25-27 June 2019

Zilina - Slovakia

Proceedings of

The International Conference on

Information and Digital Technologies 2019

IEEE

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Experience with Using Robots for Teaching Programming

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***Abstract*— The contribution deals with several robotic activities involving components such as gamepad, IoT Crowtail Starter Kit for micro:bit, micro:bits, mBot Ranger, Kitibot and Sparkfun moto:bit. These robots were used at Extracurricular Computer Science Activity at Computer Science Department, Natural Sciences Faculty, Matej Bel University. The aim is to give our future Computer Science teachers and students of Applied Computer Science an opportunity to teach and gain some experience with kids especially in the field of programming. The project lasts the second academic year and is very popular among people from the department and kids from primary schools as well. Thanks to REGIOgrant, we received funds to buy new robotic and programmable toys. The aim of the activity is STEM programming what includes Science, Technology, Engineering, and Mathematics. We suppose the robots we deal with are suitable tools to teach STEM method and popularize Computer Science among kids in primary school in Banská Bystrica. For future Computer Science teachers, it gives the opportunity to educate kids and work with robots which they can face in their future jobs in schools. Students of Applied Computer Science can achieve experience in teaching programming IoT as well.**

Keywords*— *programming, robot, STEM education, BBC micro:bit.

I. INTRODUCTION

Recently, an increasing number of educators have considered educational robotics as a promising field for applying the embodied cognition view [1]. Researchers and teachers are popularizing Computer Science and its practical usage in Slovakia as well [2-5].

Robotics for STEM is an interdisciplinary emphasizing collaborative learning, and robots have been perceived as a potentially powerful vehicle providing opportunities for construction, experimentation and collaboration between learners [6].

STEM is joining Science, Technology, Engineering and Mathematics what cause natural scientific, technical, analytical and mathematical skills. Moreover, there can be implemented problem-solving, creativity, critical thinking, team working and other skill of the 21st century.

The reason why we focus on STEM learning is mainly because of the probability that in 15 years:

- many jobs will no longer exist because of automatization,
- current jobs will be transformed,
- there will be new jobs,
- 75 % of them will require STEM skills.

Why we should be focused on STEM now?

- 1/3 current 15-year-olds do not have any STEM skills which will be required by employers.
- 58 % students under 25 years study professions/majors which will be changed by automatization.

It is known [7] that STEM learning has positive effects on STEM teachers and their teaching. They understood the mathematics and science better; and felt more prepared to teach mathematics and science. Moreover [8], integrated STEM activities allow teachers to focus on big ideas connected or interrelated between subjects.

II. COMPUTER SCIENCE EXTRACURRICULAR ACTIVITY

We ran a pilot project – Computer Science Extracurricular Activity – in the academic year 2017/2018 directly at Computer Science Department, NSF, Matej Bel University. Based on the success of the activity and 48 taught lessons, the department decided to continue in the next academic year 2018/2019.

There are some updates occurred. We ran the activity not only once per week, but twice per week – based on kids' spare time, they divided into two groups, on Wednesdays and Thursdays. It enlarged because of positive feedbacks and, moreover, it is no cost. Kids can use many innovative aids and educating toys suitable for learning programming. Another innovation is bringing a teaching experience. Until 3rd study year, future teachers (students of our department) have no chance to try teaching in the case of pedagogical practicing. It is a way how to obtain a superior pedagogical practice.

In the winter semester 2018/19, 21 students from the department received a pedagogical experience with the teaching of 47 pupils from several elementary schools within the city of Banská Bystrica. Compared to the previous academic year, 7 students from the major of Applied Informatics joined this year in addition to future Computer Science teachers. These students had the opportunity to try a teacher's profession, which they would not otherwise have the chance to.

III. PREPARATION FOR TEACHING WITH ROBOTICS

The REGIOgrant realised by Živica supported us by the cost of 500 €. The aim of our workshop was to provide knowledge of STEM learning. Firstly, we purchased micro-bit board accessories (2 x programmable driver, Sparkfun moto:bit), robot mBot Ranger and Kitibot. All the funds we received, were used to buy the robots.

Figure 1. The robots we use to teach programming.

The preparation itself consisted of making the robots and the programmable Sparkfun moto:bit. Originally, we wanted to prepare a workshop of robots where kids can build robots by themselves. What we found out was the robots consist of a large number of small components (and instructions in English). Finally, we decided to build it by ourselves.

The most demanding part for us was the creation of learning materials (teachers' resources) for purchased robots (see Fig. 1) and accessories for the micro: bit educational board.

IV. TEACHING WITH ROBOTICS

In the winter semester (September 17 – December 14, 2018), the learning process at the Extracurricular activity focused on teaching programming, mainly by the STEM method. In both activities (Wednesdays and Thursdays), kids were divided into groups of up to four pupils. In each group, at least one student from the Department of Computer Science, Faculty of Natural Sciences, Matej Bel University, was in charge of teaching through the assigned device. The provided method is partly transformed and based on voluntary participation, but the center is a team-teaching, a group of kids taught by at least 2 teachers who collaborate between themselves.

A. *Gamepad for micro:bit*

The first group had accessories to the BBC micro: bit - joystick and colour display board. BBC micro:bit is a programmable board that includes 25 red LED diodes, two buttons, accelerometer, compass, radio and bluetooth antenna. With these educational boards, students have the opportunity to work with the Meet and Code initiative and the SPY o.z.

BBC micro:bit can be programmed with JavaScript, Python, and Scratch-like programming languages. The advantage of this educational board is the possibility of connecting a variety of devices to make the educational board even more attractive to pupils. The first task was to connect the extension of a joystick and a colour display extension to an educational board. When talking about the colour display extension, the task was to display different numbers, words, dots and lines. More exciting extension for them (based on the experience of observation) was to create their own joystick. Kids were given the task of programming the actions that are done after pressing all the buttons (each button had to do another action). Because of their previous experience with BBC micro:bit, there was no problem for students to program actions to press keys A, B, C, D, E, F. The trouble was to program actions like joystick movement (we assumed that this action will be too difficult for kids and later on, it turned out we were right, the student assigned to their group (the lecturer) explained to them how it works – which blocks they should use and why.) The output of this group were two programmed joysticks with various activities (see Fig. 2) that appear when the button is pressed, and the joystick moves (writing words, letters, smileys and arrows in the case of joystick), rendering lines and text to a 1.8-inch screen. Kids began to program the snake game (the popular game on keyboards) and its control via the controller, but due to the lack of time, unfortunately, they did not complete this activity.

Figure 2. Gamepad on the left and color display on the right in the use.

More interesting and useful task was to create something that could be used in the real world. That is also the aim of STEM. For 1.8inch BBC micro:bit display kids suggested to program it like a banner which can be found next to roads..

Identify applicable sponsor/s here. If no sponsors, delete this text box. *(sponsors)*

Banner display two advertisements with a different text 2,5 seconds each. Fig. 3 shows the source code of the banner.

Figure 3. Source code of 1.8inch micro:bit LCD.

Another group of kids from primary school decided to program a gamepad for controlling the movement of Sparkfun moto:bit (chapter D). The fig 4 shows the source code of the gamepad. After interaction with buttons or joystick BBC micro:bit sends an "encrypted" data to another BBC micro:bit that is set on the same radio wave.

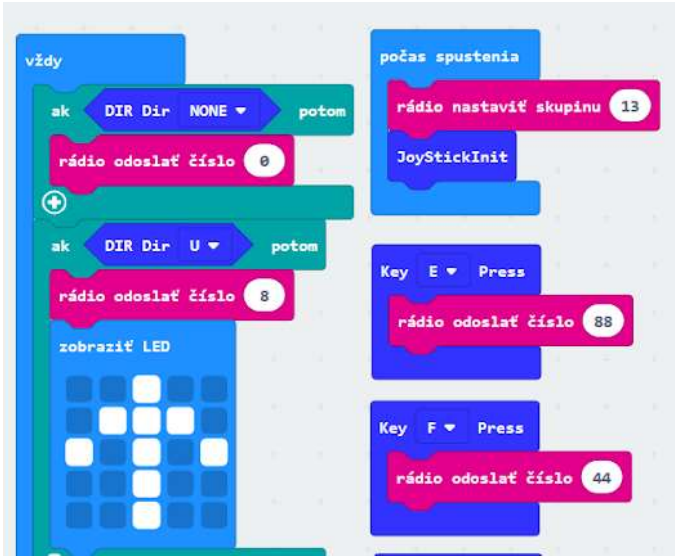

Figure 4. Example of micro:bit gamepad code.

B. *The IoT and micro:bit*

The second and third group were working with BBC micro:bits with pins and thus to the creation of IoT devices. The term Internet of Things (IoT) is an increasingly popular term and is gaining more and more fans not only in the field of computer science. These years, the most common use of IoT is the Arduino microcontroller. The device is very popular, unfortunately, we think it is not so appropriate for teaching at elementary schools. Using BBC micro:bits and extensions to IoT (cables, buttons, LED diodes, etc.), you can create your own IoT device. We bought two sets thanks to REGIOgrant. Using the Elecrow Basic Kit for BBC micro:bit the pupils were programming to turn on and off the LED diodes via BBC micro:bit buttons (buttons A, B) and also started to program the semaphore principle (sequencing change of LED diodes - red, orange and green). Fig. 5 shows the code of IoT semaphore. The principle is:

- **Digital write pin P0 to 1 -** light the red LED and pause 10 seconds, then turn it off and wait 1 second,
- **Digital write pin P1 to 1 -** light the orange LED and pause 10 seconds, then turn it off and wait 1 second,
- **Digital write pin P2 to 1 -** light the green LED and pause 10 seconds, then turn it off and wait 1 second.

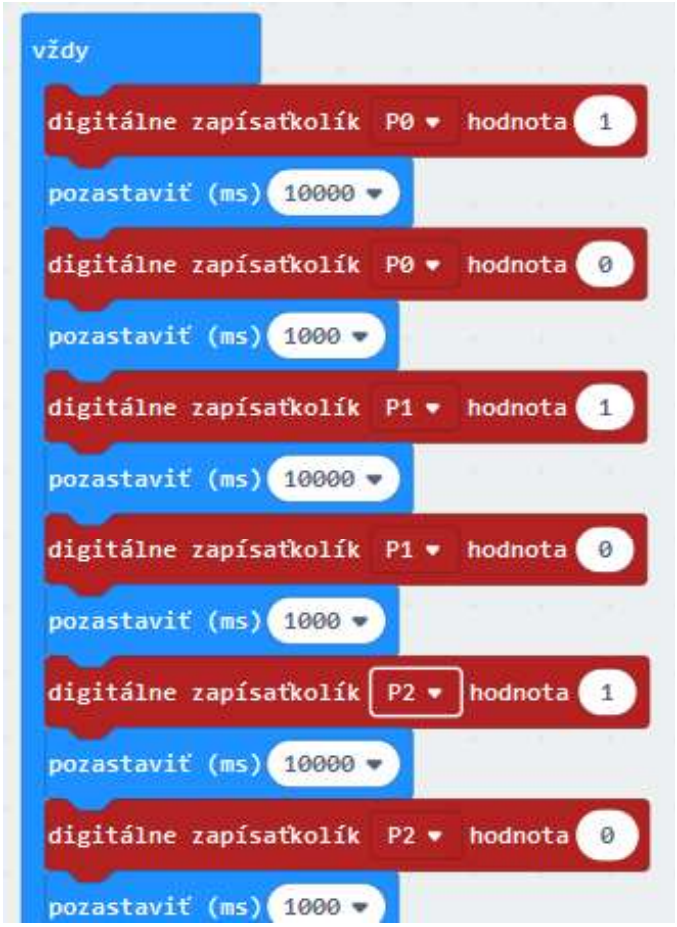

Figure 5. The code of IoT semaphore.

Fig. 6 shows the programming of micro:bit IoT semaphore.

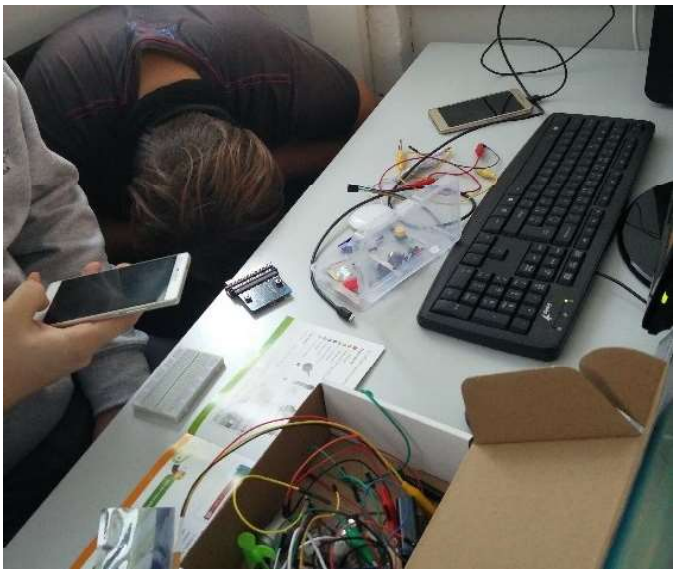

Figure 6. Programming the Elecrow Basic Kit for micro:bit.

The third group used the IoT Crowtail Starter Kit for BBC micro:bit which is similar to the previous set, but a little easier (because we do not have to connect so many cables). The second group used materials that we received as a supplement to the IoT set, and the third group used the materials created by a Computer Science student (the lecturer of the activity) based on his bachelor thesis (other materials to this set are still in progress of creating). Fig. 7 shows the Crowtail kit for BBC micro:bit during the programming process (using a motion sensor to detect movement and then signal it with the buzzer).

Figure 7. Crowtail kit for BBC micro:bit.

Fig. 8 shows the code of motion detection.

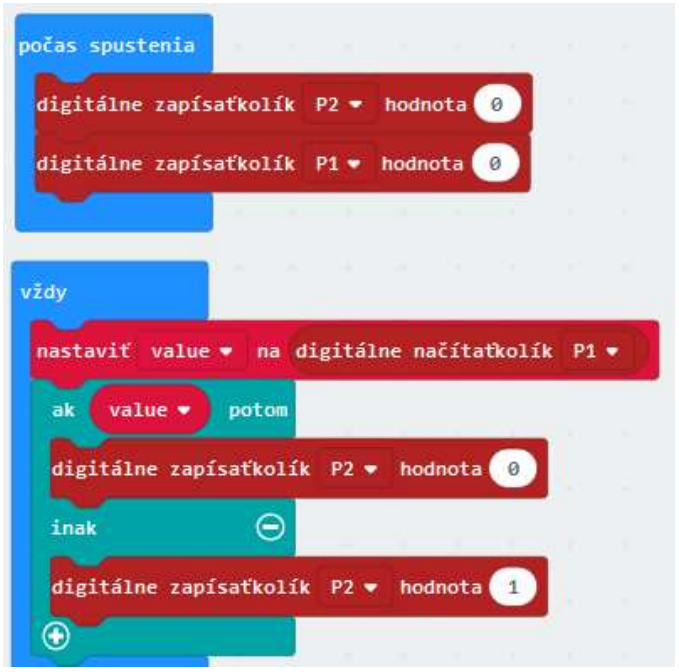

Figure 8. Crowtail kit – source code.

C. *mBot Ranger*

The fourth group was programming the robot mBot Ranger. This activity was among the students most popular. The robot looks like a tank and can be programmed directly via smartphones. In the case that not every pupil who visits the activity has already had the opportunity to try out and control the car, or rather to say a drone with the remote control by a mobile device, the first task was to learn how to control the robot. Before testing, students had the opportunity to get familiar with the hardware part of the robot (how it is made, what components are seen and what their names are etc.). The advantage of this robot is the ability to create your own mobile phone environment - the appearance and components of the joystick. Individual components can be programmed using blocks (the Scratch language). The pupils were given the task to program simple robotic activities, e.g. a button to take action "go ahead at a certain speed, wait 5 seconds, turn right, light up with a certain colour, etc.".

Fig. 9 shows the created gamepad environment, which consists of 4 buttons, a joystick and a slider button.

Figure 9. Gamepad environment.

Fig. 10 shows that drag-and-drop blocks are divided into the following categories:

- **Begin** - what happens when the button is pressed/released, power on/off
- **Move** - move, turn, rising, roll, shake, hover and landing drone.
- **Display** - set LED or play a note.
- **Event** - shake tablet, switch on/off tablet, tilt tablet.
- **Detect** - slider value, read gyro value, temperature, battery level
- **Math** - mathematical operation (addition, subtraction, Boolean value, change item, round, random integer, etc.)
- **Controls** - if condition, wait, repeat, break the loop, etc.

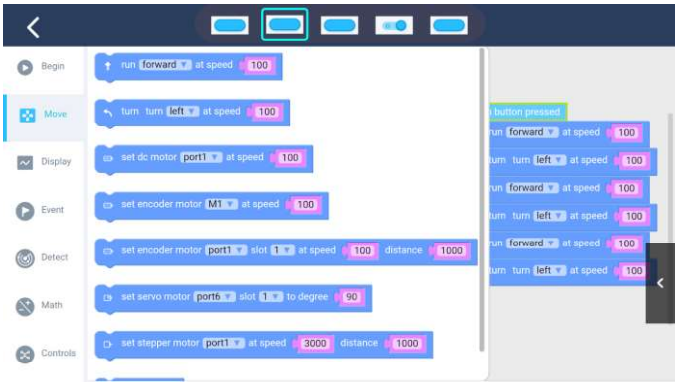

Figure 10. Drag-and-drop blocks.

Fig. 11 shows code result of a programming task for mBot Ranger. In this task the pupils have to use variables and mathematical operation. The task is to create behaviour of a button – after the button is pressed the random number between 1 to 10 is generated and saved into a variable. If the generated number is even then the LED of the mBot ranger is to display to the green color and the robot is moving forward. If the generated number is odd then the LED will be red and the mBot ranger is moving backward. After the task is done, then there are various types of continuing with this behaviour - for example the change behaviour of moving mBot forward/backward to obstacle avoidance (even number) or following lines (odd number).

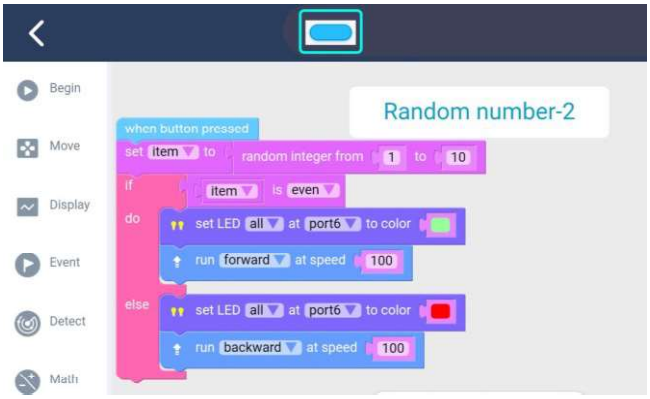

Figure 11. Programming task – Random number.

D. *Sparkfun moto:bit*

The fifth group has been provided with Sparkfun moto:bit (see Fig. 12) that requires a BBC micro:bit educational board for programming. The moto:bit offers robot controller capable of operating a basic robotic chassis. Onboard each motorcycle:bit I / O pins are capable of hooking up servos, sensors and other circuits.

Like the previous group, the students have programmed a simple robot and a programmable car moto:bit action.

The kids developed behaviour of controlling moto:bit with gamepad:

- **controlling moto:bit with joystick** - move left, right, forward and backward,

- **C button pressed -** turn motor on and move it with the speed 100 %,
- **D button pressed -** turn motor on and rotate car left with the speed 50 %,
- **E button pressed -** turn motor off,
- **F button pressed -** turn motor on and rotate car right with the speed 50 %.

Figure 12. Programming Sparkfun moto:bit and testing it with the joystick.

For the controlling, there was used a gamepad for BBC micro:bit from the kid's code of the first group (chapter 4 A). Fig. 13 shows the source code of moto:bit.

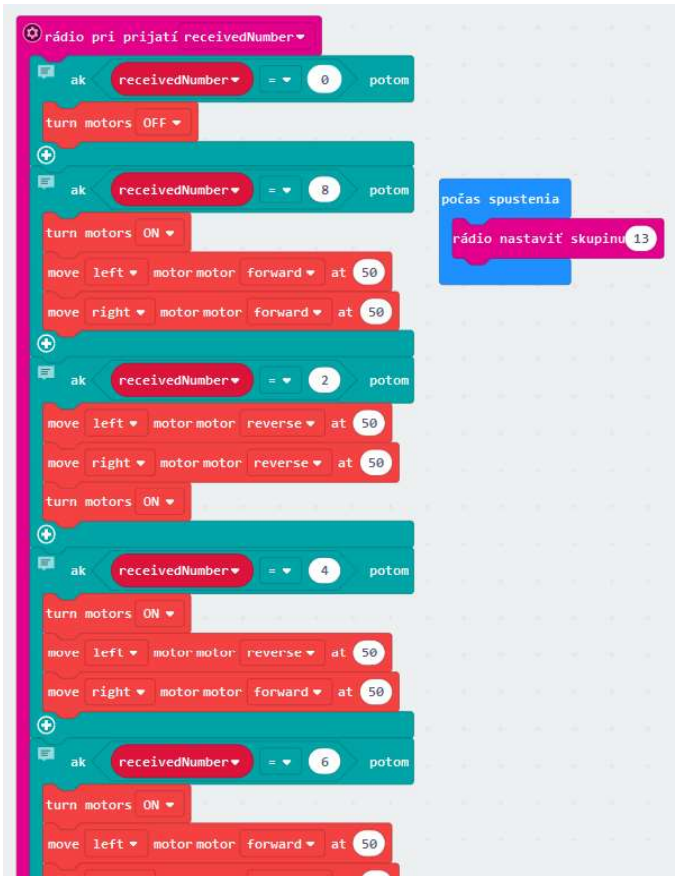

Figure 13. Sparkfun moto:bit source code.

V. Feedback

We obtained some feedbacks from the kids:

"I really liked it and enjoyed it very much. I think I am not so good at programming but what I miss, is my own lecturer I am always working with"

"Well, we were learning to program BBC micro:bits, they were joined with joysticks... but we had to program it in a couple ... and I was working with a guy."

"I'd love to program a bigger robot."

Feedbacks from the future teachers (lecturers):

"Together with Marek, we were teaching two boys. One of them came to the activity and told us he will do nothing, and he is bored. We think it happened because parents forced him to attend this extracurricular activity. Another boy worked well and he obviously enjoyed it. In the end we walked to the hallway with Mirka, where they controlled the robot via their cellphone."

"I was working with mBot and it was great, but we had a problem with batteries first, because they were not all well-charged. Kids enjoyed activities."

Moreover, we received a feedback from the qualified teacher who attend the activity with her kids from her primary school:

Did you like a workshop?
I liked the workshop. Pupils enjoyed being able to work with robots and drones which they do not have at school. By working in small groups, it turned out that each pupil could actually try something out to program or control a robot.

How did you like robots?
They were very interesting. With some I met for the first time at the workshop. It is interesting to see what can be done in schools for kids at affordable prices.

Do you think the pupils were interested?
I think my pupils were interested :) They did not want to go home.

Are these robots suitable for you to teach or use it at your school?
I think the majority of robots are suitable. It is possible to verify whether they understand what they have learned. Because they can immediately see and check robot movements. Practicing logical and algorithmic thinking (how to program the most effective program) is the aim of this activity.

From the obtained feedback, we can summarize both kids and lecturer enjoyed activities. Lecturers were much more

critical than their students. We suppose it happened because they had plans they wanted to follow and not every time it was successful. We think it is important to accept situations like these just happen in a teaching profession.

VI. Conclusion

Future Computer Science teachers and students of Applied Computer Science attended the Extracurricular Computer Science activity focused at robotics at the Computer Science Department in Banská Bystrica. We purchased robotic and programmable toys thanks to REGIOgrant funds. The aim of the activity is also a STEM which is taught with certain robotic toys. Attendees are kids mainly from the lower-secondary schools who can program the robots with cooperation of the department students (lecturers) in the small groups. We used various robotic tools – gamepad, The IoT set, BBC micro:bit, mBot Ranger, Sparkfun moto:bit, Kitibot. Based on positive feedbacks from primary school pupils, parents, teachers (from the Research Night), students from the Department of Computer Science, NSF MBU, we plan to continue with such activities and also we would like to expand the hardware of the department so that our students (especially future Computer Science teachers) will have the opportunity to use the newest technologies which are also used in abroad and to prepare future Computer Science teachers to their future jobs.

Acknowledgment

This contribution has been processed as part of the grant project Implementation of Blended Learning into Preparation of Future Mathematics Teachers, project no. 003UMB-4 / 2017th and project Interactive Applications for Teaching Mathematics at Primary Schools, project no. 003TTU-4/2018.

References

[1] A. Merkouris and K. Chorianopoulos, “Programming touch and full-body interaction with a remotely controlled robot in a secondary education STEM course,” Proceedings of the 22nd Pan-Hellenic Conference on Informatics - PCI 18, 2018.

[2] E. Klimeková, et al., “Case Study on Physical Computing with NodeMCU on Summer School,” International Conference on Robotics and Education RiE 2017, 2018.

[3] G. Lovászová, V. Palmárová, “Location-based games in informatics education,” International Conference on Informatics in Schools: Situation, Evolution, and Perspectives, 2013.

[4] M. Cápay,:” Engaging games with the computer science underlying concepts, Interactive Collaborative Learning (ICL),” International Conference on. IEEE, 2015.

[5] J. Fialová, “Tvorba a využitie aplikácií pre mobilné telefóny v školskej matematike,” EME Proceedings, 2018.

[6] D. Alimissis, “Educational robotics: Open questions and new challenges,” Themes in Science and Technology Education, 2013.

[7] K. Fulton, T. Britton, “STEM Teachers in Professional Learning Communities: From Good Teachers to Great Teaching,” National Commission on Teaching and America's Future, 2011.

[8] M. Stohlmann, T. Moore, G. Roehrig, “Considerations for teaching integrated STEM education,” Journal of Pre-College Engineering Education Research (J-PEER), 2012, 2.1: 4.