Chapter #12

HOW TO USE ROBOTICS IN EDUCATION

Leonardo Mesquita, Galeno José de Sena, & Matheus de Felippe Ferreira
São Paulo State University – UNESP, Av. Dr Ariberto Pereira da Cunha, 333 – Portal das Colinas – Guaratinguetá – SP, Brazil

ABSTRACT
This article describes a method for structuring and developing training programs based on educational robotics. The method can be applied in short-term programs, such as workshops, as well as in longer-term courses. We also present a mini-course structured according to the method, proposed and applied in form of a workshop to students and teachers of public secondary schools. The use of educational robotics to stimulate student learning in public schools is a reality in several developed countries of the world. In the Brazilian context, the main motivation underlying this project is the shortage of laboratories and materials for the development of experimental activities, observed in public schools. Thus, the development of the course allows not only students, but also their teachers, a contact with technological innovations, in particular in the field of educational robotics. The developed mini-course covers the topics and concepts of electronics and programming based on the Arduino platform, aiming to present the main resources available in this platform to propose and develop robotic-based educational activities. The course presupposes an active attitude of the students, who are instigated to "get hands dirty", which also contributes to their formation, through the development of new skills and abilities.

Keywords: educational robotics, arduino, robotics platform.

1. INTRODUCTION

Changing educational methodologies designed to cope up with the industries' human resources demands for new skills and competencies is an ongoing challenge. Accentuated in the late 20th century (D'Aveni, 1994) and in the 21st century, the search for individuals best suited for specific knowledge areas and social prowess has given rise to several new educational formats, as the traditional education system from earlier decades proved to be outdated to meet such standards.

Alas, most developing countries' schools do not apply these new methodologies in an efficient way, due to un-readiness of educators, lack of investment in education, or even lack of student motivation in specific subjects (OECD, 2013). To tackle such issues, some methodologies have been tailored and adapted according to such scenarios, providing training materials for educators, developing interactive and challenging activities for students and doing so with reduced costs for low-income schools.

One such methodology is called "STEM Education", in which educators encourages learning in Science, Mathematics, Engineering and Technology courses, crucial areas for developing competencies needed in the professional market that normally sounds unappealing in traditional teaching formats (Horta, 2013). The use of robotics platforms is commonly adopted in this approach, as it broadens the range of activities that educators can exploit, as well as the possibility of integrating project management tools in higher education scopes (Oliveira, Oliveira, & Carvalho, 2016).

As Vasques points out, Educational Robotics can be considered an essentially interdisciplinary area (Vasques, 2010). Therefore, in this educational environment constituted by robotic devices, there is a constant dialogue of several disciplines such as mathematics, physics, computation, electronics, mechanics, among others. When students program a robot, they must develop/compose an algorithm to solve the problem in a logical mode and also need knowledge of physics to understand how the sensors operate.

According to Santos and Menezes (2005), educational robotics can be defined as the pedagogical context in which the student uses computers, electromechanical components (motors, gears, sensors, wheels, etc.), electronics (hardware interface) and programming, so that a given action can be performed.

For Sena dos Anjos (2008), Giordan (2006) and Miranda Junior (2005), educational robotics can offer important contributions to the teaching of science, especially for physics teaching. This is because it can offer important applications of fundamental physics concepts, as well as enable the development of procedural skills and competences.

In addition, it can be affirmed that educational robotics can motivate the student to learn concepts in view of the playfulness of knowing how to make something work. In this sense Vargas, .Menezes, Massaro, & Gonçalves. (2012) show that, unlike traditional teaching methods, this new pedagogical strategy has a significant impact on teaching and learning process because it arouses curiosity and elicits students' greater interest in the proposed activities. Thus, in each proposed activity, the student is challenged to find creative solutions, mobilizing knowledge, skills and competences. In this perspective, they are encouraged to formulate and test hypotheses, discuss new possibilities and interact more broadly with their peers.

Currently, different possibilities of application of robotics projects are offered for teaching science, among them Lego Mindstorms NXT and Arduino board, a platform of electronic prototyping of free hardware based on a circuit with inputs and outputs of digital and/or analog signal (Schivani & Pietrocola, 2012).

The low cost of the Arduino boards has made this platform an appropriate resource for different didactic applications. However, the teacher is not always technically and/or methodologically prepared to use this innovation in his classes. In addition, it should be noted that, given the limitations of time and the large amount of scientific content to be addressed in the high school physics and mathematics classes, teachers feel unmotivated to implement the use of educational robotics in their classes, as this would involve more content to be worked on.

In Brazil’s current scenario, public and private schools that implement this type of education format are few and far between, mostly limited to major institutions in big urban districts. As such, the vast majority of students up to secondary education are unable to maintain an interest in STEM fields, thus compromising R&D capacity of the national industry. While there is much room for improvement with regards to teaching strategies and how to motivate students, there is an aspiration towards better education by providing better equipment and teaching materials for middle and higher schools, even when considering disadvantaged regions and socioeconomic classes.

In this context, this article describes a method for structuring and developing a mini-course based on educational robotics, aimed mainly at students of public secondary schools located in region of the Campus of UNESP Guaratinguetá, Brazil. The main motivation underlying this project is the lack of laboratories and materials, as well as the lack of preparation of teachers for the development of experimental projects and activities, observed in Brazilian public schools. Thus, the development of the course, in the university itself or in the schools, allows not only for students but also to their teachers, a contact with technological innovations, in particular in the field of educational robotics. Among other aspects, the course presupposes an active attitude of the students, who are instigated to "get hands dirty" during all its accomplishment, which also contributes to their formation, through the development of new skills and abilities.

Although this paper focuses on a mini-course about electronics programming and robotics concepts applied to high school students, the elaborated material can be extended for longer workshops, semester or yearlong subjects in schools, and even for tertiary education. Also, by gathering feedback from the students before, during and after the course is completed, educators can continually improve their teaching methods, giving flexibility and engaging incrementally larger group of students in STEM fields.

This paper is divided into four sections. The first section describes the robotics course proposal, presenting the main phases and core values of this course. In the second section a methodology for a robotics course application is proposed. The third section presents and discusses the results of the application of the robotics workshop within the activities planned for a Science Fair held at UNESP. This section also presents results of the application of the robotics course for a public high school, which is under the jurisdiction of the Teaching Board of the Guaratinguetá region in Brazil. And finally, in the fourth section, some conclusions of the work are presented.

2. COURSE STRUCTURE AND CORE VALUES

The primary idea for the course is to be succinct, straightforward and as interactive as possible, so that the students do not feel discouraged by being passive listeners. To do so, the educator must indulge in the main concepts of the course, comprehend the desired learning curve, adapt its sub-concepts for the age and previous background experiences of the students, and elaborate flexible and diverse applications for the studied topics. By doing so, not only can the educator better apply the methodology through the adjustments during application, but, by identifying the students' potential skills and competencies, multi-task groups can be formed between students to maximize their success in activities and projects, while also fostering a friendly competition and rewarding creativity.

Considering this, the course is divided into three main phases: theoretical learning, practical learning and project development. To maximize flexibility and cost-efficiency, the entire course is based on the Arduino platform, which is currently one of the most supported open-source platforms (Arduíno, 2017), providing easy-to-use programming language and extensive collection of electronic devices that can be connected to it. An image of one Arduino circuit board used in the course, Arduino UNO, is depicted in Figure 1.

Figure 1.
Arduino UNO board.

In theoretical learning, students learn the basics of electronics and programming principles, going from units for measuring voltage and current, Ohm's law, primitive components, sensors, programming logic, flowcharts, conditional structures, and so on. The key factor in this phase is to supply the required knowledge to the students regarding how electrical circuits work, while stressing the core concepts repeatedly throughout all the classes. Instead of focusing on overly complex mathematical equations and expressions in advanced circuit analysis, the educator can use simple examples that fit the reality of high schoolers, while still using basic expressions to convert electrical units, convert between number formats (decimal to binary, for example) and calculate voltage drops in simple resistor arrangements.

In practical learning, students apply understandings from theory by building the circuits and programs. The educator can use the first part of the class to reinforce core concepts and provide examples, using new components or commands, while the second part of the class focuses on students executing the planned activities by themselves and in groups. Here, the educator is encouraged to incrementally increase the difficulty of the course planned activities, taking previous examples or activities' programs and circuits as a basis for more complex ones. It is highly advised and encouraged to use good practices in programming such as flowcharts to illustrate the logic of the intended functionality and dividing the main program into multiple independent simpler functions instead of writing the whole program during the first attempt, so that the students can become more efficient and apply the same behaviors outside the school.

Finally, the project development phase focuses on evaluating how much content the students have absorbed, while testing their creativity, originality and developed competencies by means of implementing the learned concepts in a functional product based on what is available on the market or in their daily lives. In an application of the course, for example, a modern car served as a motivational factor to make students excited for what could be built at the end of the course, as well as a basis for introducing several concepts in electronics such as applications of motors, LED (light emitting diode), distance sensors, infrared receivers, LCD (liquid crystal display), and so on. Figure 2 illustrates that learning platform.

Figure 2.
Automated toy car as a robotics learning platform.

Although this phase is to be expected in the last part of the course, it is recommended to approach this phase along the last topics of the previous parts, so that students can have time to look for inspiration for their projects inside the classroom and not be taken by surprise. As previously mentioned, the educator should ensure that the main goal of this phase is not to prioritize time to completion or features involved in the project, but rather to consider projects in more abstract terms such as their originality, flexibility in operation, interactivity with the end user and visual appeal.

Throughout the entire course, the educator should provide and receive feedback as much as possible in order to acknowledge potential gaps in teaching methodology, opportunities for implementing new devices during the course development, discarding concepts that are hardly used in practical examples and adapting the level of challenge for each topic. If possible, providing a communication channel like a blog or intranet community and encouraging students to share ideas, doubts, findings and developed circuits and programs is recommended to unify the classroom students and build up a sense of belonging between them.

3. METHODOLOGY

For Maxwell (2006), Papert and Piaget were adept of the idea that young people build their own knowledge from their interaction with the learning object. However, Papert (1991) proposed a much richer environment of stimulations and possibilities of experience. He believed that the learning process is increasingly effective the more the teaching context offers possibilities for concrete activities in which the students not only try and test, but also build a meaningful product after their interactions with objects. However, even though educational robotics provides a "building" environment in the sense discussed, like experimental activities, robotics is just an additional tool available to the teacher, which should be correctly used to be effective. In this context, the method for structuring a course proposed here contemplates in its second phase an interaction of students with the "objects" used in the activities, Arduino platform and various electronic devices and, in the third phase, the development of a challenging project to verify if the students acquired and retained the knowledge about the proposed theme.

3.1. Robotics course

In the proposal for the application of the robotics course, we proposed that every class will result in a complete activity that includes development of software, hardware and documentation of the project. The intention was to make all course activities have predefined requirements that enable teachers to use technology as a tool in the teaching-learning process. These requirements were previously discussed by the team of researchers in order to provide participants with an overview and context of a problem so that students not only learn the necessary programming requirements but also learn concepts related to the development of electronic and mechanical systems (hardware), and also have the capacity to carry out all project documentation. Based on the actions described above, the proposed course focuses on the following issues during the execution of each lesson:

- **Contextualization:** The teacher must present the characteristics around a certain real problem of any area to start a discussion of the subject with the students participating in the course. The problem can be about any area of knowledge, such as telecommunication, transportation, entertainment, etc.

- **Material:** It is the moment when the student gets to know the devices (hardware). At this time, students will also be presented with the measuring equipment normally used as support tools during assembly of the hardware. It is of fundamental importance that every student understands not only the main characteristics of the equipment but also how the components relate to each other before starting the assembly of the schematic circuit itself.
- **Assembly:** The time when students will assemble the hardware. This step is extremely important because the students will perform previously discussed actions and, at the end of this stage, will gain confidence to work with components, wires, measuring instruments and with the breadboard.
- **Flowchart:** Logic concepts are presented to the students. They will understand the flow of information and the actions of the experiment, developing the concepts of logic with ideas that will be used in the programming.
- **Coding:** Here the flowchart is translated into code (software). The students will learn the syntax of the instructions and how the programming language can help in solving the problem.
- **Characterization:** At this moment, the students will do the integration between hardware and software of the proposed project. Verification tests will be performed to prove the operation of the experiment according to its previous specification.
- **Discussion of the results:** The conclusion of the lesson is presented by making a correlation between the activity performed and something that is part of the daily life of the student. The teacher should also instigate and suggest changes to the proposed project, always questioning the students regarding the consequences of such changes. A good practice, too, would be to suggest a challenge to the participants linked to the concepts presented during the lesson.

Some of the mentioned issues coincide with the sections proposed in Rafael et al. for the execution of experiments (Alves, Silva, Pinto, Sampaio, & Elia, 2012). For example, the issues related to the material and assembly, in which we presented the list of necessary materials and how we must mount them are similar. Meantime, the approach is different, since in our proposal we also emphasize the main characteristics of all component necessary for the assembly of the experiment and how we must use the available equipments of measurement. Another example of the difference of the approach of the proposals can be seen in the issue of codification, in which we carry out the transformation of the flowchart into software (code) to execute the action of the proposed experiment, whereas in the above-mentioned work the students only copy a code previously developed by the instructors for the experiment to be executed.

The above mentioned issues proposed for the execution of a class activity during the workshop correlate with the phases of course development, indicated in section 2, as follows. The theoretical learning can be inserted in the tasks contextualization, material and flowchart; practical learning is part of the assembly phase of hardware, code development (coding) and execution of the prototype characterization built in the application. And finally, the project development stage is associated with the results discussion stage, in which the teacher should instigate the participating students to perform other tasks with the concepts discussed and learned during the course of the lesson.

3.2. Development of the mini-course

The methodology used in this work was the development of practical activities involving the use of Arduino and the IDE programming environment in form of workshops. The activities were attended by 109 students from public schools in the state of São Paulo - Brazil, and the duration of a workshop such as the one described here is from 2 to 3 hours. Supervision of the activities was carried out by 2 higher education teachers and 10 scholarship holders linked to the research, were the scholars acted as tutors during the execution of the activities. In order to promote a greater interaction between tutors and students, the activities were performed in a laboratory containing benches, computers and all the measurement instrumentation necessary for the execution of a workshop, as this provides a different environment to the participants in relation to the classrooms in the public schools they attend.

The activities proposed for the execution of the workshop were structured according to the theoretical and practical learning phases for the development of a course, as described in section 2. The activity begins with the distribution of the kits containing the necessary materials for the execution of the tasks. A presentation is held on fundamentals of programming logic as well as the Arduino platform showing students its main features and its electronic components. After a brief exposition, students may experience the use of the IDE programming environment and the use of some electronic components that will be employed in the development of activities. We finish this introductory action with the assembly of a basic project, this being an electronic light activation system. Usually, this action has an average duration of 30 minutes.

The next activity is to teach students the differences between analog and digital inputs. To introduce these concepts we present new electronic components, such as: potentiometer and luminosity sensors. At the moment, new programming structures are presented, mainly conditional programming structures. In this phase, the projects developed were the control of the brightness of a lighting system and an automatic lighting activation system. The average duration of these projects is 1 hour.

We finished the workshop by executing a challenging project, that is, this action emphasized the execution of the project development stage, presented as the last phase of the proposal for structuring a course, as indicated in section 2. Therefore, in this action the students were instigated to develop (give the solution to) a basic electronic project in the area of residential automation, with the concepts learned during the initial stages of the workshop. At this stage, students were already familiar with the IDE programming interface and with the Arduino platform, as well as with the electronic components needed to perform the task: LED, resistors, potentiometer, and light sensor (LDR). The proposed challenging project was the control of simultaneous activation of lighting of several existing environments in a residence. Thirty minutes was stipulated as the minimum duration time to execute this task.

4. RESULTS

The first Robotics Course was conducted within the planned actions of a Technological Fair called EXPRECI - Regional Exhibition of Engineering and Science. The fair included the Robotics Workshop aimed at high school students who, for the most part, had not had any previous contact with robotic platforms or the like. The workshop lasted 2 hours and each class had 21 students who were divided into 7 groups of 3 students each. The proposed activity consisted of 3 complementary projects, and for each project each student in a group performed a pre-established action. In the first project one student was responsible for the development of the project software, the second participant of the group was responsible for the development and assembly of the hardware and the third student was responsible for the documentation of all the stages of development of the project. At the end of each project, the members of the group took turns and began to develop a new project. By the end of the three activities (projects) all the members of the group had participated in all the planned actions of the workshop, including development of the hardware, software and documentation of the project.

The course was applied in 3 classes totaling the application in a group of 63 students. The team responsible for the application was composed of teachers and tutors linked to the Center for Innovation in Energy Efficiency - INOVEE of the Faculty of Engineering of Guaratinguetá - UNESP.

At the beginning and end of the activities, pre and post workshop questionnaires were completed with the intention of evaluating the results obtained from the application of the course. Table 1 presents the questions answered by the students before the beginning of the course activities.

Table 1.
Questionnaire and its results before the application of Robotics Course.

	Yes	No
Have you heard of robotics?	60	1
Have you ever wanted to create some electronic equipment?	33	28
Are you curious about how electronic equipment works?	46	15
Do you know how to relate robotics to things from your everyday life?	41	20

From the obtained results we can affirm that the great majority of the students (60) had already heard of robotics; moreover, most of them (41) knew how to relate robotics to their daily lives. It was also very interesting to find out that most students were curious about how electronic instruments work.

Table 2.
*Results obtained after the application of the Robotics Course to high school students.**

	Strongly Agree	Agree	Disagree	Strongly Disagree
1) Was there anything interesting at the beginning and during the realization of the Robotics Workshop that caught my attention?	16	36	4	2
2) Was there anything during the Robotics Workshop that was demotivating?	3	17	28	10
3) Did I enjoy doing the activities?	18	30	6	4
4) Is the content seen during the workshop related to things I already knew?	4	14	24	15
5) Can I relate day-to-day situations to the subject of the workshop?	17	24	15	1
6) Did I feel that the proposed activities are appropriate for my level of education?	12	30	11	4
7) Did the laboratory experiments favor my development to work in a group?	20	34	3	0
8) Did the development of group activities during the experiments help my learning?	15	33	8	1
9) Did I have difficulty working with the IDE programming platform?	16	24	14	3
10) Did I enjoy performing the activities of the Robotics Workshop?	18	28	8	3
11) Did I like the content presented in the Workshop?	17	29	8	3

(*) Some students did not answer the questionnaire.

Table 2 shows the results of the application of another questionnaire to the students after the execution of the expected activities of the robotics course. From results presented in table we can conclude that the participants approved the proposed format of the workshop, since most of the students liked to carry out the activities, were motivated during the execution of the tasks and that they also approved the content presented in the workshop (answers to questions 1, 3, 10 and 11). The dynamics adopted for the course was also approved by the students, since the great majority liked to work in groups and felt that the group work helps their learning process on the robotic theme. A point to be worked on in the next applications of this course refers to the use IDE-based Arduíno programming platform, since the great majority of the students indicated that they had difficulties in the use of this interface. One option would be to use some graphical interface to accomplish this task.

The second Robotics Course was conducted with students from a public high school in the jurisdiction of the Teaching Board of the Guaratinguetá region. This activity was carried out with two distinct classes of students enrolled in the last year of high school. In total, 46 students participated in the Robotics Course, of which 25 students participated in the first activity that occurred on August 18, 2017, and we had 21 students participating in the second activity that occurred on October 20, 2017. The activity had the expected duration of 3 hours and, during the activities, the students were divided into groups of 3 students each. At the end of the activities a questionnaire was applied with the intention of evaluating the impact of the course for the students participating in the activity. A Likert-type scale was used in the proposed questionnaire, containing the options: (1) Strongly disagree; (2) Disagree; (3) Indifferent (neither agree nor disagree); (4) Agree; (5) Strongly agree. Table 3 presents the responses presented by the participating students during the proposed Robotics Course.

Table 3.
*Results obtained after the application of the Robotics Course to public high school students.**

	1	2	3	4	5
1) There was something interesting at the beginning and during the realization of the Robotics Course that caught your attention	0	1	0	18	26
2) There was something during the realization of the Robotics Course that left you unmotivated	26	12	5	1	1
3) It was pleasant for you to carry out the activities	0	0	2	10	33
4) The content seen during the course is related to things you already knew	7	12	10	11	5
5) The content seen during the course is relevant to your interests at school or in your professional life	0	3	10	20	17
6) You were able to relate day-to-day situations with the subjects worked in the course	0	3	3	24	14
7) You realized that the proposed activities were appropriate for your level of knowledge	0	5	13	18	9
8) The implementation of the activities in the course favored the development of their capacity to work in groups	0	1	2	17	24
9) The development of the group activities in the course helped you to learn better	0	0	1	20	24
10) During the course there were times when you felt bored	19	12	7	4	3
11) You had difficulty working with the Arduino IDE programming platform	8	12	11	12	1
12) Did you enjoy performing the activities of the Robotics Course	0	0	0	7	38
13) You liked the content presented in the course	0	1	0	7	37

(*) Some students did not answer the questionnaire.

The answers to questions (1), (2), (3) and (10) indicate that the dynamics proposed for the application of the Robotics Workshop is extremely consistent with the wishes of the target audience, composed of young people aged 15 to 17 years. After a 3-hour activity, participants report that there was something interesting, not only at the beginning of the activity, but also throughout the activity to the end. Overall, students indicated that they were very motivated and that it was pleasant to participate in the course.

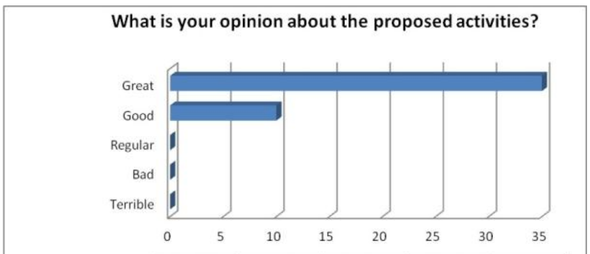
Analyzing the responses from question (4) we find that students still have difficulty in relating the experimental activities performed during the course with their previous knowledge or even with situations found in everyday life. This reinforces the teacher's need, when discussing the results, not only to discuss with students daily aspects where the concepts seen during the workshop are applied, but also to correlate the execution of the experimental activities carried out in the course with the content already discussed in the classroom, mainly in the subjects of Science and Mathematics.

Based on the responses to the question (11), we observed that there was a reduction of students who had difficulty using the IDE programming interface, when compared to the students who performed the activity during EXPRECI. But, even with this positive result, the work team is checking the possibility of using another programming platform for the Arduino controller to introduce the concept of programming in a more intuitive way for students participating in the course. As the vast majority of participants do not have prior experience with programming environments, we believe that it may be useful to use an Arduino graphical programming interface for the initial development of activities.

Finally, we must reiterate that the application methodology proposed in this work was very effective, since almost 100% of the participants indicated that they liked the activities they performed during the Robotics Course (answers to questions (12) and (13)). It is also important to highlight that the students stated that they liked the activity (Figure 3) and also that they feel motivated to continue the activities planned for the Robotics Course at an upcoming meeting (Figure 4). We list below some of the justifications given by students about why they would attend a new meeting on educational robotics.

"It's very interesting, I learned something new and different."
"Yes, it was very productive and interesting."
"Yes, because the activities are very interesting."
"Yes, because I really enjoyed learning new things."
"Because it was super cool and I wanted to learn more."
"Because I really enjoyed this subject."
"I found the development very interesting"
"Yes, because it is not a difficult thing to learn but rather easy for your general knowledge."
"It's motivating"

Figure 3.
What is your opinion about the proposed activities?



	Terrible	Bad	Regular	Good	Great
Number of students	0	0	0	10	35

Figure 4.
Do you feel motivated to continue workshop activities at an upcoming meeting?

Therefore, at the end of the workshops, we found that the students were able to perform a challenge activity, which corresponded to an update of one of the proposed systems, so, intentionally not being a more complex project, since there would not be enough time in a single workshop. At the level of knowledge, the students, with the help of teachers and tutors, were able to relate the proposed activities to everyday situations experienced by them; at the level of understanding they could interpret the proposed specification, identifying that the challenging activity was only an update of one of the systems proposed and discussed in the course of the actions of the workshop; and, at the application level, they were able to build the hardware and software, from modifications in the codes used in previous activities, necessary to perform the task. With a view to reinforce concepts, the students were encouraged to explain to the teachers and tutors the actions taken to solve the challenge task, which they were able to accomplish at a very satisfactory level.

5. CONCLUSION

In this work we present a methodology for the application of a robotics course for high school students based on three main actions: learning of theoretical concepts, practical learning and execution of a robotics project. In the proposed methodology, the following issues should be worked out during each lesson: contextualization of the problem, material, hardware assembly, flowchart and coding (software development), characterization and discussion of the results. Robotics is a multidisciplinary area, therefore, it stimulates students to seek solutions that integrate concepts from other disciplines involved, such as mathematics, physics, electronics, computer science, mechanics, among others.

It is important to emphasize the importance of the tutors in the execution of the activities, because during the execution of all the planned actions of the workshop the tutors supervised the activities performed by the students, and in this way the doubts raised were quickly remedied. We also highlight the action of interaction between the tutors (students of higher education) with the high school students of the public network of the state of São Paulo, coming to the meeting of development for citizenship, since the tutors and students of the public network, in general, come from different social contexts.

Another important aspect concerns the number of students who composed the groups in the two robotics courses described in this article: each group was made up of 3 students, a number that we could observe facilitated the understanding of the proposed activities and promoted a greater interaction between the students of the group itself and also with the tutors, creating an environment that enabled a greater exchange of experiences.

We also emphasize that the application of the course, in the form of workshops, following the method described in this article, provides an environment conducive to group work rather than individual work, and with this, execution of the activities turns out to be more productive. Joining theory and practice, the workshops of the robotics course allowed students to develop skills such as: creativity, autonomy, problem-solving ability and responsibility in performing the tasks that made up the activities.

REFERENCES

Alves, R. M., Silva, A. L. C., Pinto, M. C., Sampaio, F. F., & Elia, M. F. (2012). Uso do harware livre arduíno em ambientes de ensino-aprendizagem [Use of the arduino in teaching-learning enviroments]. Jornada de Atualização em Informática na Educação – JAIE 2012, p. 162-187.

Arduino. (2017). *Getting Started*: Introduction. Retrieved May 27th, 2017, from: https://www.arduino.cc/en/guide/introduction.

D'Aveni, D. (1994). *Hypercompetition*. New York: Free Press.

Giordan, M. (2006). Uma perspective sociocultural para os estudos sobre elaboração de significados em situações de uso do computador na Educação em Ciências [A sociocultural perspective for the studies on the elaboration of meanings in situations of computer use in Science Education]. (Postdoctoral dissertation, University of São Paulo, São Paulo, Brazil).

Horta, H. (2013). *Education in Brazil: Access, Quality and STEM*. Retrieved May 27th, 2017, from: http://www.acola.org.au/PDF/SAF02Consultants/Consultant%20Report%20-%20Brazil.pdf

Maxwell, J. W. (2006). Re-situating Constructionism. *The International Handbook of Virtual Learning Environments*, 279–298.

Miranda Junior, M. R. (2005). Introdução ao uso da informática no Ensino Médio [Introduction to the use of computers in High School]. (Master's thesis, Federal University of Rio Grande do Sul, Porto Alegre, Brazil).

OECD. (2013). PISA 2012 Results: What Makes Schools Succesful? *Resources, Policies and Practices, Volume IV*. PISA, OECD Publishing. Retrieved May 27th, 2017, from: http://www.oecd-ilibrary.org/docserver/download/9813061e.pdf?expires=1495889895&id=id&accname=guest&checksum=726C9015600988837B007490E83123BB

Oliveira, E. T. H., Oliveira, H. A. B. F., & Carvalho, J. R. H. (2016). Generation of Critical Mass in Education: An initiative to engagement. Proceedings of the IEEE Frontiers in Education Conference (FIE), pp. 1-7. Retrieved May 27th, 2017, from: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7757397

Papert, S. (1991). Situating constructionism. In I. Harel & and S. Papert, (Eds.) *Constructionism*. Norwood, NJ: Ablex Publishing.

Santos, C. F., & Menezes, C. S. (2005). A aprendizagem da física no ensino fundamental em um ambiente de robótica educacional [The learning of physics in elementary education in an educational robotic environment]. In XXV Congresso da Sociedade Brasileira de Computação. Unisinos.

Schivani, M., & Pietrocola, M. (2012) Robótica educacional no ensino de física: estudo preliminar sob uma perspectiva praxeológica [Educational robotics in physics teaching: preliminary study from a praxeological perspective]. XIV Encontro de Pesquisa em Ensino de Física – Maresias.

Sena dos Anjos, A. J. (2008). As Novas Tecnologias e o uso dos Recursos Telemáticos na Educação Científica: a simulação computacional na educação em física [The New Technologies and the use of Telematic Resources in Scientific Education: the computational simulation in physics education]. *Caderno Brasileiro de Ensino de Física*, *25*(3), 569-600.

Vasques, C. K. (2010). Robótica Educacional e a Produção Cientifica na Base de Dados da CAPES [Educational Robotics and Scientific Production in the CAPES Database]. *Revista Electrónica de Investigation y Docencia*, *4*, 35-53.

Vargas, M. N., Menezes, A. G. C., Massaro, C. M., & Gonçalves, T. M. (2012). Utilização da robótica educacional como ferramenta lúdica de aprendizagem na engenharia de produção: introdução à produção automatizada [Use of educational robotics as a playful learning tool in production engineering: introduction to automated production]. In COBENGE, 1-12.

AUTHORS INFORMATION

Full name: Leonardo Mesquita
Institutional affiliation: São Paulo State University - UNESP, Department of Electrical Engineering
Institutional address: *Av. Dr Ariberto Pereira da Cunha, 333 – Portal das Colinas – Guaratinguetá – SP, Brazil.*
Email address*: mesquita@feg.unesp.br*
Short biographical sketch: The researcher holds a PhD in Electronic Engineering and Computing from the Instituto Tecnológico de Aeronáutica - ITA (2002). He is currently a Faculty Member with the Department of Electrical Engineering, at São Paulo University - UNESP, teaching Electronics subjects. He has experience in the design of analog and digital integrated circuits, where the digital projects are modeled and synthesized with the help of the programming language VHDL.

Full name: Galeno José de Sena
Institutional affiliation: São Paulo State University - UNESP, Department of Mathematics
Institutional address: *Av. Dr Ariberto Pereira da Cunha, 333 – Portal das Colinas – Guaratinguetá – SP, Brazil.*
Email address*: gsena@feg.unesp.br*
Short biographical sketch: The researcher holds a doctor degree in Informatics from the Pontifical Catholic University of Rio de Janeiro - PUC / RJ (1992) - in the area of Programming and Computer Theory, and a postdoctoral degree by the National Institute of Multimedia Education (NIME), Chiba-shi, Japan (2004). He is currently a Faculty Member with the Department of Mathematics, at São Paulo State University - UNESP, teaching Computer Science subjects. He has research experience in Education, with emphasis on New Technologies in Education, working mainly in the following subjects: project-based learning, new teaching techniques, interdisciplinary projects, educational technology, educational robotics and web environments to support the teaching.

Full name: Matheus de Felippe Ferreira
Institutional affiliation: São Paulo State University - UNESP, graduate in Electrical Engineering.
Institutional address: *Av. Dr Ariberto Pereira da Cunha, 333 – Portal das Colinas – Guaratinguetá – SP, Brazil.*
Email address*: mat.f.ferreira@gmail.com*
Short biographical sketch: Lover of all things robotics since my childhood, my aspirations always were to deepen myself in this area of study, while finding ways to optimize procedures and minimizing design complexity for better understanding for the overall public. My experiences with a scholarship program and volunteer teaching activities opened my eyes for the value of educational excellence in early stages of life, and so I have engaged myself in several projects with Education as the main focus, including development of course syllabus, workshop scheduling and choosing alternate activities to draw the student's attention into STEM fields."