Introducing Programming to Basic Schools Students Using Robotics

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Abstract. The present work reports on the development of programming activities with students from the 1st and 2nd cycles of schools in the town of Braga in the northwestern Portuguese region of Minho. These activities of promotion of computer programming were applied in order to promote the programming and innovative practices on science and technology education. The explored interdisciplinary methodologies in STEM teaching-learning processes, stimulate critical thinking and creativity while promoting the benefits of learning in collaborative environments.

The active involvement of the students in these robot programming, "high tech" and trendy, activities is easy to achieve if the proposed challenges are set at an adequate level of difficulty and appealing enough to the age group and level of cognitive development of the student. Whenever possible to the students is given the possibility of chosing or even defining the problem/subjet they will be exploring by programming a robot, which is seen as a mechanical artificial being the students will be able to understand, interact with and use and control.

The teacher/educator should be available to provide to the students a proper empowering environment and to provide all support requested by the students giving, as much as possible, not straight answers but yes clues and small hints and examples leading the students to reach, themselves, to a solution to the problem the students face or to an answer to the students' question that satisfy their own critical judgment.

Through the programming testing process, it is possible to verify and see the level of perception and proficiency of the students assessing what students have learned and accomplished, creating immediate feedback for students and adjusting or re-orienting the students' focus on a particular task or reasoning process.

If well succeeded these activities can develop among the students a sound appreaciation towards Science Technology and Engineering while establishing relevant knowledge, creativity critical reasoning abilities and a large number of other competencies that will be valuable for the future development of the students in their studies and academic life but also in their future careers.

The improvement of the self-esteem of the students when they realize they can actualy "do it" is also a major benefit of this type of activities. As well in what concerns the boost of the self-esteem and selft-appreaciation of their teachers and educators, that often fear to explore this type of innovative approaches.

Keywords. Programming, STEM, Robotics, Hands-on, Creativity.

1. Introduction

The teaching of programming is being a clear concern for the implementation of educational measures, as one of the fundamental skills for living in the 21st century.

Automation and robot programming are increasingly important in our modern societies and exploring ways to introduce it in the formal and or informal and non formal education is being done for several years [1-5].

Constructivist, inquiry based, problem solving, hands-on and other student centred active pedagogic approaches are being extensively and successfully used in science and STEM education including at early ages [6].

The introduction of robotics as "tool" in the process of learning the basics of science and technology in basic schools or even at pre-school level is also being tried with success in different approaches [2-5].

2. Educational Robot Programming

Gonçalves and Freire in 2012 defined robotic programming in education by saying it can be characterized as "a work environment,

where students have the opportunity to assemble and program their own robot, controlling it through a computer with specialized software. The student becomes a builder of knowledge, through observation, practice itself and the collaborative work that arises between teachers and students" [5].

Figure 1. The NXT Smart Brick of the Mindstorms NXT 2.0 LEGO robotics kits

Experimental studies indicate that learning processes based on problem solving, using programming logic, show an increase in brain areas, reasoning ability and concentration of students [7].

Different robots and programming languages exists are being used with pedagogic purposes [1,4]. Among those LEGO Mindstorm [8-9] became particularly popular are extensively used.

For the work herein reported Mindstorms NXT 2.0 Lego's robotics kits were used. The CPU of the NXT 2.0 robot, the central element of the robot, is the NXT Smart Brick (Fig. 1) with an ARM7 microcontroller already successfully tested for years with RCX (Robotic Commander Explorer) centrals. The new control brick have upgrades that allow the use some of the current technologies, such as Bluetooth connections. It has a 32-bit ARM7 Microprocessor, with 256 kb of memory; USB 2.0 port; 4 input ports; 3 output ports; a 100 x 64 pixel LCD monitor, a speaker and a rechargeable battery.

Sensors and actuators are connected to the central block of the NXT Smart Brick, the 4-Port (input), with RJ12 inputs. Ports A, B or C (output) can be used with RJ12 cables connected to 3 servo motors. For graphical programming, it is possible to use the native environment that comes with LEGO Mindstorms NXT 2.0 robot kit, called the NXT-G language. Alternatively other programming platforms such as Java (leJOS), Python (NXT-Python) or C (NXC) can be used. ADA (GNAT GPL), Forth (pbFORTH), Lua (pbLua) and Visual basic (using COM+ resources), can also be used requiring a replacement of the original firmware provided by LEGO Mindstorms, with the firmware of the desired platform.

For young students graphical programming is far easier and more adequate (Fig. 2). The use of the NXT graphical programming tool appeals to the young students with its commands, simple or more advances, represented by graphical blocks that the student will place on the programming board connected in a proper sequential way.

Figure 2. 1st grade classroom discussion of the programming of a robot

3. Implementation

The robot programming activites were performed at two 1st and 2nd cycles schools in the town of Braga in the northwestern Portuguese region of Minho, Externato Paulo VI school (first cycle) and André Soares School Group (second cycle).

The study took place in the school years 2018/2019, 2019/2020 and 2020/2021 and involved students 7 to 11 years old. The activities were carried out using four NXT 2.0 robot kits provided by the Associação Hands-on Science Network. Different programming and construction activities were introduced and developed at different paces and depth levels:

- Manipulation and assembly of legos pieces in order create small objects and simple constructions as training to the building of a moving robot (or a robot with moving parts).
- Programming a robot directely from the physical interface of the NXT Smart Brick Central Block, with visualization on the existing LCD.

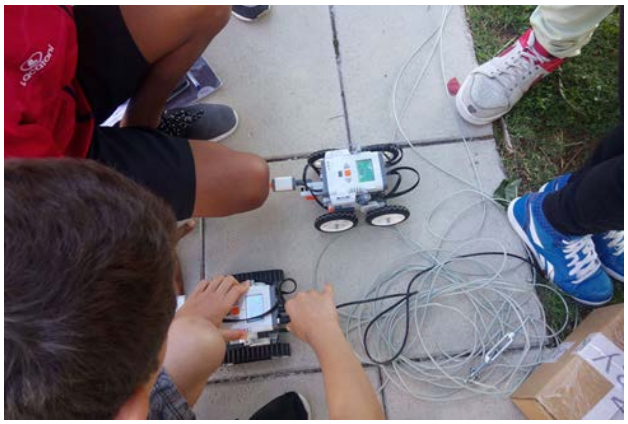

Figure 3. Transfering the program to a robot and checking the programming outcome

- Introduction to logic block programming using the graphical interface creating simple routines and commands (Fig. 3).
- Spatial location-oriented challenges
- Lateral straightforward and backward movement simulation challenges making the robots to make left turns, to turn right, and to move backward and forward reversing motion.
- Development of tasks to follow a path or route drawn in the floor of the classroom, in which students would program their robots in order to make them travel from one point of the room to another point following a particular route, more or less complicated. These challenges were carried out in small groups. Students would have to estimate the number of turns that the wheels would have to make (addressing the notion of perimeter for students in the 2nd cycle) in order to go from departure point to the point of arrival.
- To program a robot to run a course in a runway filled with obstacles that the robot must contour.
- Study of the drawing of quadrilaterals exploring the problem of the robot performing a partial rotation (notion of angle). In the same line to solve the challenge of the construction of triangles exploring the concept of internal and external angles (Fig. 5).

Figure 4. Using different sizes or types of "wheels" may demand adjusts to be done to the programming of the robot

Figure 5. Exploring the notion of angles with robot rotation adjustment

4. Conclusions

Activities involving programming and robotics, in project-based learning, allow students to develop skills for the century XXI. As well they can be used to stimulate the interest and skills in STEM (Science, Technology, Engineering and Mathematics).

The use of these technological tools in the learning environment, particularly in interdisciplinary processes, can be very useful and should be taken into account also in teacher training.

5. References

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