Arandu Project: Engineering applied to Basic Education based on a MAKER and STEM perspective

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ABSTRACT
The ARANDU Project was created in 2016 with the objective of applying engineering project to high school and the 9th year of elementary school with the construction of CanSat. It has support from the Pro-Rectory of Extension and Culture of the Federal University of ABC because it is a project of Brazilian extension that brings students from Basic Education to the University. The theoretical and practical classes are supervised by professors of Aerospace Engineering and taught at the Federal University of ABC by students of Aerospace Engineering. It adopts a maker perspective once the students construct the artifacts to carry out the experiments and the methodology STEM (Science, Technology, Engineering and Mathematics) disseminated by the educational projects of NASA (STEM Lessons From Space). It has stimulated several young people to follow careers in the Engineering courses and also attracted the interest of the students by the Space Sciences.

Keywords
Aerospace Engineering. Science teaching. Perspective Maker. STEM.

1. INTRODUCTION
The STEM perspective began to be inserted in Science Teaching driven mainly by the space race, mainly by the launch of Sputnik 1. It was necessary to increase the competitive advantage in Science and Technology. The dispute in the area of Space Sciences between Russians and Americans led Americans to rethink the question how scientific knowledge was being developed in schools and then public education policies began to encourage scientific and technological knowledge to be developed in an applied way. Overcoming the experimental classes of proof of scientific concepts, the STEM perspective engages in the hands on culture of stimulating creativity for students to create. Blikstein [1] says: "Digital fabrication and 'making' could be a new and major chapter in this process of bringing powerful ideas, literacies, and expressive tools to children. Today, the range of accepted disciplinary knowledge has expanded to include not only programming, but also engineering and design. In addition, there are calls everywhere for educational approaches that foster creativity and inventiveness." STEM focuses on integrating fields of knowledge into participatory and project-based learning. It aims to develop skills and competences so that students are faced with the various challenges that arise in a globalized world and with scientific and technological development advancing faster. Today, STEM education is a priority in public funding in the USA [2] as it is possible to perceive from the speech of the ex-President Barack Obama: "We need to make this a priority to train an army of new teachers in these subject areas, and to make sure that all of us as a country are lifting up these subjects. " Thus, in this article we report a Brazilian educational experience with the STEM perspective that has been successful and stimulated students' interest in Science and Technology, especially engineering.

2. Description of the educational experience: The Project ARANDU
The classes of the Extension Project ARANDU 2018 are taught by the students volunteers and scholars, and most of the time, the students work in practical activities, aiming at the theoretical and practical approach of the subjects necessary for the construction of a CanSat picossatellite, main objective from the project. They are taught using an active learning methodology, with a duration of 4 hours, where the students act in the construction of knowledge and also collaborate with the learning of the class, thus achieving an excellent use and engagement of the students. In the first moment of each class, the discussion between the groups of the question of the week is carried out, which was previously published by the official Facebook page of Arandu and to which all have access. The following is the theoretical approach and an experiment related to the theme. At the end, a questionnaire is carried out to analyze the determination of the subjects presented in class. However, this is analyzed in class, no data collection is performed. The collection of data on content fixation takes place at the beginning and end of the course, which questions questions with the same themes from the beginning are asked to analyze how much was learned throughout the course. After opening the answers to the whole class, there is the theoretical approach by the students, according to the theme of each class. Among them we have: Introduction to Astronautics, Introduction to Electrical and Electronics, Introduction to Programming Language, Programming, Sensors and Microcontrollers, Communication and Networks, Aerospace Materials and Their Properties, Concepts of Technical Design and Modeling, Project Management, Assembly of CanSat. In some classes a game called Kahoot was used, which is an application that the teachers insert the questions and he designs them one by one for the students in video game form, generally taking 30 seconds to respond. This tool promotes a certain competition to respond between groups, who responds faster earns more points. With the support of the UFABC - NTE Educational Technologies Center, it was possible to carry out an integration activity of the

class through virtual reality technology, and with logical tests, where the students could meet and integrate with the colleagues who would accompany them until the end of the course.

2.1. Methodology used in class

In the first class, Introduction to Astronautics (Figure 1), in the first module were introduced concepts of physical quantities, scalar quantities, vector quantities, units of measurement, dimensional analysis and international system of units. Already in the second module, themes on the laws of Newton, law of universal gravitation, Laws of Kepler. These were necessary to arrive at the answer to the question of the week suggested by the teachers and discussed at the beginning of the lesson by the groups. To analyze the progress of content fixation by students, we used the Kahoot![3] With questions related to the theme of the lesson. In the second part of the class, after the whole theoretical approach, there was the application of an experiment that sought to apply the Laws of Newton and Universal Gravitation. The experiment consisted of a square base of wood, measuring 20cmx20cm, with a plastic cup containing water on top of the base. This was tied with a string, so that when rotating 360º the base with the string, the contents of the glass did not fall. The students carried out the construction of the set and carried out the experiment, and spontaneously presented hypotheses of what would explain the contents did not fall, interconnecting these hypotheses on a macroscopic scale, which linking to the theme, are the celestial bodies. At the end of the class the following questionnaire was carried out to analyze knowledge fixation during class, but without data collection. If there were any doubts, the matter was resumed to remedy them.

Figure 1. Lecture on Introduction to Astronautics in the Arandu Project

In the second lecture, on Introduction to Electrical and Electronics, the question of the proposed week was "How is electric power generated from equipment that is in space?". The aim was for them to discuss the possible answers among themselves and to help develop the correct concept throughout the class content. At the beginning there was a presentation of the history and the applications of electric current and electrical tension in everyday life. A physics laboratory at the Federal University of ABC (UFABC) was used for the application, which technicians provided the students with multimeters (Figure 2) so that they could measure the voltage and resistance that an Arduino board had when connected to a potential difference. During the lesson, there were moments of exercises to capture some concepts, such as the Laws of Ohm, which the students had a little more difficulty and needed more attention, especially in the mathematical approach.

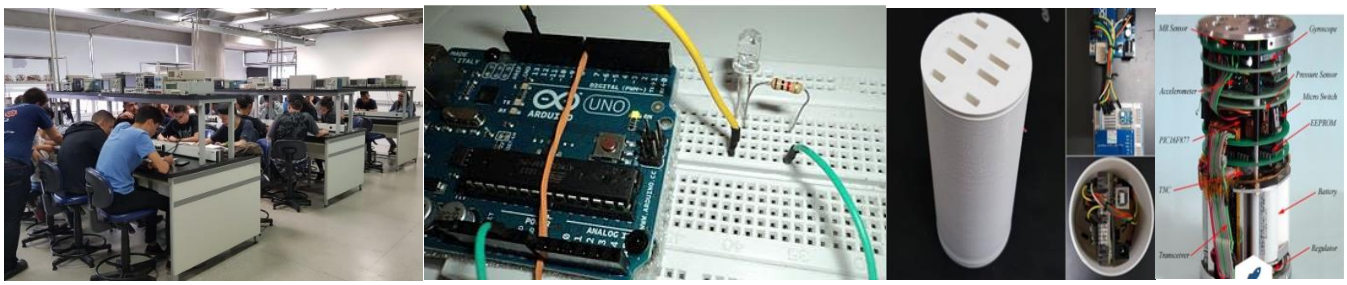

Figure 2. Students with multimeter and Arduino and CanSat

After the application of the questionnaires, the theoretical approach of the Arduino and Protoboard Boards began to be introduced to the experiment, which would be to pass the programming of the computer with Arduino software to the board and to connect the Board to the Protoboard correctly, with the final objective of lighting an LED (Figure 2). After the experiment, the questionnaire was applied with questions to analyze the fixation of the contents. With the introduction of students to Arduino, they had the first contact with the language used in the software. In the following class, the Introduction to Programming Logic was started, so that the requirements and standards of the programming languages were explained in detail. A question was asked for the students: "How is a program created?" Although it is a very broad question, the students have brought positive answers, which explained in general how the programs worked, which exist and are most used, both in teaching and by large companies. Flowchart concepts were presented, some examples of algorithms in Portugol and Java, trying to demonstrate all the standards and requirements that programming requires. In the first part of the lesson, we focused on making students create programs in three different activities, so they could perceive the most common mistakes that are made in algorithms, regardless of language. The first activity consists in creating a simple algorithm so that a robot, interpreted by one of the teachers, who does not know what a door is, a door handle and does not see any of the objects distributed in the room, walk from the back of the room and manage to open

the door of the room, without the program giving error. The main goal was to work together with the mistakes of each group, to discuss what would be the possibilities of optimizing a program that describes an activity common to all. None of the programs suggested by the groups performed successfully because either the robot collided with the objects in the room, or the functions determined to turn the knob were not described correctly. At the end of this activity, the best possible program was created together with all the students, describing in detail all the activities so that the robot could successfully carry out its activity.

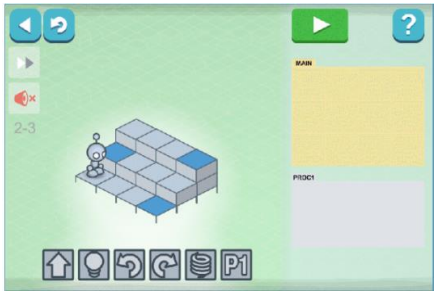

Figure 3. LightRobot Program used for second activity during class

The second activity developed through a program called LightRobot [4] [Figure 3], in which the main objective is to create an algorithm, also simple with difficulty increasing gradually, that the robot should light the lamp of its head in the blue squares. In PROC1 (or PROC2, when the difficulty is greater), the part of the program that repeats itself (loop), and in main is the main program. The students developed together with the teachers the first schedules and the time was left for them to develop the next phases. In the end, anyone who came to the last was invited to come and show their show to everyone in the room. The third activity is the Tower of Hanoi [5], which is a "puzzle" consisting of a rectangular base containing three pins, and one must change the pin disks by placing them in ascending order of diameter, from top to bottom. The main objective was to get students to realize the logic behind the program so that they have the least amount of movement possible to achieve the ultimate goal, regardless of the number of initial disks. The second moment of the lesson was dedicated to the suggested experiment, the RoboMind Academy software, a tool slightly more advanced than the previous ones, to have contact with an instrument very used academically in the learning of programming logic, in the courses of Engineering of with the learning they acquired at the beginning of the lesson, about the requirements and details an algorithm needs to have, students were instructed to create more complex programs within of RoboMind [Figure 4],. The final objective of the experiment was to make students familiar with the programming logic, containing all the necessary tools that may exist in an algorithm, such as repetition loops, declaring optimized as possible.

Figure 4. Students doing the RoboMind activity

In this class, no questionnaires were carried out, only the activities described, which had an active participation of the students, it was possible to evaluate them orally on the progression of the absorption of knowledge. In the following class, the students had contact with the programming language in C. In this, there was no "question of the week" for the fact that this is continuity to the theme of the previous one. The language in C is considered to be one of the simplest used, and The gateway for those who want to program. The C syntax is relatively easy to learn, and as long as you follow the rules, you will hardly make any mistakes that could compromise the program. In addition, the compiler warns you of most of the syntax errors that may have been committed and will give you tips to fix it. Therefore, we saw the opportunity to apply this language to students. Assessment exercises were applied during the first part of the lesson, prior to the experiment, so that they could become more familiar with the language. Below are the exercises applied in class, with difficulty increasing each exercise. Before each one, the theoretical basis was explained, and in the exercise applied. In the second part of the class, teachers proposed that the students carry out the construction of a C program, calculate the grade average and inform the user. Introduced to the programming, the following lesson was started on the topic of Sensors and Microcontrollers, in which the objective was to show them the different types of sensors that are found in daily life and how they work. The question of the week was chosen so that they could bring to the discussion in class about the ultrasonic sensors, as is the case of Bat Biossonar resembling it to the ultrasound used in the Arduino, HC-SR04. In the first part of the class, an activity was suggested for an interaction between the students and the teachers to create a simple sensor, indicating which of the ones they would use to create their own. When everyone finished building theirs, one representative from each group volunteered to present to the others the sensor model used. In the second part of the class, students constructed a distance sensor (parking alarm) with an ultrasonic sensor HC-SR04 and a buzzer, which emits sound as it approaches the Arduino. An experiment manual was made available to all, explaining each component that would be used, so that construction could be possible. The next lesson, on the importance of information and

communication, gave the basics of how the creation, manipulation and communication of various types of data works. Concepts related to signals, bits, codes, networks, security and communications in general were discussed. The question of the week aimed to get students to reflect and research how in some everyday activities of each, communication and information flow was infiltrated so that they would bring the answer for everyone in the class to discuss the answers found. The experiment of this class, had as objective the practice of programming of a Central VOIP. To perform the tasks of the laboratory, a Linux central (running the Freeswitch software) and two Windows client machines were used running the X-Lite application. The goal was to understand basic programming principles of a VoIP-based telephone system. After that lesson, the student is expected to understand where a facebook post comes from, for example, through all the inner layers of the algorithm, to the screen of the algorithm, and how the media uses those tools to create their news. In addition, show the role of satellites for communications nowadays, evidencing their participation in the current global network. Aiming at a greater focus on the aerospace industry, Lesson 7 on Aerospace Materials and Its Properties talked a little bit about the most commonly used structures in aircraft and satellites, describing all of them. In order for the students to have a first knowledge of these, the question of the week aimed at the students to research and bring a first idea of what would be treated in the classroom. This class was used a longer period for the experiment compared to theory. The goal was to build a bridge of sticks, in which they could see, according to the mold assembled by the teachers, what would be the ideal bridge. The bridge is built with ice cream sticks, so it is an incentive to recycle and reuse materials that are present in everyday life and can serve for practical scientific activities, and thereby help reduce litter in the environment. However, they should create the bridge itself, using low-cost materials made available by teachers. In this class there was no questionnaire application, the form of evaluation would be according to the bridge mounted. With all the bridges mounted, the one that held the largest mass was approximately 12kg. The teachers explained, according to the solids mechanics, the reason for the load difference supported by each one, in terms of distribution of forces, forms of each bridge, quantity of sticks used, adequate amount of glue. At the end of the project, students visit science museums, such as the Brazilian Aerospace Memorial where they can connect the knowledge learned in class with the exhibition. [Figure 5]

Figure 5. Students of the Arandu Project visiting the Brazilian Aerospace Memorial

4. CONCLUSION

The classes of the Arandu Project contribute to the scientific and technological literacy of the Basic Education students, especially the students who study in public schools. It is important for the Brazilian University to contribute to improving Science Education in Basic Education, because in Brazil public schools need to improve the quality of teaching, because there is a deficit in the scientific knowledge of the students, since the structure of the public education system presents many problems, from lack of laboratory materials to practical classes, curricular differences, lack of specialized teachers in disciplines such as Physics. The STEM perspective brings the students closer to Science and Technology and the Arandu Project allows in the practical classes the students to construct the artifacts with which they will learn new knowledge and will resignify already learned scientific knowledge, therefore, focuses on the maker culture, awakening the creativity of the students. The work developed in groups helps develop cooperation and respect for diverse opinions, as well as potentiate scientific argumentation, logical reasoning, the ability to hypothesize and justify. The Arandu project fulfills an important social role in Brazil in that it keeps the students in educational activities, so that they are occupied and studying and avoids more exposure to the problems due to social vulnerability. Thus, with this project, it is hoped to enable students to engage with exact sciences applied to engineering, through laboratory practices and proposals for the execution of engineering projects, in an attempt to understand what engineers perform when developing projects and motivate them to join an Engineering career, especially in the Aerospace modality. The project has been an inspiration for the students to enter the scientific area and to form the new generation of young Brazilian scientists.

5. REFERENCES

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