CONTINUING EDUCATION OF TEACHERS IN EDUCATIONAL ROBOTICS: AN APPROACH WITH BASIC, INTERMEDIATE AND ADVANCED LEVELS

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ABSTRACT
This article aims to describe the actions of a project developed at UNESP, Guaratinguetá Campus, aimed at the training of teachers from the public school system in the region of the Education Board (DE) of Guaratinguetá. The project was developed in partnership with the DE of Guaratinguetá and included the offering of courses at three levels: basic, intermediate and advanced. In parallel with the offering of courses at the basic and intermediate levels, a board coupled to a mobile robot was developed, including several components, whose functionalities are being presented in the advanced level course. The article briefly presents the objectives of the courses offered at each level, as well as the results of the evaluations of the courses at the basic and intermediate levels. It also briefly describes the design of the mobile board/robot, the object of the advanced course.

Keywords: Teacher training. Educational Robotics. Arduino.

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INTRODUCTION

This article aims to describe the actions of a project developed at UNESP, Guaratinguetá Campus, aimed at the training of teachers from the public school system in the region of the Education Board (DE) of Guaratinguetá. The project began in 2022 and had the support of the Legislative Assembly of the State of São Paulo, via State Parliamentary Amendment No. 2022.088.38181, for the purposes of funding and investment in the project to train teachers in the public network of the State of São Paulo.

The project was developed in partnership with the DE of Guaratinguetá, the courses having been structured in partnership with the Curriculum Specialist Teachers - PEC, in the areas of Mathematics and Educational Technology. The project included offering courses at three levels: basic, intermediate and advanced. Three editions of the basic course were held, one of the intermediate course and the first edition of the advanced course is being held.

One of the motivations for the proposal of the project is the fact that Basic Education schools have presented difficulties in changing their pedagogical practices to the new proposal of teaching by skills and competencies, recommended by the new BNCC (GERHARD and ROCHA FILHO, 2012). In this context, it is necessary to re-signify certain pedagogical practices to prepare students to face real problems, to the detriment of artificial ones, applied, most of the time, in a decontextualized way in the classroom, giving students greater prominence in the teaching and learning process.

In parallel with the offering of courses at the basic and intermediate levels, a board coupled to a mobile robot was developed, including several components, whose functionalities are being presented in the advanced level course. The microcontrolled multifunctional electronic unit for training in sensor technologies and robotics was developed based on the Arduino NANO and is equipped with a range of sensors and actuators, allowing the performance of several different experiments, ranging from the fundamentals of electronics and programming to advanced robotics projects, such as assembling an electric energy meter, Internet of Things (IoT) applications, home automation applications, configuration of a line-following robot, configuration of a robot that avoids obstacles, among other projects.

The article briefly presents the objectives of the courses offered at each level, as well as the results of the evaluations of the courses at the basic and intermediate levels. It also briefly describes the design of the mobile board/robot, the object of the advanced course. The article is organized as follows. In this section, a general presentation of the project was made. In section 2, the theoretical foundation of the project is presented. The methodology used is presented in section 3. Section 4 describes the development of the project succinctly, presenting the objectives of each of the levels of the courses offered. Results of the evaluations of the courses by the participants, as well as data on the application of the project in the schools of the course teachers, are presented in section 5. Section 6 presents some conclusions and discussions arising from the development of the project.

THEORETICAL BASIS AND RELATED WORKS

The project sought to guide its actions in a way that is consistent with the National Common Curricular Base – BNCC (BRASIL, 2018), a document of the Brazilian Federal Government (Ministry of Education) that contains the curricular guidelines that must be followed by basic education schools. The National Common Curricular Base - BNCC is based on two premises: the integral formation of the human being and the construction of a more just, democratic and inclusive society.

The BNCC establishes as a goal, for the entire course of Basic Education, the development of 10 general competencies to be worked on with all students. The emphasis on the use of digital information and communication technologies (ICT) in the different stages of Basic Education are included in these competencies. For example, competency 5 defends the importance of:

> "Understand, use and create digital information and communication technologies in a critical, meaningful, reflective and ethical way in the various social practices (including school ones) to communicate, access and disseminate information, produce knowledge, solve problems and exercise protagonism and authorship in personal and collective life." (BRASIL, 2018, p. 9)

It is observed, therefore, that the insertion of Robotics in the educational context is consistent with this competence. Regarding this insertion, one can mention, initially, the development of the LOGO language by Seymour Papert and other researchers, which allowed children to control a robotic turtle through computer commands (Massa; Olive tree; Santos, 2022). The language was developed in the 60s, when the foundations of computing were still being established. The programming of the robot by the children, which was carried out by means of a computer, made it possible, for example, to draw various geometric figures. Papert was convinced that the machine would be able to change the way children learn, considering that this learning process would take place through the creation, reflection and purification of ideas. Papert's vision remains relevant to the present day, encouraging several schools to adopt methodologies and disciplines that work on this learning process, as is the case of Robotics actions used as learning instruments in various disciplines.

In the 80s, Papert and his research group at MIT started a partnership with the LEGO company, which resulted, in 1986, in the LEGO/Logo system, which allowed children to build various mechanical artifacts, which were connected to an interface and whose movements could be programmed with the Logo language (MARTIN et al., 2000). Martin et al. point out that this system was the first widely made robotic construction kit.

The insertion of Educational Robotics in schools should include teacher training programs because, as Reis et al. (2014) point out, it is not enough for schools to have materials such as robotics kits if there are no trained personnel to use them appropriately in the classroom. The authors also recognize the multidisciplinary character of Educational Robotics, emphasizing that it is not much explored by schools, especially public schools, partly due to the costs involved in the acquisition of kits, but also due to the lack of trained personnel for its use. In this context, the authors emphasize the relevance of establishing partnerships between universities and schools, as "an important means to introduce educational robotics in elementary and secondary education" (REIS et al., 2014, v. 2, p. 56).

The project developed by Silva et al. (2018) also presents a teacher training program for basic education teachers, carried out in 10 meetings of 3 hours, using the Criatecno CT100® Educational Robotics kit, based on the Arduino platform. The project is part of an extension program of Feevale, the training activities being carried out on the premises of the university campus. The programming of the kit's controller board was carried out using the Ardublock language, which is based on pre-defined blocks. In addition to the training program, the program also included workshops using the LEGO® MINDSTORM® NXT kit, aimed at students in the final grades of elementary school and high school students. The workshops could take place both at the university and in schools, with the necessary kits being made available by Feevale.

Da Fonseca Silva, Ramos da Silva and Roger Silva (2018) present the result of a survey carried out with teachers of a private Early Childhood Education school, which was the only school in the city of Uberlândia that included Educational Robotics in its curriculum. Robotics classes were offered to students aged 3 to 6 years, who carried out activities in groups of up to 4 participants, making assemblies using LEGO kits®. In the conclusions of the work, the authors suggest the need for new discussions on the use of Robotics in schools, and highlight, in this context, the need for better teacher training to use this resource in the classroom, thus contributing to a more meaningful learning by students.

Pinto, Elia and Sampaio (2012) describe the application of a teacher training course in Educational Robotics, which is structured in two axes, namely: the technological axis and the pedagogical axis. The technological axis comprises two dimensions, hardware and software, namely: (i) hardware – computer, Arduino and electronic components; and (ii) software – environment and language for developing applications for Arduino. The pedagogical axis is called the Hierarchical Model of Interactivity in three layers - MHI-3C, which correspond to the following interaction modalities: researcher-teacher (layer 1), teacher-teacher (layer 2) and teacher-student (layer 3). The proposals for didactic activities and their application in the classroom context occur in layers 2 and 3. The authors argue, in relation to this form of organization, that "in the context of educational robotics, the role of the teacher acting both in the planning and in the execution of his didactic activity with the resources of robotics is of great importance" (PINTO; ELIA; SAMPAIO, 2012, p. 161).

The work of Souza, Rodrigues and Andrade (2016) aimed to analyze the effects of the introduction of Computational Thinking (CP) in the training of robotics teachers at SESI-PB. The project was proposed considering the difficulties presented by teachers and students, especially in the programming stage of the robots. Thus, the first phase of the project consisted of offering an introductory course to the PC for teachers and high school students at SESI-PB. The results obtained highlight the need, in the context of Educational Robotics, for the teaching of PC for teacher and student training. The authors also point out that "there are indications that CP positively influences student performance" (SOUZA; RODRIGUES; ANDRADE, 2016, p. 1266).

METHODS AND PROCEDURES

The methodological focus of the research was based, mainly in its initial phase, on action research (TRIPP, 2005), as the actions to be developed were structured together with the Curriculum Specialist Teachers - PEC, in the areas of Mathematics and Technology, of the DE Guaratinguetá, establishing a link between the university team and the teachers of the schools that would participate in the course. Also according to Tripp (2005), one of the characteristics of action research is the fact that it is participatory, thus differentiating itself from routine practice (individual) and scientific research (team/collegiate), and is also "collaborative in its way of working" (TRIPP, 2005, p.448). Under this focus, teachers of basic and intermediate level courses should participate in training activities, propose and carry out teaching projects using Educational Robotics with students from their schools, supervised by the University team.

The activities, in the basic and intermediate level courses, were developed according to the guidelines of a Project-Based Learning model – PBL, aiming to investigate, among other aspects, strategies for the use of PBL in a traditional teaching context, and the role of active learning – students participating in the development of projects involving Educational Robotics in their schools – in improving the learning of concepts related to the themes of Rational Use of Educational Robotics Energy and Energy Efficiency.

As theoretical support for the approach by PBL, the model of the BIE Institute – Buck Institute for Education (www.bie.org) (MARKHAM; LARMER; RAVITZ, 2008), which presents PBL as an appropriate model to deal with the educational reality of the twenty-first century, emphasizing the contextual and interdisciplinary nature of learning. DUCH, GROH AND ALLEN (2006) EMPHASIZE THAT THE contents to be addressed in an application of PBL should aim to develop "higher level" thinking skills in students, aiming to acquire the cognitive levels established by Bloom: knowledge, comprehension, application, analysis, synthesis and evaluation (sense of judgment) (BLOOM, 1956 apud DUCH; GROH; ALLEN, 2006). It should be noted that the taxonomy initially proposed by Bloom underwent a revision in 2001, giving rise to Bloom's revised Taxonomy, in which the categories of cognitive domain are: remember, understand, apply, analyze, synthesize and create (FERRAZ; BELHOT, 2010). Thus, an application of PBL must meet the cognitive development of students according to the current categorization of the aforementioned Taxonomy.

The BIE institute proposes a standards-focused PBL model (MARKHAM; LARMER; RAVITZ, 2008), and, according to this model, the organization of a project must follow the principles briefly described below:

i. Start with the end in mind: definition, among other things, of the content standards, key skills, and mental habits that will constitute the expected results of the project.
ii. Formulate the Guiding Question: proposition of a relevant and significant question that makes students get involved with the project, requiring them to have an active posture and dedication to seek their own answers and their own knowledge (POZO, 1998).
iii. Plan the evaluation: specification of the products and artifacts expected from the project and how they will be evaluated, noting that the evaluation, in an ABP application, is commonly based on performance, as it involves a problem-solving activity.
iv. Map the project: it includes, among other aspects, the organization of the tasks and activities to be developed, the selection of the necessary resources and the preparation of a visual script (which can be a storyboard or a schedule, among others).

v. Manage the process: description of tools and strategies to assist in managing project development. It should provide, for example, the use of reference frameworks, which allow monitoring the students' learning with the project activities.

RATIONALE AND DEVELOPMENT

An essential aspect in the use of technologies in schools is to prepare teachers for the use of these technologies, that is, it is necessary to present, train and make indications of when and how to use a certain resource in the classroom. The indiscriminate and, in some cases, mechanical use of new technologies may not promote desirable qualitative and quantitative changes in the teaching-learning process.

Usually, when teachers do not have a more comprehensive training or, for example, without the proper training in a certain technology, they make minimal adjustments to the procedures performed in the classroom. That is, teachers reproduce the practices to which they were already accustomed, not taking into account the available technological resources.

As the use of new technological resources is quite limited, the lack of motivation, both of the teacher and the students, is an explicit consequence of this lack of training. The better prepared the teacher is in the use of a new technological resource, such as the use of Robotics, the more chances he will have of succeeding in the use of this instrument in his classroom actions. No less important is also to know how this resource can help you in the transmission of a given content in the classroom.

In the proposed courses, the contents were related to the Energy theme, mainly to the themes Rational Use of Energy and Energy Efficiency, under the prism of Robotics, and to those addressed in the new curricular matrix of the New High School in the state of São Paulo, within the Curricular Units planned for schools with Integral Education Program – PEI.

The courses were held according to the hybrid modality, that is, in the blended format. The face-to-face actions consisted of 4 (four) meetings, being held on Saturdays from 9:00 am to 1:00 pm at the Center for Innovation in Energy Efficiency – INOVEE, located at UNESP – Faculty of Engineering campus of Guaratinguetá. The face-to-face activities were used for the development of the content, as well as for the presentation of a task-based learning model and general guidelines for the development of teaching projects, which were developed in the schools by the course teachers.

Each face-to-face meeting was held in a technological workshop format, in which the course teachers were separated into teams, usually made up of teachers belonging to the same high school. After that, the theme proposed for the activities was presented, prepared by the course tutors, aiming to provide a first presentation of the organization of the script and the support materials of the experiment, and also to motivate the course teachers about the actions that would be carried out during the meeting. Figure 1 shows the holding of a face-to-face meeting of one of the basic level robotics courses, held on the premises of the Center for Innovation in Energy Efficiency – INOVEE.

Figure 1. Face-to-face activity of the course "Introduction to Educational Robotics: from Theory to Practice".

Source: Authorship.

The project's online actions were developed from 8 (eight) activities, lasting 2 (two) hours each, aiming to complement the conceptual content presented during the course's face-to-face activities. In addition to the conceptual contents, the training presented themes that were used by the course teacher to develop, with his students, a teaching project related to the subjects covered throughout the course.

Throughout the execution of the courses, the online actions were carried out synchronously and asynchronously. In synchronous mode, the actions were carried out in a "live" format, in which a theme related to the course was presented and discussed. In the asynchronous mode, video classes lasting between 20 and 60 minutes were available, in addition to complementary materials, such as: handout and manuals of electronic components. In both formats, electronic circuit simulation software was used that allowed the execution of experiments in a virtual way, that is, in online actions virtual laboratory activities were always performed. At the end of each online activity, an Evaluation Form was made available, which was open accepting a response for a period of 7 (seven) days.

The syllabus proposed for the execution of the basic level course consisted of the following topics: Notions of electricity and electronics. Electrical signals. Voltage, current, and power. Energy sources. Instruments of measurement. Electronic components: resistor, capacitor, switches, diode, light-emitting diode (LED), display, transistor, relay. Fundamental rules of circuit analysis. Integrated circuits. Analog and digital sensors (temperature, pressure, ultrasonic, among others). Motor: DC and servo motor. Notions of algorithm construction and its forms of representation. Logical, relational, and arithmetic data types and operators. Arduino programming via IDE. Definition of the structure of a sketch. Types of variables and constants. Functions: configuration, digital I/O, analog I/O, mathematical, time, trigonometric, advanced I/O. Control structures. Comparison and Boolean operators. Serial communication. Library.

The proposed syllabus for the execution of the intermediate level course consisted of the following topics: Concept and forms of algorithm representation. Scheduling structure: assignment, selection, repetition, procedures, and functions. Vectors and matrices. Analog and digital sensors. Position, speed, pressure, optical, temperature, current, ultrasonic, piezoelectric sensors. LCD and OLED type display. PWM modulation concepts – *Pulse Width Modulation* . Practical applications of sensors. Electromechanical actuators, solenoids, motors. Programming with Arduino: Data types, data conversion, constants. Functions: mathematical, trigonometric, random numbers, advanced I/O, character. Communication: serial and I2C. Control structures, operators (bitwise, composite, boolean, arithmetic). How to create a function. How to install and use a library. Construction of robotic platforms with shields. Individual programming of the shields and integration of the modules for the construction of the robot: line follower robot and/or obstacle avoidance robot and robotic arm. Application of educational robotics content in interdisciplinary areas of teaching.

The pedagogical resources used in the execution of the course were:

- **Script:** material containing the objectives and concepts necessary for the execution of the experimental activity.
- **Multimedia material:** complementary reference material on the practical experiment, developed in a language adapted to the resources made available digitally, mainly in the form of hypermedia and/or hypertext.
- **Workbook:** class notes, formatted in the format of booklets, made available in order to be used as support material for the development of the proposed activities.
- **Video classes:** availability of online classes for students, with multiple video classes linked to the proposed themes and worked on during the online actions of the course.

- **Virtual laboratory:** learning object developed to allow simulations of virtual multifunctional electronic systems, so that the course teacher can exercise investigative attitudes about a particular subject.

The technological resources used in the execution of the course are listed below:

- The Google for Education platform: within the framework of this virtual environment, the Google Classroom and Google meet tools were mainly used.
- For the planned online actions, in order to perform virtual laboratory actions, the Autodesk Tinkercad online tool was used.
- Test bench containing the following equipment: power supply, multimeter, function generator and oscilloscope.
- Notebook, with internet access and with the Arduino IDE pre-installed.
- Arduino UNO R3 platform and various electronic circuits for the execution of the planned experimental activities.

RESULTS AND DISCUSSION

INTRODUCTION TO EDUCATIONAL ROBOTICS COURSE: FROM THEORY TO PRACTICE

150 vacancies were offered for the basic level course, being intended exclusively for teachers from the public school system of the State of São Paulo. The modalities allowed for registration, in the 1st and 2nd edition of the course, were: Basic Education II Teachers of Mathematics, Physics and Chemistry, or Basic Education II Teachers with classes assigned in the Technology and Innovation component (INOVA). In the 3rd edition of the course, the modalities allowed for registration were expanded to Basic Education teachers with classes assigned in Elementary or High School of any component in the calendar year 2023 and Pedagogical Management Coordinating Teachers (CGP/CGPA/CGPG). Considering that the use of robotics in the classroom can promote interdisciplinarity and motivate the execution of multiple activities in areas related to Science and Technology, we had an excellent demand for interested teachers, with 136 teachers registered to take the courses offered at the basic level, and 69 (sixty-nine) students were successful in concluding. The enrolled teachers came from schools in several cities in the region of the Board of Education of Guaratinguetá / SP, among which we can mention: Aparecida, Areias, Bananal, Cachoeira Paulista, Canas, Cruzeiro, Cunha, Guaratinguetá, Lavrinhas, Lorena, Piquete, Potim, Queluz, São João do Barreiro and Roseira.

The course teachers were evaluated through the development of the activities proposed during the face-to-face actions, and through evaluative questionnaires referring to the online actions carried out in the course. In addition, the evaluation process also included the development of a teaching project that should be applied in the classroom, and the results of this project should be socialized with the other participants of the course. Figure 2 shows the socialization meeting of the basic level course.

Figure 2. Socialization meeting of the course "Introduction to Educational Robotics: from Theory to Practice".

Source: Authorship.

Table 1 presents the list of teaching projects developed by the course teachers (1st Edition) in their respective schools, whose results were socialized in the last face-to-face meeting of the course.

Table 1. It presents the following information regarding the teaching projects carried out during the 1st Edition of the Robotics Course: responsible, the title of the teaching project, the curricular component in which the action was carried out, the general competencies of the São Paulo curriculum and the objects of knowledge.

ACCOUNTABLE	**PROJECT TITLE**	**CURRICULAR COMPONENT IN WHICH IT WAS APPLIED**	**GENERAL COMPETENCIES OF THE SÃO PAULO CURRICULUM**	**OBJECTS OF KNOWLEDGE**
EE Professor Miquelina Cartolano	Producing Motion with Servo Motor: Ghost Project	Physics Practice	Scientific, critical and creative thinking	Electrical circuits, electronics and computers (semiconductors; transistors; integrated circuits; diodes), Electrical and electronic equipment (electrical voltage; electric potential; units of measurement; intensity of electric current).
E Murillo do Amaral	Audiometry test with LCD display.	Physics	Knowledge Scientific, critical and creative thinking	Technology and scientific language, and introduction to science education. Sound waves (pitch, frequency, timbre, intensity, propagation, and

				physiological qualities of the sound).
EE Sylvio José Marcondes Coelho	Mixing colors	Technology	Knowledge Scientific, critical and creative thinking Communication Digital culture	Programming (Plugged/Unplugged) Maker Culture Scientific thinking.
EE Prof. Luiz de Castro Pinto EE Prof. José Pereira Éboli	Parking sensor	Elective	Scientific, critical and creative thinking Digital culture Work and life project Responsibility and citizenship	Robotics (Technology and Innovation); Sources and types of energy Energy transformation Electrical circuits Conscious use of electrical energy (Science)
EE PEI Ernesto Quissak	Robotic arm	Elective Technology Mathematics Physics	Knowledge Scientific, critical and creative thinking Digital culture Work and life project	Directly proportional quantities and inversely proportional quantities. The Technical, Scientific and Informational Environment and the impacts on the use of the territory by the relations of the world of work.
148 Paulo Verghnis	Home automation	Physics	Scientific, critical and creative thinking Digital culture	Electrodynamics (electric current; resistors; Ohm's laws; electrical measuring equipment; capacitors; electric energy and power). Electrical generators and receivers. Electrical circuits.
EE PEI Maria Izabel Fontoura	Construction of a traffic light	Elective	Scientific, critical and creative thinking	Programming, hardware: Arduino Uno R3, Breadboard (Protoboard), wires, use of the TinkerCad platform.
ACCOUNTABLE	**PROJECT TITLE**	**CURRICULAR COMPONENT IN WHICH IT WAS APPLIED**	**GENERAL COMPETENCIES OF THE SÃO PAULO CURRICULUM**	**OBJECTS OF KNOWLEDGE**
EE Counselor Rodrigues Alves	Genius Game, Automatic Door, Temperature Sensor, Traffic Light	Curricular Deepening - Connected Mathematics	Knowledge Scientific, critical and creative thinking Digital culture Empathy and cooperation	Block Programming; Programming Language; Arduino; Basic concepts of Physics (led, resistor, motors, electrical circuit)
EE Prof. José de Paula França	Obstacle deflection robe	Elective Technology Physics	Knowledge Scientific, critical and creative thinking Digital culture Work and life project Empathy and cooperation	Programming, reading and interpretation of electrical circuits, electronic components, electricity, solutions and dilution, quantities and measurements.

EE Professor Paulina Cardoso	Sensor On Alarm and Off Button	Technology	Knowledge Scientific, critical and creative thinking Digital culture	To create solutions, based on robotics, identifying problems and proposing solutions related to the concepts of engineering, mathematics and art (STEAM).
148 Paulo Verghnis	Mixing colors	Technology	Knowledge Scientific, critical and creative thinking Digital culture Self-knowledge and self-care	Programming (Plugged in and out of the way), critical thinking
EE LIKE Oswaldo Cruz	Buzzer drive	Elective	Scientific, critical and creative thinking Digital culture Empathy and cooperation Responsibility and citizenship	Flowchart to determine the parity of a natural number. Multiples and divisors of a natural number. Prime and composite numbers.
EE Prof. Francisco Marques de Oliveira Junior	Mixing colors	Technology Mathematics Physics	Knowledge Scientific, critical and creative thinking Work and life project Empathy and cooperation	Electrical circuits. Electromagnetism. Electronics and computer science (semiconductors; transistors; integrated circuits; diodes). Electrical and electronic equipment (electrical voltage; electric potential, units of measurement; intensity of electric current and capacitors); Photoelectric effect (transformation of electromagnetic radiation into photoelectron current)
EE Prof. Nilo Santos Vieira	Obstacle deflection robe	Elective Mathematics	Digital culture	Introduction to algorithms and programming logic; Introduction to Basic Programming in C++. Practice with electronic components, shields, sensors, actuators. Electronic circuits, protoboard, and circuit analysis.
ACCOUNTABLE	**PROJECT TITLE**	**CURRICULAR COMPONENT IN WHICH IT WAS APPLIED**	**GENERAL COMPETENCIES OF THE SÃO PAULO CURRICULUM**	**OBJECTS OF KNOWLEDGE**
EE Prof. Edgard de Souza	Home automation	Elective	Knowledge Digital culture	To make students aware of the multifunctionality that Arduino has.
EE Prof. Abraão Benjamin	Mixing colors	Technology Mathematics Sociology	Knowledge Scientific, critical and creative thinking Digital culture	Programming (Plugged/Unplugged) and Maker Culture. The role of youth in territorial contexts: central and peripheral; material and virtual;

			Empathy and cooperation	professional and academic and cultural and political.
EE Gabriel Prestes	Automation in agriculture	Elective	Work and life project	Simple machines Natural phenomena and environmental impacts Public health programs and indicators

Source: Authorship.

At the end of the course, an evaluation instrument was applied to the students, containing questions grouped into two groups:

- **Group I:** objective questions about the course professors, didactic material, approaches used, development of the planned actions, both face-to-face and online; such questions about the expected results and expectations for the development of the activities aimed to evaluate the degree of agreement of the students with the statements presented, according to a 5-point Likert scale, ranging from 1 = totally dissatisfied / totally disagree to 5 = very satisfied / I totally agree.
- **Group II:** discursive questions, for the students to express their opinions on various aspects of the course.

For group I, 15 (fifteen) statements were listed for which the degree of agreement of the participants was verified, and they were listed below:

1) Achievement of course objectives
2) Development of the course program
3) The theoretical approach of the course
4) The practical approach of the course
5) The facilities and resources used to carry out the course
6) The teaching materials used
7) Your use/learning in the course
8) The distribution of the workload between theory and practice
9) The application of the knowledge acquired in the course in your professional practice
10) Ability of teachers/instructors to use teaching methods and techniques in the development of the course
11) Clarity and objectivity of the teachers/instructors when exposing the subject
12) Knowledge of teachers/instructors about the content taught

13) Potential contribution of the robotics course to develop in students competencies and skills, scientific, critical and creative thinking
14) Usefulness of the robotics course for the application of competencies recommended in the BNCC
15) General organization of the course (facilities, teaching material, platforms, teachers/instructors)

It was observed that most students agreed with most of the statements, with percentages above 70% (in relation to the answer options: "satisfied" and "very satisfied / totally agree"). For example, for statement (9), we obtained a degree of agreement of 94%, and for statement (14) we obtained a degree of agreement of 99%. On the other hand, we observe that some points need to be improved. The first aspect is related to the statement "The distribution of the workload between theory and practice", in which 30.3% disagreed (considering the options "dissatisfied" and "neutral"). Another point of attention is related to didactics and the way of presenting the contents, as we obtained a degree of disagreement of 12.1% in relation to the statement "Clarity and objectivity of the teachers/instructors when exposing the subject".

In relation to group II, it included, as mentioned, open questions, in which the students could express themselves on aspects related to the development of the course, such as: the points that most benefited them in the course, the points to improve in the actions developed, and there were specific questions for both the face-to-face and online approaches. Finally, we ask for suggestions for improvements in future editions of the course.

Some of the answers regarding the positive points of the course are listed below:

> "The practice of the work, getting to know other tools, clarifying doubts."
> "Welcome, facilities, preparation of teachers/instructors."
> "Theoretical classes giving foundation to practical classes."
> "Classes on Saturdays, qualified teachers, and availability of materials."
> "Class schedule; use of tinkercad together with the teacher; recording of the class to have access later (in case of doubts)."
> "Flexibility of schedules, videos, good quality and objective pdf material."
> "Punctuality, support material, excellent quality classes."
> "Practical, good assistance from the monitors and materials available."
> "Quality of the material made available, monitoring in practice and working in pairs."
> "Face-to-face classes, robotics kit and the help of students and teachers in relation to the assembly of circuits with arduino".
> "Knowledge of the arduino, assembly of the circuits and group work."
> "Hands on; practical class; Support from teachers regarding the assembly of circuits with arduino."
> "Monitoring the monitors, working with physical material and contact with the teachers."
> "Very didactic programming, use of available resources, answering questions with other students."
> "To have the material available. Help from teachers and monitors."
> "Face-to-face classes gave the opportunity for questions for further clarification."

"The resources used in the course."
"The didactics presented in the course."
"The practical approach of the course."
"The safety of teachers and trainees."
"The gradual expansion of the contents."
"The time dedicated to face-to-face classes."
"Instructors' skills, patience and facilities."
"Good explanation, good attention from the instructors and attentive."

Some positions of the course teachers on the points to be improved are presented below:

"A single point to consider would be the possibility of more face-to-face classes."
"The student group (50) is very large, it could be smaller, to enable more interactions."
"I believe that the challenge is in relation to our workload at school, which makes it difficult to effectively participate in distance classes."
"The approach is great, the only problem is the internet in schools, there is always some failure in the connection."
"To have more time to explore each content more calmly."
"Develop more assemblies, review the connections together with us."
"Having more face-to-face classes, for those who don't know anything, it's very difficult to learn at a distance."
"I think Time would be one of the words, since, incredible as it may seem, classes pass very quickly"
"Increase the number of classes or the school term on the day of the final presentations."
"Internet access."
"Demand for the activities because uniting with the school day to day was a challenge."
"Self-discipline and time management."
"Technological and connectivity challenges."
"It would be good to have greater availability of exercises to assist in learning..."
"The course coincided at times with the 360 assessment, which ends up overloading the teachers."

Finally, we list some suggestions presented by the course teachers for the continuous improvement of the course:

"Have more time for the development of projects."
"The possibility of increasing the number of face-to-face classes."
"Put a specific time for questions and comments at the end of class."
"The distance class is important, but to improve the follow-up, the teacher would have to have the robotics kit."
"To be placed with more emphasis on face-to-face."
"Creating a question chat."
"More face-to-face classes for better use."
"The possibility of having greater communication so that doubts can be explained."
"Longer time for practices."
"Longer time for face-to-face classes."
"Work on the final project, from the beginning of the course, along with the other subjects covered."
"Schedule of lives.."

Analyzing the answers of the students, with regard to what they liked the most, most expressed that the face-to-face classes on Saturdays, and the flexibility of the schedule to follow the actions online, facilitated the monitoring of the course activities. They also praised the quality of the didactic material as well as the preparation of the team, teachers, scholarship holders and collaborators, who carried out the training action. Regarding what they liked the least, the points highlighted by the vast majority were the lack (or a reduced number) of robotics kits in schools, infrastructure problems related to the data network (internet/wifi), and problems arising from the large workload of the students in their respective schools. There were also manifestations about the insufficient time for the execution of the proposed activities within the face-to-face workshops, about the difficulty related to the programming actions, and also about the need to extend the deadline for the delivery of the forms referring to the distance learning activities developed throughout the course.

EDUCATIONAL ROBOTICS COURSE WITH ARDUINO: DEVELOPING INTERMEDIATE PROJECTS

50 vacancies were offered for the intermediate level course, being intended exclusively for teachers from the public school system of the State of São Paulo. Only the course teachers who had taken and achieved approval in the previous extension course – "Introduction to Educational Robotics: from Theory to Practice", were able to participate in this training. In this course we had 27 students enrolled, from schools in several cities in the region of the Board of Education of Guaratinguetá / SP, among which we can mention: Aparecida, Cachoeira Paulista, Cruzeiro, Cunha, Guaratinguetá, Lavrinhas and Lorena.

17 (seventeen) students were successful in completing the course. Considering that the course aimed to expand the contents seen in the basic level course ("Introduction to Educational Robotics: from Theory to Practice"), complementing the levels of theoretical and practical knowledge in the area of Robotics of basic education course teachers, demonstrating the potential of using robotics for the teaching of multiple contents, and reinforcing the use of another teaching tool focused on technology, It is considered that the number of graduating teachers was satisfactory.

At the end of the course, an evaluation instrument was applied to the participants in order to evaluate the course. The system and model of the evaluation form followed the same molds as the one used in the evaluation process of the basic level course. Below we present an analysis of the results obtained.

We recall that the objective questions were prepared in order to obtain evaluation results related to the didactic material used throughout the actions, the approaches used both in the development of face-to-face actions and in online actions, and about the team, teacher and tutors, responsible for the application of the course. We used the 5-point Likert scale, ranging from 1 = totally dissatisfied / totally disagree to 5 = very satisfied / totally agree, in order to assess the degree of agreement of the students with the information presented.

Considering, in this analysis, the answers to the options "satisfied" and "very satisfied / totally agree", it was observed that the students agreed with all the statements, with percentage indexes, in the vast majority of questions, above 70%. For example, for statement (2) we obtained a degree of agreement of 93.8%, for statement (10) we obtained a degree of agreement of 100%, for statement (6) we obtained a degree of agreement of 93.8%, and for statement (13) we obtained a degree of agreement of 100%.

On the other hand, we observed that there are still some points to be improved, such as, for example, in relation to the statement "The distribution of the workload between theory and practice", 56.3% of the students positioned themselves as "satisfied". But we emphasize that the students evaluated the theoretical and practical approach of the course carried out by the responsible team in an extremely positive way.

Regarding the discursive questions, as in the previous course, the students expressed themselves on aspects related to the development of the course, such as: the points of the course that most benefited them, the points to improve in the actions developed, and, in both cases, different questions were proposed for face-to-face and online activities.

Some of the answers of the students regarding the positive points of the course are listed below:

> "Problem solving in practice, stimulating creativity and innovation, and preparing for future challenges."
> "Structure, material, support from teachers."
> "Support from teachers in the assembly of projects, interaction with colleagues and components available for assembly."
> "Quality of classes; knowledge of teachers/instructors; projects."
> "The use of the multimeter, the construction of the cart and the programming."
> "Flexibility of schedule, interaction (Network) and use of screen sharing to help with the challenges of remote classes."
> "Improved use of the Tinkercad platform and synchrony with face-to-face classes."
> "Expansion of knowledge of the Tinkercad platform; Complementation of distance learning classes with face-to-face classes."
> "Expansion of the use of the tinkercad platform, Theoretical class complements face-to-face practice."

Considerations on the points to be improved, indicated by the students, are listed below:

> "Very long face-to-face class period."

> "Leave the codes ready and as the class progresses, the student can modify it. Typing takes a long time."
> "Suggestion for the duration of the one-hour online class."
> "Schedule at the beginning of the course and according to the SEDUC calendar, and more face-to-face classes."
> "Very long (tiring) class time,"
> "Time management by teachers (for culmination)."

Analyzing the answers of the students, with regard to what they liked the most, most expressed that the face-to-face classes on Saturdays and the flexibility of schedule to follow the actions online, were positive points that facilitated the monitoring of the course activities. The use of the instrumentation bench, used in the face-to-face actions, as well as the availability of robotics material so that the students could carry out the electronic assemblies, were also pointed out as positive points of the course. The synchronism between the content presented during the distance learning actions, and in these activities new features of the Autodesk TinkerCad software were used, and the face-to-face activities was also highlighted as one of the strengths of the course. The students also praised the quality of the didactic material, as well as the preparation of the team: professors, UNESP/FEG scholarship holders, and collaborators, who carried out the training action.

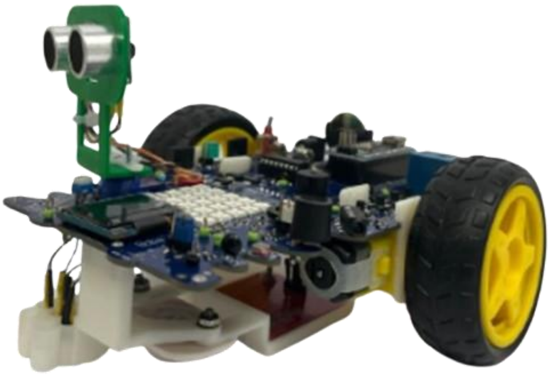
A point of attention is in relation to the duration of the face-to-face activity, because in this course the face-to-face activities lasted 6 hours/meeting, and the addition of 2 hours/meeting made the face-to-face actions very extensive.

EDUCATIONAL ROBOTICS COURSE WITH ARDUINO: DEVELOPING ADVANCED PROJECTS

The course, still in progress, is intended for the training of teachers from the public school system in the state of São Paulo approved in the previous extension course "Educational Robotics with Arduino: Developing Intermediate Projects", offered by UNESP – Faculty of Engineering and Sciences Campus of Guaratinguetá. 20 vacancies were offered for the course.

As the advanced level course is still running, we still do not have the indicative data to carry out an evaluative analysis of its completion. The activities of this course are being carried out with the robotic platform called "Robot-INOVEE" (Figure 3).

Figure 3. Robotic platform "Robot-INOVEE" developed by researchers from the Center for Innovation in Energy Efficiency.



Source: The author.

The Robot-INOVEE platform was developed by researchers from the Center for Innovation in Energy Efficiency – INOVEE, aiming at its use in robotics courses of all levels, from those involving fundamentals of electronics and programming to advanced robotics projects. This robust and versatile kit is equipped with a wide range of sensors and actuators that allow you to configure the robot both as a line follower and as an obstacle avoidance robot. Among the components, ultrasonic, light, sound, temperature, and current sensors stand out, as well as an RFID (*Radio Frequency Identification*) sensor for object recognition and a *Real Time Clock* (RTC) sensor, which allows you to perform timed tasks accurately. The microprocessor LED array makes it possible to create interactive light patterns, while the electronic relay provides additional control over external devices. The kit also features Bluetooth and Wi-Fi connectivity, making it easy to communicate and remotely control the robot. In addition, there are several measurement points where the user can monitor different parameters during the experiments, further expanding the learning possibilities. With this kit, it is possible to carry out up to 100 different experiments, being an ideal tool for a practical, rich and engaging experience, at each stage of the student's journey towards the world of robotics.

The syllabus proposed for this course was: Fundamentals of the robotic platform "Robot-INOVEE": microcontroller, integrated components and connectivity. Programming of the INOVEE Robot by IDE. Sensor reading. Visual output and physical output triggering. Remote mode control of external devices. Dial activation. Use of timing. Establishment of communication using I2C protocol and wireless communication. Development of applications in interdisciplinary areas using the Robot-INOVAE platform.

CONCLUSION

We observed that the courses, especially the editions referring to the introductory approach (basic course), aroused a great interest in the teachers of the public schools in the region of the Board of Education of Guaratinguetá, considering not only the number of teachers enrolled, but also the discussions related to the possibility of expanding, at a later time, the target audience of the course. In this context, the organizing team considers the possibility of establishing new partnerships, between the University and other Education Boards, or even with city halls in the region, aiming to offer new editions of the courses, revised and improved based on the suggestions and criticisms reported by the participants of the courses already held.

At the end of this project, we can highlight that teacher training courses, such as those described in this article, contribute to a better and more efficient use of new technological resources in the classroom by teachers, meeting the curricular guidelines established for basic education. More specifically, in the case of the state of São Paulo, the courses meet the need to better prepare teachers for the use of robotics kits, made available by the state for several public schools, as well as the preparation of teachers responsible for disciplines in the area of technology.

It should also be noted that the partnership established between UNESP and the Board of Education of the region of Guaratinguetá, aiming at teacher training for the use of new technologies in the classroom, can be beneficial for UNESP itself, as better prepared teachers will be able to offer better training to their students. This better training, based on new technologies, can contribute to the motivation of these students to pursue careers, at a higher level, in the areas of exact sciences (for example, opting for Engineering courses), and they may be, in a few years, students of the University itself.

REFERENCES

1. Brasil. (2018). *Base Nacional Comum Curricular: Educação é a Base*. Brasília, DF: Ministério da Educação. Disponível em: http://basenacionalcomum.mec.gov.br/images/BNCC_EI_EF_110518_versaofinal_site.pdf. Acesso em: 20 de março de 2020.

2. Da Fonseca Silva, S., Ramos da Silva, J., & Roger Silva, H. (2018). Robótica educacional e a capacitação de professores da educação infantil. *CIET:EnPED*. São Carlos, maio 2018. ISSN 2316-8722. Disponível em: . Acesso em: 14 de novembro de 2019.

3. Duch, B. J., Groh, S. E., & Allen, D. E. (2006). *El poder del aprendizaje basado en problemas: Una guía práctica para la enseñanza universitaria* (1ª ed.). Lima: Fondo Editorial de la Pontificia Universidad Católica del Perú.

4. Ferraz, A. P. C. M., & Belhot, R. V. (2010). Taxonomia de Bloom: Revisão teórica e apresentação das adequações do instrumento para definição de objetivos instrucionais. *Gestão & Produção*, 17(2), 421–431. Disponível em: https://doi.org/10.1590/S0104-530X2010000200015. Acesso em: 11 de outubro de 2024.

5. Gerhard, A. C., & Rocha Filho, J. B. (2012). A fragmentação dos saberes na educação científica escolar na percepção de professores de uma escola do ensino médio. *Investigações em Ensino de Ciências*, 17(1).

6. Markham, T., Larmer, J., & Ravitz, J. (2008). *Aprendizagem baseada em projetos: Guia para professores de ensino fundamental e médio* (2ª ed.). Porto Alegre: Artmed.

7. Martin, F., Mikhak, B., Resnick, M., Silverman, B., & Berg, R. (2000). To mindstorms and beyond: Evolution of a construction kit for magical machines. In Druin, A. & Hendler, J. (Orgs.), *Robots for kids: Exploring new technologies for learning* (pp. 9–33). San Francisco: Morgan Kaufmann.

8. Massa, N. P., Oliveira, G. S., & Santos, J. A. (2022). O construcionismo de Seymour Papert e os computadores na educação. *Cadernos da Fucamp*, 21(52), 110–122.

9. Pinto, M. C., Elia, M. F., & Sampaio, F. F. (2012). Formação de professores em robótica educacional com hardware livre Arduino no contexto Um Computador por Aluno. *Anais do Workshop de Informática na Escola*, (p. 158–167). ISSN 2316-6541. Disponível em: http://dx.doi.org/10.5753/cbie.wie.2012.%p. Acesso em: 13 de novembro de 2019.

10. Reis, G. L., Souza, L. F. F., Barroso, M. F. S., Pereira, E. B., Nepomuceno, E. G., & Amaral, G. F. (2014). A relevância da integração entre universidades e escolas: Um estudo de caso de atividades extensionistas em robótica educacional voltadas para rede pública de ensino. *Interfaces– Revista de Extensão da UFMG*, 2(3), 52–76.

11. Silva, F. V. E., Kottwitz, P. W., Rosa, J. A., Scheid, R., & Ribeiro, L. D. N. (2018). Uso da robótica como ferramenta para o ensino das ciências exatas. *Cataventos - Revista de Extensão da Universidade de Cruz Alta*, 10(2), 82–93.

12. Souza, I. M. L., Rodrigues, R. S., & Andrade, W. L. (2016). Introdução do pensamento computacional na formação docente para ensino de robótica educacional. *Anais dos Workshops do V Congresso Brasileiro de Informática na Educação (CBIE 2016)*, 1265–1274.

13. Tripp, D. (2005). Pesquisa-ação: Uma introdução metodológica. *Educação e Pesquisa*, 31(3), 443–466.