

**COB-2023-1737**

## **EDUCATIONAL ROBOTICS AND MOVEMENT MAKER APPLIED ON STUDY OF NATURAL PHENOMENA.**

**Erick Bernabé Zanelato**  
**Ghabriel Barbieri Molinarolli**  
**Douglas Goesse Cardoso**

Instituto Federal do Espírito Santo - campus Cachoeiro de Itapemirim  
erick.zanelato@ifes.edu.br

**Mayara Barbosa de Souza**

EMEB Pe. Gino Zatelli - Bairro Gilson Carone - Cachoeiro de Itapemirim - ES

**Abstract.** *This paper aims to apply alternative methodologies to classes in the school environment since the Brazilian educational level of schools needs improvement. The applied methodology for this paper is based on educational robotics in an Elementary School located in a socially vulnerable area. Through this technique, the student learns new abilities and tools that complement the school curriculum, allowing better internalization of concepts learned in the classroom. Another system to be used is established on maker culture, also called do-it-yourself. Under supervision, the student will be able to manipulate tools and machinery in a maker space, improving their motor coordination, handling different instruments, and training new skills. As a result, the students produced study apparatus of natural phenomena that can be found in their daily lives. The emphasis was given to the heat transfer effects with Matter and Energy analyses. The kits were composed of specific sensors for reading relevant data to study temperature, humidity, and radiation intensity by interface with microcontroller Arduino. For example, the student will be able to quantify how much heat goes through a conductive or thermally insulating body and what impacts this causes in his life and society. Therefore, it was concluded that robotics activities can make more interesting classes and help explore concepts in several fields of Matter and Energy, in a playful and challenging way. The result was the observation of a more dynamic, proud, and curious student, who can solve real and daily life problems. Through this work, students cognitive and intellectual capacities were strengthened and the technical-scientific concepts became more closely linked to the nature that surrounds them.*

**Keywords:** *Educational robotics, heat transfer, maker culture, meaningful learning, Arduino.*

### **1. INTRODUCTION**

In recent years, the difficulties of Brazilian students with mathematics and science subjects have been perceived more frequently. Along with the perspective of greater inclusion of skills related to computational knowledge in the National Common Curricular Base, or BNCC as the original abbreviation (Brasil, 2018), the teaching of educational technologies based on robotics and programming can constitute a propelling element for enhancing these levels. They are commonly called science, technology, engineering, arts, and mathematics, customarily known by the acronym STEAM.

In addition, considering the social vulnerability factors where the school is located, as well as the intention to popularize the results of this work, there is also a concern about not using high-cost resources, either by the school or by the students who may be able to produce beyond this project. For Pinto (2011), the elementary school shows more difficulty in accompanying the fast pace of tech evolution. In that regard, teachers and educational professionals must apply technology and innovations as a way to complement teaching and provide more understanding of concepts and phenomena in students learning (Corazza, 2005).

In this way, low-cost equipment and methodologies were used in order to face socioeconomic levels in the environment assisted by the partner school. One of the objectives is to build simple mechanisms for viewing natural physical phenomena from a technical-scientific side, allowing further understanding by the lay population. Thus, popularizing scientific knowledge goes beyond the act of making it public or broadcasting it. It is necessary that everyone can be protagonists of their thoughts and be aware of their discoveries and conclusions. Germano and Kulesza (2007) refer to this topic emphasizing that simplifying science is to place it in the scope of dialogue, referring to the reflective dimension of communication.

Since the 80s, there has been a concern about applied robotics in the school environment, providing a means of curiosity, exploration, and knowledge. These characteristics are developed in different areas and subjects, making it a propitious tool for interdisciplinarity (Papert, 1980). For Feitosa (2013), robotics is inserted in a context of technological education, in which students are prepared to become a user of technological tools, be able to create, solve problems, and

use multiple kinds of technologies in a rational, efficient, and meaningful move.

Melo (2009) reports that the use of technologies, especially robotics, enriches and increases learning, understanding, and development of concepts in different areas of science. Focusing on the scope of this proposal, Feitosa (2013) pointed out that these practical activities in the teaching of physical sciences provide students with a better relationship of the concepts learned in the classroom with phenomena, situations, and problem-solving in their daily lives. In front of the field of action and application of sciences, knowledge cannot be restricted to the theoretical foundation by the method exposition. This can lead to a demotivating class that is far from the students reality (Heineck *et al.*, 2007).

Currently, a powerful tool used on a large scale around the world, used in academic work, by research groups, companies, and even in the field of the Internet of Things (IoT) and automated home security systems, is Arduino created in Italy in 2005. Arduino devices were used in the development of this paper allowing the student to act in all constructive stages of the experimental apparatus. Another meaningful factor is the low cost since these systems are considerably less expensive when compared to other equipment that performs the same task object of this proposal, such as Lego Mindstorms and Modelix. Consequently, this favors the dissemination of knowledge and the popularization of scientific development in different social environments (Ramos *et al.*, 2018; Medeiros and Wunsch, 2019).

Thus, due to the need to improve students school development rates, especially in the early stages of education in Brazil and more emphatically when dealing with public education, this project aims to strengthen practices for scientific development and amplify their popularization (Oliveira and Guedes, 2015). The students will be able to analyze and apply the theoretical concepts learned in the classroom in their real lives and in the society in which they are inserted.

Therefore, in order to fulfill the objectives and use the aforementioned resources and models, science study systems will be designed and set up, more specifically of physical phenomena related to matter and energy.

## 2. METHODOLOGY

Strategic actions and teaching methodologies englobing educational robotics making use of Arduino and Maker culture were used. Choosing the topic as well as the initial target audience is justified on the content mentioned because its objectives are included in the BNCC.

The following steps were taken during the evolution of this proposal:

- a. Pedagogical intervention with a bibliographic review on matter and energy. The intervention consisted of remembering and reinforcing specific science content from the first years of Elementary School, which could be easily associated with physical phenomena that occur in the students daily life. Among the effects, the following ones stand out: heat transfer (by conduction, convection, and radiation), thermal sensation (temperature and humidity), and variation of light intensity.
- b. Presentation of educational robotics systems with Arduino and maker culture. Fundamental concepts and operating principles of an Arduino board were presented based on McRoberts (2013); Monk (2017) work. Programming language, automation, and computational technologies were used. These items were shown in practice through the development of a simple tutorial, with a resistor and LED. From the assembly and progress of this initial tutorial, a parallel was made regarding the analysis of the phenomena to be observed and the specific goals of the project, such as temperature, humidity, light sensors, connection cables, and their respective programming in the Arduino's Integrated Development Environment (IDE). Along with the assembly stages, the functioning of a maker space and its potential were shown.

A visit was made to the Maker Laboratory at IFES Cachoeiro de Itapemirim campus to present its facilities and equipment available. Figure 1 shows graduate students teaching on Arduino system to Junior scholarship students.



Figure 1. Pedagogical intervention on theoretical concepts and robotics.

- c. Preparation of technical drawings of study kits. Before students actually assemble their prototypes, they had to pass through an essential stage in the construction of any component: the project. It is from the technical drawing that they have an overview of the parts as a whole and their respective fittings. The first step was to produce designs on A4 paper, as shown in Fig. 2. Next, if they don't master all possible computer aided design (CAD) software tools, they should know that this step can save time (and money) further. In order to do that, and under the guidance and collaboration of the graduates, juniors produced the technical drawing using CAD software via Solid Edge.



Figure 2. Juniors scholarship drawing a blueprint's object.

- d. Construction and assembly of kits. The maker space and its specific tools were used for the physical construction of the study modules, such as boxes, supports, closed chambers, and structures, among others that were outlined in CAD software. The structural elements were made using 3D printers and a laser cutting machine, as well as a computer numerical control (CNC) router and some machinery from the Mechanical Fabrication Laboratory.

After making and acquiring each component, the assembly was carried out at IFES Cachoeiro de Itapemirim Campus laboratories and also at the partner school laboratory EMEB Pe. Gino Zatelli. So as to carry out the stages and finish the proposal, 05 (five) different study instruments were built with the following topics and respective fields of study and application:

- Thermal radiation: variation of light intensity on the influence of heat transfer by radiation;
- Thermal convection: natural and forced convection effects;
- Thermal conduction: study of the influence of insulators or good thermal conductors;
- Luminosity: efficiency of incandescent and LED light bulbs as a function of electromagnetic waves at different wavelengths;
- Relative humidity: the relationship between air humidity and thermal comfort.

### 3. RESULTS

Pedagogical interventions were carried out after the topics had been presented, and the students who showed good comprehension helped with the next step of the construction of the didactic kits. Five projects were finished successfully and became part of the teaching resources of the partner school. Figure 3 shows junior scholarship students at the beginning of this process, assembling a didactic apparatus with Arduino for simulating a traffic light.



Figure 3. Maker culture is applied to the construction of an apparatus.

The first apparatus contains three LED lights, with different colors (red, yellow, and green) that, when exposed to different levels of luminosity, make transitions between the colors, simulating a lamp activation relay on a light pole. Figure 4 represents this kit, where the red LED lights up under low light, the yellow LED lights up with only one of the bulbs turned on and the green one turns on when both light bulbs are active. Another discussion that can be raised is the efficiency of LED lights and incandescent light bulbs, presenting their luminosity efficiency over the power of each one. In this kit, there is a 100W incandescent light bulb and a 9W LED light.

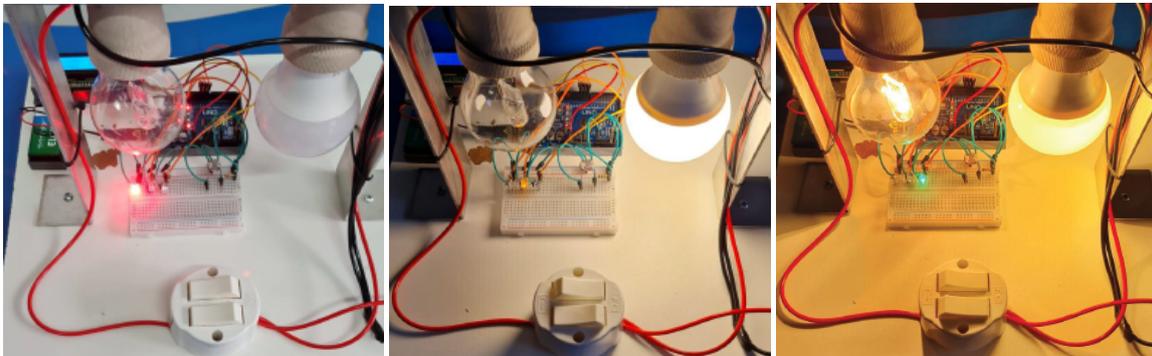


Figure 4. This kit simulates the operation of an electric pole with different luminosity levels.

The next kit aims to show how a closed and wet environment affects the humidity and local temperature of the place – factors directly related to the thermal sensation. Figure 5 shows the sensor next to two water holders (to increase humidity) and also shows the final assembly, with the closure to confine the internal air.

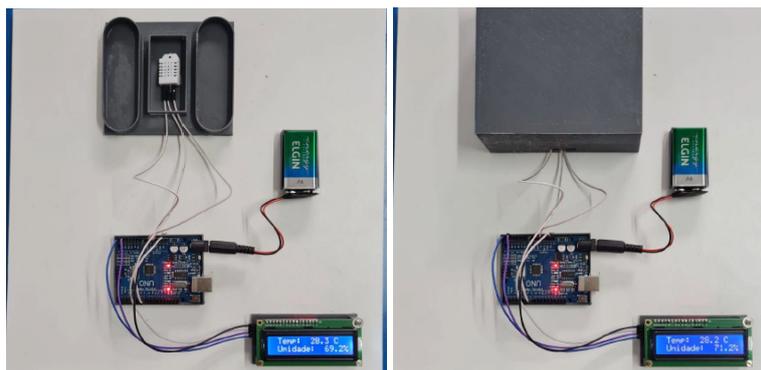


Figure 5. Humidity and temperature kit for wind chill theme.

One of the capabilities of Arduino is to export the data read from sensors for plotting graphs, allowing a better visualization of the behavior of the properties under analysis. For temperature and humidity, Fig. 6 shows a graph plotted from the results after adding water and enclosing the box.

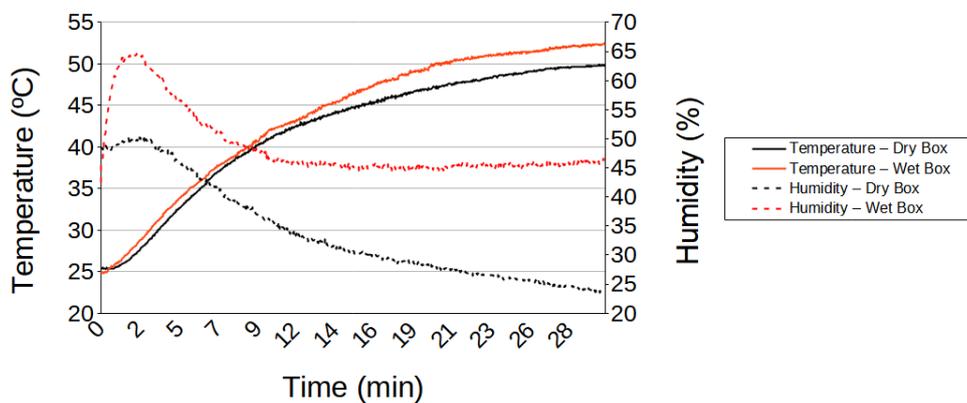


Figure 6. Temperature and relative humidity *versus* time.

The results are consistent since the data obtained with water bags filled with water (wet environment) shows higher

temperatures and higher humidity when compared to the dry environment. This outcome allows the student to better understand the meteorological data mentioned during the weather forecast, for example.

The purpose of the kit shown in Fig. 7 is to analyze the difference in temperature and luminosity between a 60W LED light bulb and a 100W incandescent light bulb. In addition, it is also possible to better understand the efficiency of different technology light bulbs. Figure 7 shows the assembled kit and also the incandescent light bulb.

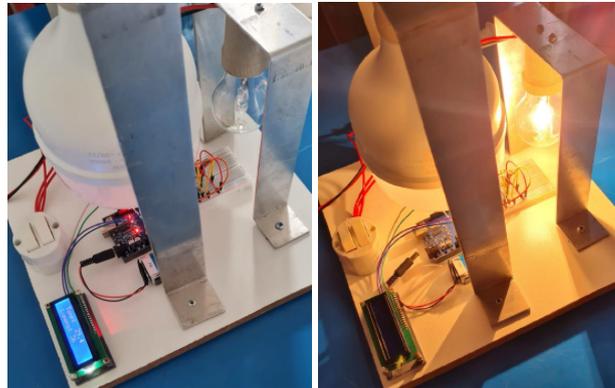


Figure 7. Light efficiency kit for incandescent and LED lamps.

One of the images with a 60W LED light bulb was overexposed due to the amount of light emitted and could not be registered here. The temperature graphs for both light bulbs are shown in Fig. 8. Note that, even with the incandescent light bulb having almost twice the power, it produces a much smaller amount of light and, on the other hand, it heats up much more than the LED one used. In Fig. 8, the lumens adopted are the manufacturers data.

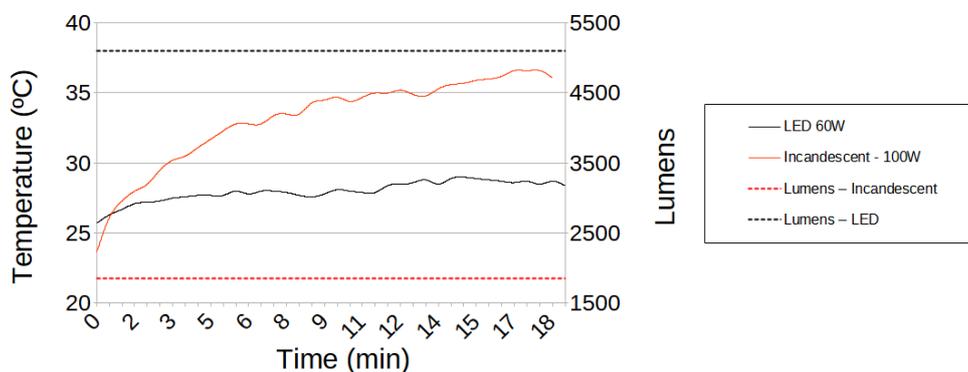


Figure 8. Graph temperature versus luminosity with lumens included as a reference.

The next two kits work similarly. The difference between them is the analysis material concerning heat absorption and transmission. In one of them, there are two metal parts: one was painted in black, and the other in white, as shown in Fig. 9. In another kit, the composition materials of the parts are different, whereas one is metal and the other is wood, as shown in Fig. 10.

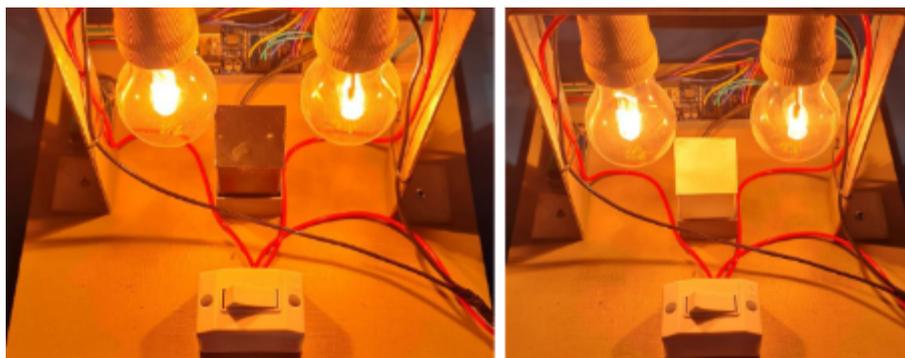


Figure 9. Kit with black (left) and white (right) pieces.

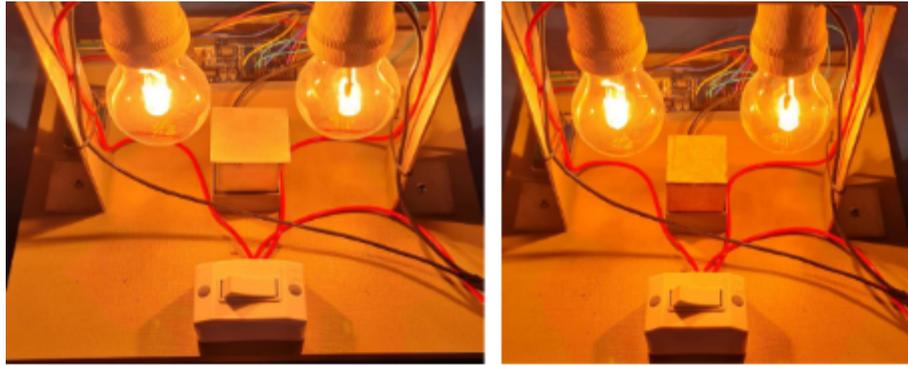


Figure 10. Kit with steel parts (on the left) and wood (on the right).

The purpose of these last two projects is to measure, in the first case, how the color affects the temperature of an object and in the second one, how the thermal conductivity of the component material interferes directly with heat transmission. Two 100W incandescent light bulbs each were connected to the referred pieces. Temperature values as a function of time were collected for plotting graphs as shown in Fig. 11 and Fig. 12.

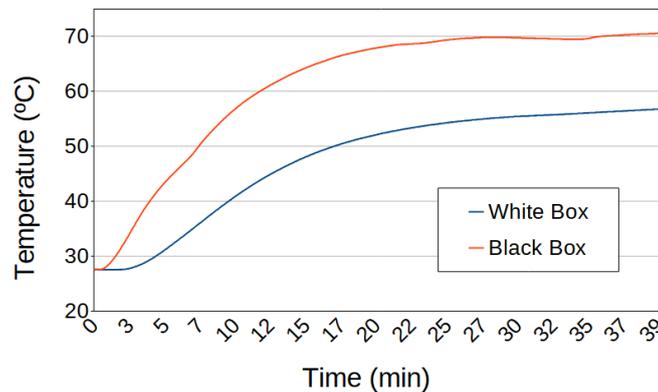


Figure 11. Graph temperature versus time for black and white metal boxes under radiation.

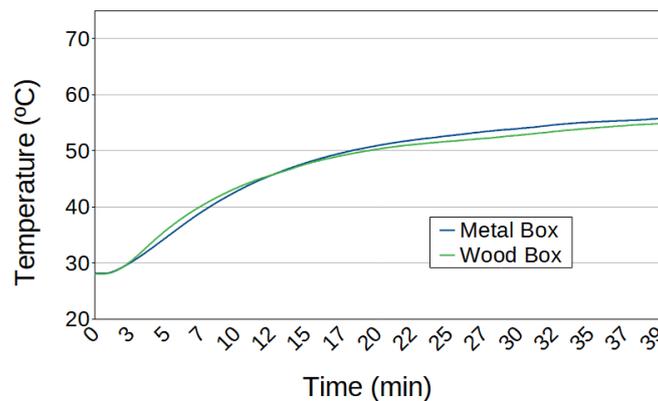


Figure 12. Graph temperature versus time for metal and woody boxes under radiation.

For white and black boxes, a huge difference can be observed. Discussions about reflectivity and absorptivity can be done. Furthermore, it can be noted that the difference in temperature between the wooden box and the metal box is low. This was due to the lower thermal conductivity of the wood. In this way, the heat applied to the top of the container takes longer to dissipate throughout the box. In addition, the wall thickness of the wood box, compared to the metal box, was higher, contributing to the result shown above.

#### 4. CONCLUSIONS

Facing the development, execution, and results obtained, it can be concluded that there was success in several fields, since the technical-scientific analysis of the data obtained to social benefits to students involved in the project.

Since the partner school is from a social vulnerability area, and is also assisted by the Governments program “Estado Presente”, the project allowed greater advances in terms of the connection between theory and practice. Schools with few resources seldom achieve the expected progress with students due to a lack of equipment (even if these are elementary ones). In this sense, students and society were able to become aware of the adversities in general regarding the understanding of the different physical phenomena present in their daily lives.

Furthermore, it was an interdisciplinary project. The awareness of applying scientific knowledge in other areas that directly influence society, especially in the social field, through multidisciplinary practices that culminate in critical thinking aimed at solving real problems. It also involved computer science, engineering, physics, electricity, and others.

Simple and efficient didactic materials were built using the sequence of steps developed. They are facilitators in terms of understanding the manifestations of nature and bringing theories and practices together.

Therefore, there were mainly benefits applied to knowledge in the engineering field. Generally, it allows satisfying demands by solving problems, innovating, and overcoming challenges. All of this was possible due to the popularization of science and technical-scientific knowledge and it can be accomplished by applying low-cost and simple-to-understand techniques.

#### 5. ACKNOWLEDGEMENTS

The authors are thankful to FAPES and IFES for technical and financial support and to EMEB Pe. Gino Zatelli for collaboration and partnership.

#### 6. REFERENCES

- Brasil, M., 2018. *BNCC - Base Nacional Comum Curricular*. MEC, Brasília.
- Corazza, S.M., 2005. “Nos tempos da educação: cenas de uma vida de professora”. *Revista da ABEM*, Vol. 12, pp. 7–10.
- Feitosa, J.G., 2013. *Manual didático-pedagógico*. ZOOM Editora Educacional, Curitiba.
- Germano, M.G. and Kulesza, W.A., 2007. “Popularização da ciência: uma revisão conceitual”. *Caderno Brasileiro de Ensino de Física*, Vol. 24, pp. 7–25.
- Heineck, R., Valiati, E.R.A. and da Rosa, C.T.W., 2007. “Software educativo no ensino de física: análise quantitativa e qualitativa”. *Revista Ibero Americana de Educacion*, Vol. 46, pp. 1–12.
- McRoberts, M., 2013. *Beginning Arduino, 2nd. Ed.* Apress, Berkeley.
- Medeiros, L.F. and Wunsch, L.P., 2019. “Ensino de programação em robótica com arduíno para alunos do ensino fundamental: Relato de experiência”. *Revista Espaço Pedagógico*, Vol. 26.
- Melo, M.M.L., 2009. *Robótica e Resolução de Problemas: Uma Experiência com o Sistema Lego Mindstorms no 12o. ano*. Master’s thesis, Faculdade de Psicologia e de Ciências da Educação - Universidade de Lisboa, Lisboa, Portugal.
- Monk, S., 2017. *Programação com Arduino: começando com sketches, 2nd. Ed.* Bookman, Porto Alegre.
- Oliveira, A. and Guedes, E., 2015. “Uma análise comparativa de kits para robótica educacional”. In *Anais do XXIII Workshop sobre Educação em Computação*. SBC - Sociedade Brasileira de Computação, Recife, PE, Brasil, pp. 110–119.
- Papert, S., 1980. *Mindstorms: children, computers and powerful ideas*. Basic Books, New York.
- Pinto, M.d., 2011. *Aplicação da arquitetura Pedagógica em Curso de Robótica Educacional em Hardware Livre*. Master’s thesis, Instituto de Matemática no Núcleo de Computação Eletrônica - UFRJ, Rio de Janeiro, Brasil.
- Ramos, A.D., Silva, F.C., Ferreira, B.F. and Magalhães, R.R., 2018. “Uso da plataforma arduino na interdisciplinaridade do ensino fundamental i: Relato extensionista em uma escola pública”. *Revista Extensão em Foco*, Vol. 17, pp. 120–132.

#### 7. RESPONSIBILITY NOTICE

The author(s) is (are) solely responsible for the printed material included in this paper.