Robotics education in public schools using recycled materials and principles of Project-based Learning

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Abstract

The proposed project aims to implement an educational robotic teaching project in public schools. The developed robot uses the concepts of meta-recycling, which aims to encourage the sustainability and the reuse of electronic components to minimize garbage generation. The teaching technique used is the methodology of Project-based Learning (PBL), defined by developing projects based on a question, problem or task, which motivate students to create solutions applying theory to practice. PBL uses collaborative problem solving to significantly increase student interest and involves analyzing each student learning evolution independently. The project also promotes interdisciplinarity among the common areas taught in schools, making the learning process more dynamic and interactive.

Keywords: Robotics; Meta-recycling; Education; Project-based learning.

1. Introduction

Teaching techniques involving computational devices and educational technologies comes, over the years, gaining recognition and respect, both in academic and institutional circles. With this, robotics educational emerges as a tool to bring computational and educational concepts closer to the disciplines common to students [1].

Because of this, educational robotics is characterized by the promotion of interdisciplinarity, bringing together diverse areas of teaching, such as computing, electronics, physics, mathematics and others, considering the various components involved in the teaching process, such as motors, actuators and sensors. Generally, for educational robotics, is recommended that these components are controlled by hardware and free software, lowering costs for constructing the projects. Manipulating and programming the operation of the assembled robotic models, stimulate the logical reasoning and the construction of new concepts related to digital inclusion, bringing practice to theory.

Robotics is also characterized as a multidisciplinary science, involving subjects such as mechanics, electronics, hydraulics, pneumatics and computing. The methods covered by educational robotics instigate

the student to question, think and seek solutions, allying theory to practice [2]. Thus, the use of educational robotic activities demonstrates the possibility of concretely and contextually approaching the different concepts used in classroom practices, establishing connections between subjects, thus promoting interdisciplinarity and stimulating cooperative work [3].

Project-based learning (PBL) aims to work with students to solve real-world problems that have a significant impact on them, where they depend on cooperative action for solutions to such problems [4]. Thus, PBL can be defined using projects based on a question, problem or task that are motivating and captivating in teaching academic content to students [5, 6]. The PBL uses collaborative problem solving to significantly increase student motivation [7]. Currently, PBL is widely used as a teaching technique, where students unconditionally acquire content through motivation to want to solve a problem [8].

On the other hand, electronic waste (e-waste) is all the material that comes from electrical and e-waste such as solid waste, toxic components and heavy metals. Ferreira and Rodrigues [9] and the United Nations (UN) affirm that Brazil is the emerging country that produces the most e-waste in quantity. It is also the country that has the largest number of discarded refrigerators, cell phones, TVs and printers. The computer, which is a classic example of electronic that is discarded, after not being considered more useful, becomes more garbage. Thus, the reuse of these prevents them from being misused in the disposal, attacking the environment, as they are composed of toxic elements such as lead, mercury and cadmium.

The meta-recycling then appears in the need to use e-waste through its deconstruction or reuse to build new products. The principles of meta-recycling are based on the deconstruction of obsolete equipment, the use of free software, the use of open licenses and action in collaborators network, where anyone can collaborate by searching for means to reuse e-waste, ideas about the appropriation of technology geared towards social transformation. This concept encompasses a diverse range of actions, such as: the capture of used computers, where digital inclusion programs can use them for teaching and donating to low-income people, the operationalization of meta-recycling laboratories, the use of free software, reuse in didactic tools such as educational robotics and the creation of environments of circulation of information through the internet, passing through all kinds of experimentation and strategic and operational support to socially engaged projects [10].

During the research carried out among the related works, it was possible to perceive that one of the greatest difficulties for the understanding of educational robotics in schools is precisely the cost for the construction of practical projects. Considering this, the application of meta-recycling to robotics becomes a very positive point for the implementation of this theme in public schools.

The project aims to attract the interest of public school students with the concept of low-cost educational robotics along with meta-recycling. Practical experiments, coupled with the theory of conventional subjects such as physics and mathematics, for example, can contribute to students' learning, especially those who have more difficulty.

2. Bibliographic review

Educational Robotics empowers skills and builds a new thinking in students, until reaching the most important phase, which is to think comprehensively and how the concepts seen in class can influence their

future. As a tool for technological inclusion, a microcontroller system, the SanUSBino [11], was developed. So that the realization of the project and the beginning of this awareness take place, it became necessary for a field of technology closer and more current to the school reality, this field that came as an aid was Educational Robotics. The SanUSBino consists of a versatile and robust board, developed primarily for use in schools as a central controller for robots, is composed of a PIC18F2550 microcontroller.

The work environment should foster the development of autonomy, creativity and organization for group work. This way of building the robots, from recyclable material, allows the students to develop logical reasoning and creativity, so that each project is low-cost and presents a unique characteristic that reflects the engineering idea of each student. With this, in another project, was built a prototype of a wheelchair that overcomes obstacles, this consists of a system with sensors and microcontroller board using a PIC18F2550 microcontroller, using the SanUSB application where it was designed for facilitating the programming of microcontrollers via embedded USB interface [3].

In this context, another article presents the project of developing a low-cost robot, based on an open architecture controller and low-cost sensors and actuators, to be used as a tool for educational robotics in public schools with elementary and medium students to promote interdisciplinarity. The robot was developed using the Arduino development platform and some embedded electronic sensors [12].

Another related project implemented a proportional-derivative (PD) controller in a mobile autonomous robot built inside a software platform and open source, that improves the execution performance of the robot reducing errors in a path made with a black ribbon in a smooth white surface. The robot was able to follow the black line effectively, moving along the path smoothly [13].

In another work an educational robotic environment was developed, named Roboeduc [14]. The Roboeduc system is an environment built of parts for assembly of prototypes. For the assembly of prototypes, the LEGO® Mindstorms® Kit, which is built with high-cost components for data processing and transmission, actuators, sensors, parts for connection and transmission of motion was used.

The project proposed in the present paper, different from the ones mentioned, does not have a microcontroller, that is, the processing is done in an analogical way, allowing the reduction of the construction cost, since it also uses the concept of meta-recycling contributing to reduce the problem of e-waste and PBL, for improving teaching-learning. One of the main objectives of the present project is to instigate and awaken the students in the spirit of learning, joining the practice of educational robotics and PBL with the concept of meta-recycling for the deconstruction of old equipment and its use in new projects of digital inclusion. In Table 1, comparison between the related and the proposed project is made.

As can be seen in Table 1, the proposed project presented a lower cost compared to one of them and allows the development of this teaching tool, which favors the development of students' autonomy and the diffusion of the interdisciplinary concepts of this project using only analogical circuits, easier to use and to find in e-waste.

Table 1. Comparative table of the projects cited

Projects	Processing	Processor	Own development	Total cost
Amorim, A. F. [13]	Digital	ATmega328	Yes	Not specified
Filho, et al. [3]	Digital	PIC18F2550	Yes	Not specified
Isaac, et al. [11]	Digital	PIC18F2550	No	Not specified
Silva, A. F. [14]	Digital	Not specified	No	Not specified
Veiga, et al. [12]	Digital	ATmega328	Yes	$ 50.80 USD
Proposed Project	**Analogical**	**None**	**Yes**	**$ 7.53 USD**

3. Materials and methods

The mobile robot proposed in this work aims to follow a certain line of a circular path. This was possible through the reuse of electronic components taken out of printers and discarded computers. Figure 1 shows the materials and electronic components used for the construction of the mobile robot.
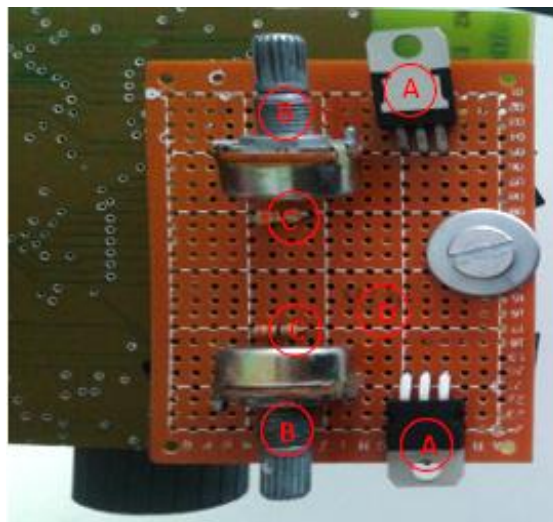

Figure 1. Circuit board with the components used in the proposed project.

For the construction of this project, two TIPs-122 (A) were used. TIP-122 is a high gain power transistor, which receives a very weak signal at the input (base) and transforms it into a powerful output signal collector or emitter [15]. Two 100k potentiometers (B) used to adjust the resistance to be passed to the LEDs, to increase or decrease the brightness intensity of both [16]. Two 360-ohm (C) resistors used primarily to reduce the current of the LEDs, and a printed circuit board (D) used to aggregate the electronic components of the circuit. Figure 2 shows an illustration of the lower part of the proposed prototype.
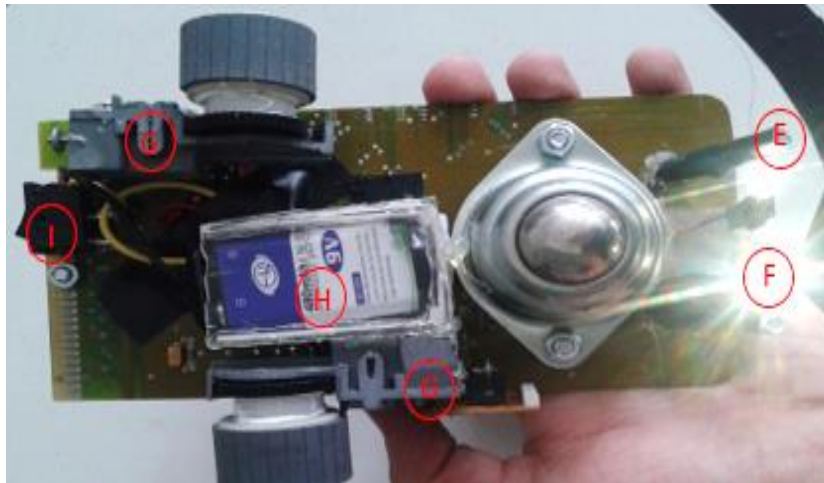
Figure 2. Bottom view of the robot.

In Figure 2 it is possible to notice other fundamental components for the operation of the mobile robot, being two LDRs (E) consisting of a light-dependent high resistance semiconductor, that upon receiving a large quantity of photons coming from the incident light of the LEDs (F), absorb the electrons that improve their conductivity, thus reducing their resistance [17], that is, when they are in contact with a great light intensity, the motor of the mobile robot will be activated and when there is low intensity of light, the engine will stop. The robot also consists of two 3V (G) motors, a 9V rechargeable battery (H), a switch to turn the robot on and off (I) and lastly a cut out plate used as the basis of the design. In Figure 3 it is possible to observe the robot from another perspective.
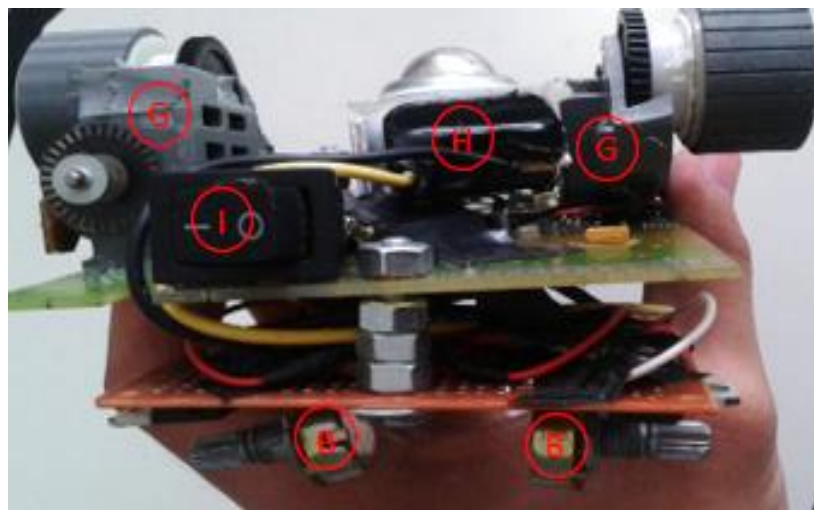

Figure 3. Robot Back View.

In Figure 4, the robot schematic circuit mounted on a protoboard is showed. Protoboard is a matrix of contacts and gives a better understanding of the electronic operation to the students during project development.
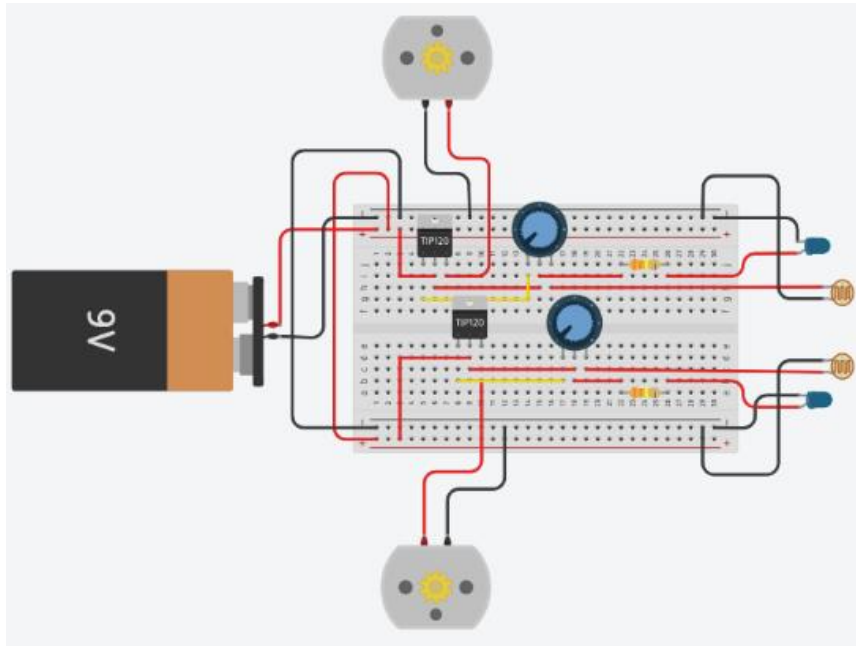
Figure 4. Schematic circuit of the proposed project mounted on protoboard.

4. Results and discussion

The robot achieved a very satisfactory performance and duly fulfilled its purpose, which was to follow a line in a circular path, as well as the operation of the circuit that was designed for any environment independent of brightness, having the possibility of reducing or increasing the luminosity of the LEDs, as well as the speed of the motors individually, as a way of adjusting their operation in a given environment. For the robot construction, it was possible to reuse electronic equipment and devices from e-waste, like old desktops. In Figure 5, it is possible to see the robot in the final phase, already tested, working correctly, where it was possible to reach the expected objectives of its operation.
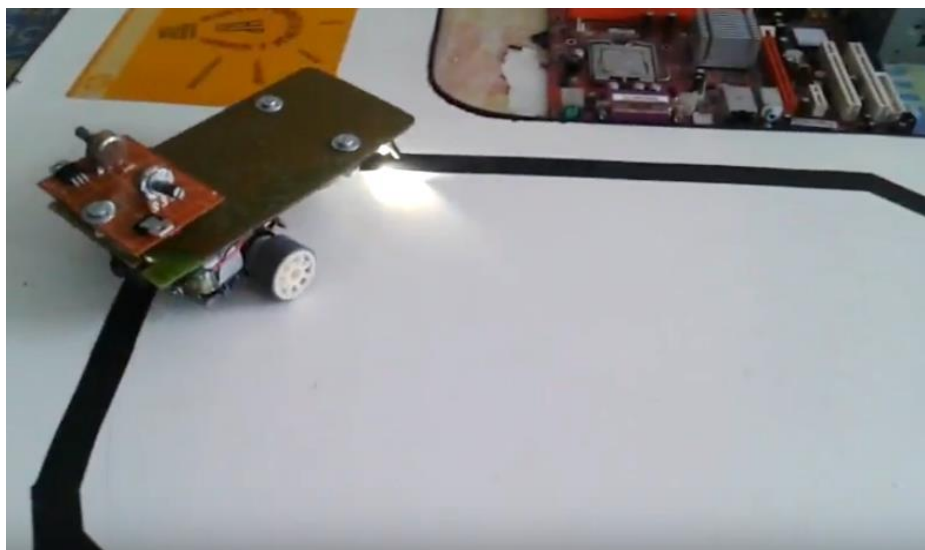

Figure 5. Operation of the line follower educational robot in a circular path.

5. Conclusion

As discussed in the proposed project, the understanding and use of educational robotics and meta-recycling in conjunction with the PBL in education can provide students with a more in-depth contact with the practice, together with theoretical concepts. These concepts, as well as the practical application of them, promoted interdisciplinarity in the classroom. This project was presented at the Idear Institute (Institute for Technological and Social Development) for students of public schools of the state of Ceará-Brazil, who aroused interest in deepening into the theme and developing other related projects.

6. References

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