of a robot and make contact with it, gaining a positive experience. Among American children, the most popular is a robot called RUBI who can, like a child, turn his head and look at a ball that jumps or at a teddy bear. Observing children's play with robots, it can be noticed that children believe that robots have the same or similar "feelings"; there is an effective non-verbal communication between children and robots. While adopting new concepts in teaching, social interactions play an important role, and the interactive relationship between children and robots positively influences the achievement of this goal. RUBI is equipped with a computer on its "stomach", that enables children to acquire some basic information or simply to entertain themselves with the use of children's music. In this way, RUBI becomes a true companion in game and acquiring knowledge.

Toy robots can ask questions and record children's responses, and the analysis of the data allows monitoring the progress of children, as well as the forma-

---

<sup>6</sup>[https://sr.wikipedia.org/sr-ec/Миомир\\_Вукобратовић](https://sr.wikipedia.org/sr-ec/Миомир_Вукобратовић)

<sup>7</sup>Available at: <https://en.wikipedia.org/wiki/ASIMO>, published on 7. 6. 2016.

tion of an individual curriculum that determines what is optimal for a certain age and interests of a child. However, learning with a robot for older children requires a more complex preparation, but due to the popularity of robots among children, it is increasingly present in teaching.

Children's interest and attachment to robots has prompted scientists to explore possibilities of using robots in education. In the case where a robot acts as an assistant or independently works with children, one of the following terms is used: educational robots, robotics in education, educational robotics. The robots used for educational purposes must be adapted to children's age, interest and previous knowledge, in order to be able to provoke their curiosity. Their appearance, functioning, installation and software must be adjusted to children's age. Numerous studies have shown that robots can be a fun platform for learning about electronics, computers, languages and music.

## ROBOTS IN THE CLASSROOM OR LEARNING WITH ROBOTS ABOUT ROBOTS

In the context of new educational technologies, in order to facilitate learning and improve education, educational robots appeared on the market. It should be kept in mind that they, as part of new technologies, are just another new tool that facilitates the process of acquiring knowledge. But their role does not end there – they are also a tool for encouraging important life skills, cognitive processes, personal development, teamwork and competitive spirit.

“Robots are being developed that can teach children at school and at home, supervise their homework, look after them and replace their parents during their busy hours at work or elsewhere. The role of a robot is to teach children, adolescents and students in a certain way, and the number of research studies is constantly increasing, not only in the field of psychology, pedagogy, methodology, but education as well. A robot appears as an assistant to all jobs, as well as in teaching.” (Nikolić 2016: 27)

In America, for many years, primary school teachers use robots to explain, in an interesting way, mathematical problems to students of lower grades, and to teach the basics of programming in higher grades. Professor of mathematics, Seymour Papert, began using robotics in mathematics in the late 1980s, through a specially constructed turtle, which prints different geometric shapes when walking, to introduce students to the basics of geometry. The turtle was operated via computer with a programming language called Logo. In the 1980s, there was a remote controlled robot, which presented various facts related to healthy food in a way acceptable to students.

There are significant differences between generations that lived without the Internet and those who are familiar with robots from early age. Playing and learning with a robot represent a positive transfer of experience that is useful for future life and work; therefore robotics is increasingly present in elementary schools.

Until recently, only the term *computer knowledge* was in use, but with the development of electronics and robotics, a new term appeared – *robotic education*. This new concept includes not only education about robots, but also the process of acquiring knowledge with them. In our country, since recently, there are folding robots, which need to be assembled first, and later to be programmed by computer. Such robots, which contain small microprocessors, are controlled by computer. In order for learners to perform this task, they need to learn the main characteristics, as well as the basics of programming robots. At the beginning, *learning* is based on simply matching different objects from elements in the set, and the obtained forms depend on child's imagination. This first step can include the basic forms of programming or pre-planned instructions that can be performed by a robot. For older children, there are sets of elements that contain certain electronic parts that need to be set up, combined and put into function with the use of a simple programming language. Such robots also contain sensors that allow certain communication with the environment. During the process of constructing a robot, students, in the simplest way, acquire knowledge from various fields such as engineering, electronics or informatics.

The application of robotic technology in the world, even in our country, has been focused on supporting teaching of certain subjects closely related to robotics, such as robot programming, construction of robots or mechatronics. These subjects were mostly present in the curricula of technical schools, or vocational schools for mechatronics technicians. But with the development of electronics, robotics has begun to attract attention of many teachers and researchers from different fields, who, on their own initiative, organize robotic sections or competitions. Using robots in teaching can result in a better quality of acquired knowledge, especially the one related to technical and social skills. At the same time, children's a motivation for technology, robotics and science in general, would be increased.

The literature highlights five important reasons for teaching robotics in schools (Nikolić 2016: 60).

“1. Children find it fun; experience has shown that robotics and video game design are the two most successful ways of introducing computer science into school hours.

2. It is an effective way of adopting programming, because students through programming robots can easier learn how to design software commands. In addition, they learn about the need for precise instructions.

3. Provides useful skills for future employment, because it is clear that in the future, the need for programmers to program mechanical devices will grow more and more. All sophisticated machines require that need, especially future robots that will be present everywhere. They also gain the skills of personal work in the production and assembly of parts, knowledge of tools and their use.

4. It is suitable for children of very different abilities, because it has been proven that robots are particularly suitable for children with autism. These children respond well to peaceful, clear and consistent interactions, just as robots do. In this sense, the NAO robot was the most advanced. There are games for NAO robots specially developed to teach autistic children. Repetitions, predictability and clear emotions are beneficial for such children.

5. Demystification of complex technologies because working with robots breaks the fear of unknown new technologies. In the near future, many jobs that people do will be replaced by robots, and in a relatively short time, some repetitive jobs or occupations will disappear, but there will be offered new creative jobs related to new technologies, especially robots.”

Robots designed for initial learning of programming work on the same principle as other robots, and one of the most famous is a bee robot or Bee Bot. By pushing a specific spot, this robot can be easily programmed with the PBASIC program and can serve as a learning tool in simple games used for learning basic mathematical operations. There are also more complicated robots that can follow the line or light, find the way out of a maze, or communicate with other robots. In addition to this, with the help of this kind of robots young learners can acquire basic concepts from mechanics, programming, physics, informatics and robotics.

In elementary school, robots can be used as tools for learning coding, that is, the ability of students to program different robot functions using the platform. One of the robots that can be used in our primary schools is the M-bot, which is based on the simple programming language Quark, it is connected to a computer wirelessly (Bluetooth or Wi-Fi) and can be assembled in about ten minutes. This robot, which consists of almost 40 parts, can be programmed to trace lines, throw out balls and circumvent obstacles. It is equipped with LED lights, electric motors and distance measurement sensors. The appropriate computer program allows students to program the behavior of the robot which executes the commands following on the data on its board. While programming sensors, students use their knowledge of algorithms, which represents a platform for learning information technologies. The M-bot robot allows the application of programming knowledge; the ultimate goal of the activity is to enable students to construct robots for specific purposes.

The robot with the greatest possibility of application in teaching is the LEGO Mindstorms set that covers a wide array of subjects – informatics, physics, robotics, etc. It is a set of small pieces that look like Lego cubes, but these elements have mechanical and electrical properties. The first Lego set appeared

in 2006 under the name RCX (Robotic Command eXplorer), and the Lego robots that belong to the third generation – EV3, appeared in September 2013. After assembling the elements, a program should be installed on a computer that is connected via a USB cable to the controller or brain of a robot, the microcomputer that controls the system of execution of the actions. The most important parts of this robot are: large motors, medium motors, EV3 controller, touch sensor, color sensor, infrared sensor and infrared remote-control module. These Lego robots are used in the process of acquiring knowledge related to automated processes because they offer some interesting topics and games, which arouses students' interest in robotics.

## USING ROBOTS IN WORKING WITH CHILDREN WITH DISABILITIES

Numerous studies have shown that children with developmental difficulties accept robots as a therapeutic tool. As a result of these research studies, the COSMOBOT robot was designed to be used in treatment of children with disabilities between the age of 5 and 12.<sup>8</sup> It has been noticed that the use of this robot has beneficial effects and longer-term results in therapy. Similar to the CosmoBot, there are robots in the form of stuffed toys, such as the PARO robot, which provides results similar to those with real animals. This robot is programmed to express different moods depending on the way of interaction with a patient; it can even react to a particular name that is repeated several times. It is suitable for working with small children, but also with patients with dementia. It was designed by the Japanese company AIST in early 1993, but was first shown to the public in late 2001.<sup>9</sup>

## ROBOT AS A TEACHER

The only two occupations that cannot be completely replaced by robots are doctor and teacher. However, in the process of acquiring knowledge a robot can serve as a teacher's assistant. Its use has many advantages – e.g. it is full of patience and can repeat the content as many times as necessary. As for teaching young learners, there are robots-teachers with multidimensional features which make learning more efficient.

---

<sup>8</sup>McNickle, M. (2012). 10 Medical Robots That Could Change Healthcare, available at [http://www.informationweek.com/mobile/10-medical-robots-that-couldchange-healthcare/d/d-id/1107696?page\\_number=7](http://www.informationweek.com/mobile/10-medical-robots-that-couldchange-healthcare/d/d-id/1107696?page_number=7), published 12. 06. 2012.

<sup>9</sup>Paro (robot), available at [https://en.wikipedia.org/wiki/Paro\\_\(robot\)](https://en.wikipedia.org/wiki/Paro_(robot)), published 28. 01. 2016.



Unlike adults, who are aware that they are dealing with a robot, children tend to give human characteristics to toys, such as dolls or bears. The researchers believe that robots can be used to encourage the development of children's social intelligence – there are robots that can cry, laugh, frown and yawn. For that purpose, researchers have been working on developing a robot that can recognize the main human emotions and adapt its behavior to the mood of the interlocutor. It changes its voice, facial expression, body movements, and pronounces words.

In the classroom robot is usually used for learning mathematics and foreign languages. A robot programmed for this type of learning should be able to see objects in its surrounding, recognize nonverbal and verbal signals coming from students, monitor their speech, and correct them with speech and gesture. Some pedagogues believe that it is better to teach a foreign language with a robot, because its language is sometimes better than teacher's. Robots-teachers are adjusted to individual needs of students and their level of thinking, which makes the teaching individualised. A child treats a robot as a friend and with its help learns new words and grammar. This is a new way of teaching language, in a pleasant environment and with the excitement that only game can bring (Stanić 2017).

In the process of education it is necessary that teaching materials and methods encourage creativity and activity among students; robots are programmed to stimulate creative thinking and problem-solving skills. In a situation where students work at their own pace, with a minimum of support from their teacher, a robot can be a mentor, a friend, medium or a tool in the learning process.

The most commonly used robot in teaching is the NAO humanoid robot, which can be programmed for learning many subjects. It can visualize objects, forms and faces, recognize twenty languages and memorize unique information about different users. Every interaction with it can be personalized. This robot has a built-in camera at the forefront and has the ability to analyze people's emotions based on their facial expression and tone of voice. It weights 5.4 kilograms, and it was designed in Paris in 2006. Children find it cute and friendly.<sup>10</sup>

## CONCLUSION

Robots have been present in human world for centuries, but in recent decades they have found their place in everyday life as well. They can move, think, speak, simulate human emotions, do hard, boring and dangerous jobs, serve as assistants in therapeutic work and in the process of acquiring knowledge.

As an educational tool, they appeared in the 1980s. They have been in use in pre-school institutions where children can, through games, design and program simple robots that play, move, blink. Numerous studies have showed

---

<sup>10</sup>Nao (Robot), available at [https://en.wikipedia.org/wiki/Nao\\_\(robot\)](https://en.wikipedia.org/wiki/Nao_(robot)), published 14. 05. 2016.

that these didactic toys, among other things, encourage logical and deductive thinking, which later emerges as a positive transfer in the further development of personality.

The use of educational robots in primary schools allows a wide range of scientific disciplines to be presented in an interesting way. In fact, this is one of the most effective ways for the youngest to improve their knowledge of STEM (Science, Technology, Engineering, Mathematics).

Why robots are used to learn about robots, why are the educational robots used in the classroom?

With the appearance and progress of artificial intelligence (AI), the process of education is transforming, which allows using robots in teaching, connected with computers, that inform students in a personalized way. Working with robots promotes creative problem solving, develops curiosity, imagination, stimulates the development of basic communication skills and the ability to cooperate and allows individual learning approaches adapted to the needs, possibilities and interests of students. In order for robots to be part of the teaching process, in the first place, it is necessary to create an educational program that recognizes the individual needs of each child. Such a program enables acquiring of skills and knowledge that are close to child's interest, making the educational process quicker. Also, this would give each child the same chance in education, since students do not wish to learn things they are not interested in or good at. In fact, the use of robots would prepare them for the career they love.

In addition to classic education, robots are also used for distance learning, especially for seriously ill children, or children with autism who are more likely to make friends with a robot than with a teacher.

In our country, educational robotics is a relatively new branch of science. In the 1980s, a series of educational robots called Robed was developed, with an advanced educational software and RC controllers, and they have been used in teaching throughout Yugoslavia. In primary schools, in recent years, in teaching programming and computer science, robots have been in use, assembled and programmed by students. Through game and competition, by assembling and programming robots, children adopt new knowledge and skills.

Although there is a good practice in the world regarding educational robots, there is still a lack of confidence in robot-teachers. Robotics in education has not yet been widely accepted; the benefits of using robots depend on their use in teaching. The way of using robots in the process of acquiring knowledge is more important than any robot. It is certain that the teacher will continue to dominate in the classroom, that formal education will not disappear, but the integration of traditional and online learning will generate a serious change in education at all levels. This will happen eventually, but it will take some micro motivation from all the participants.

Now we can answer the question: Is robot the solution of the maze?

It is and it is not – the only thing that matters is the way of using it, and it depends only on us.

## REFERENCES

Meri, Volmari (2006): Мати Мери, Кристина Волмари, Учитељ постмодернистичког доба – будући изазови учитељске професије, *Узданица*, год. III, св. 1–2, 201–203.

Nikolić (2016): Гојко Николић, Роботска едукација, *Анграјошки власник*, св. 20, бр. 1–2, 25–57.

Stanić (2017): Иван Станић, *Рођење хуманоидне роботике*, Београд: Музеј науке и технике. [https://sr.wikipedia.org/sr-ec/Миомир\\_Вукобратовић](https://sr.wikipedia.org/sr-ec/Миомир_Вукобратовић)  
<https://en.wikipedia.org/wiki/ASIMO>, published 07. 06. 2016.

McNickle (2012). M. McNickle, *10 Medical Robots That Could Change Healthcare*. Available at [http://www.informationweek.com/mobile/10-medical-robots-that-couldchange-healthcare/d/d-id/1107696?page\\_number=7](http://www.informationweek.com/mobile/10-medical-robots-that-couldchange-healthcare/d/d-id/1107696?page_number=7), published 12/6/2012.

Paro (robot), available at [https://en.wikipedia.org/wiki/Paro\\_\(robot\)](https://en.wikipedia.org/wiki/Paro_(robot)), published 28/1/2016.

Nao (Robot), available at [https://en.wikipedia.org/wiki/Nao\\_\(robot\)](https://en.wikipedia.org/wiki/Nao_(robot)), published 14/5/2016.

Маја Р. Николова

Педагошки музеј  
Београд

## УПОТРЕБА РОБОТА У ОБРАЗОВАЊУ

*Резиме:* Развој модерне технологије и њена примена у свакодневном животу створили су потребу да се младе генерације припреме за нову еру у којој ће роботи играти значајну улогу. Као део образовног процеса, роботика је све присутнија у основним и средњим школама. Наиме, употреба робота у настави омогућава стицање нових знања кроз игру, разбија страх од непознатих нових технологија, развија машту и креативност, проширује знања из области програмирања, механике и електронике. При томе, конструисање и програмирање робота представља мотив за напредовање у послу, у школи и ваншколским активностима.

Циљ овог рада је да укаже на потребу коришћења образовних робота у настави. Методологија је базирана на објављеним истраживањима у овој области, као и на анализи прикупљених чињеница. Резултати добијени квалитативном анализом

указују на значајно место које у новом систему образовања треба да заузима учење уз помоћ робота.

Аутор рада сматра да професионални развој и компетенције наставника у области роботике могу да имају далекосежан утицај на развој курикулума за образовање учитеља.

*Кључне речи:* робот, програмски језици, машта и креативност, компетенције наставника.