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# Three-dimensional models for teaching about Mars exploration linking astronomy and robotics

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**Abstract.** Mars is a planet that has been fascinating mankind for a long time. Its proximity and characteristics have made it possible to send rovers to collect chemical and geological information. This technological advance can inspire and contextualize the robotics classes that are widely offered in Paraná's state public schools. In these classes, the Arduino Uno microcontroller and various sensors and electronic devices are used. This study is a project to use a servo motor, an OLED display and the Arduino Uno board to construct three-dimensional models of a Martian rover and a mission control center. The aim is to link the study of astronomy and robotics. This activity was applied in a robotics class for elementary school students in a public school in Curitiba, Paraná. The three-dimensional models were made from colored paper and packaging (such as soap and medicine packaging). The mBlock software was used to control the electronic components in the models. During the development of this project, the students were curious not only about the exploration of Mars, but also about the possibility of life on other planets. The methodology proved to be productive and has potential for improvement, for example the inclusion of other electronic devices (LEDs and motion sensors, for example) in the rover models. In addition, this tactile and three-dimensional project is also interesting for inclusive teaching for visually impaired students.

**Resumo.** Marte é um planeta que fascina a humanidade há muito tempo. Sua proximidade e características tornaram possível o envio de veículos exploradores, os rovers, que coletam informações químicas e geológicas do planeta. Tal avanço tecnológico pode inspirar e contextualizar as aulas de robótica que são amplamente ofertadas nas escolas estaduais do Paraná. Nestas aulas, o microcontrolador Arduino Uno e diversos sensores e dispositivos eletrônicos são utilizados. Este trabalho é uma proposta de utilizar um servo motor, um display OLED e a placa Arduino Uno para a montagem de um modelo tridimensional de um rover marciano e um centro de controle de missão.O objetivo é relacionar o estudo de astronomia e robótica. Esta atividade foi aplicada em uma turma de robótica para o ensino fundamental II no contraturno de uma escola pública em Curitiba, Paraná. Os modelos tridimensionais foi feito a partir de papeis coloridos e embalagens (como caixas de sabonete e remédio). O software mBlock foi utilizado para controlar os componentes eletrônicos dos modelos. Durante o desenvolvimento desta proposta, os alunos demonstraram curiosidade não só sobre a exploração de Marte, mas também sobre a possibilidade de vida em outros planetas. A metodologia se mostrou produtiva e tem potencial para melhorias, como a inclusão de outros dispositivos eletrônicos (LEDs e sensores de movimento, por exemplo) nos modelos dos rovers. Além disso, este projeto tátil e tridimensional também é interessante para o ensino inclusivo de alunos com dificiência visual.

**Keywords.** Teaching of Astronomy – Space vehicles.

## 1. Introduction

Since August 2021, robotics classes have been offered in Paraná's public schools. Part of these classes are extracurricular, and the students can learn about arduino and various sensors and electronic devices. Arduino is a programmable electronic prototyping platform used in various projects for interactive and automated systems. This study is a project to use a servo motor, an organic light emission diode (OLED) display, and the Arduino Uno board to construct three-dimensional models of a Martian rover and a mission control center. The aim is to link the study of astronomy and robotics, as astronomy can be a motivating factor for studying other areas, especially the natural sciences, and can also promote interdisciplinarity (Langhi & Nardi (2015)). NASA and other space agencies have sent some exploratory vehicles (rovers) to Mars over the past few decades. The exploration of Mars by these vehicles highly equipped with experiments and machines is a topic that can be discussed in classes.

## 2. Methods

The activity was applied in a robotics class for elementary school students in a public school in Curitiba, Paraná. Normally, the topics and projects are suggested by the state Education Department, but teachers can adapt them. In this study, new projects were created for the lessons on servo motors and OLED displays, components shown in Fig. 1, along with other components used in this project.

A servo motor is an electromechanical device with a shaft that moves 180 °. The position and speed can be controlled using Arduino. This type of motor is used in various applications when it is necessary to precisely move something. And an OLED display is a small screen used in many Arduino projects to display text and images.

During the first part of the project, some aspects about Mars were discussed, such as general characteristics (composition, location, size, habitability) and the history, importance and equipments of the martian rovers. Sojouner, Spirit, Opportunity, Curiosity and Perseverance were mentioned, but the focus was on the mission and equipments of the last two. Slides with videos and images were used to contextualize, as shown in Fig. 2.

After this, the students were divided into pairs and began building three-dimensional models. The first model constructed was the rover, inspired by the Curiosity and Perseverance design, shown in Fig. 3. The materials used were:

- paper (color: black)
- soap/toothpaste/medicine packaging

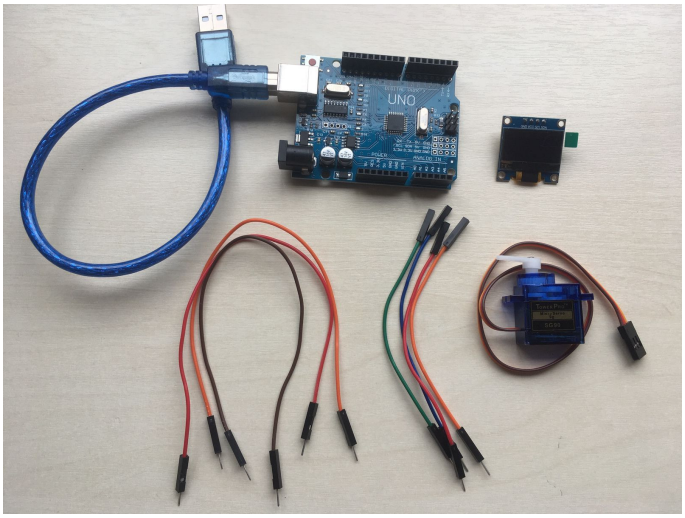

**Figure 1.** Electronic components used to build the three-dimensional models: Arduino Uno, servo motor, OLED display and jumpers.

- glue
- scissors
- adhesive tape
- screwdriver
- servo motor
- jumpers
- Arduino Uno + USB cable
- notebook

Most of the materials are from the school, and the students only brought the packaging, which were used with the paper to make the rover's body and wheels. The servo motor is positioned inside the paper structure that represents the body of the rover. The moving part of the servo motor (the shaft) was used to support a part which on Curiosity rover is a structure containing some important instruments such as the Chemistry and Camera (ChemCam). This instrument uses a laser to vaporize materials and then analyzes the sample with an on-board spectrometer. The back paper structure represents the power source, which in real rovers is a nuclear-powered system. The robotic arm structure was not represented.

Figure 4 shows the steps involved in building the three-dimensional rover model.

The second model built was a mission control room, inspired by the appearance of NASA rooms and those that appear in science fiction movies. These models should contain the following parts of a mission control center: desks with computers, chairs, and a screen showing the rover's landing on Mars (in real control centers it is not exactly like this, but some simplifications have been made so that the students can understand it better). There was not enough time to make a representation of the scientists working in the room. The materials used were:

- paper (colors: white and black)
- soap/toothpaste/medicine packaging
- glue
- scissors
- adhesive tape
- colored pencils
- OLED display
- jumpers
- Arduino Uno + USB cable
- notebook

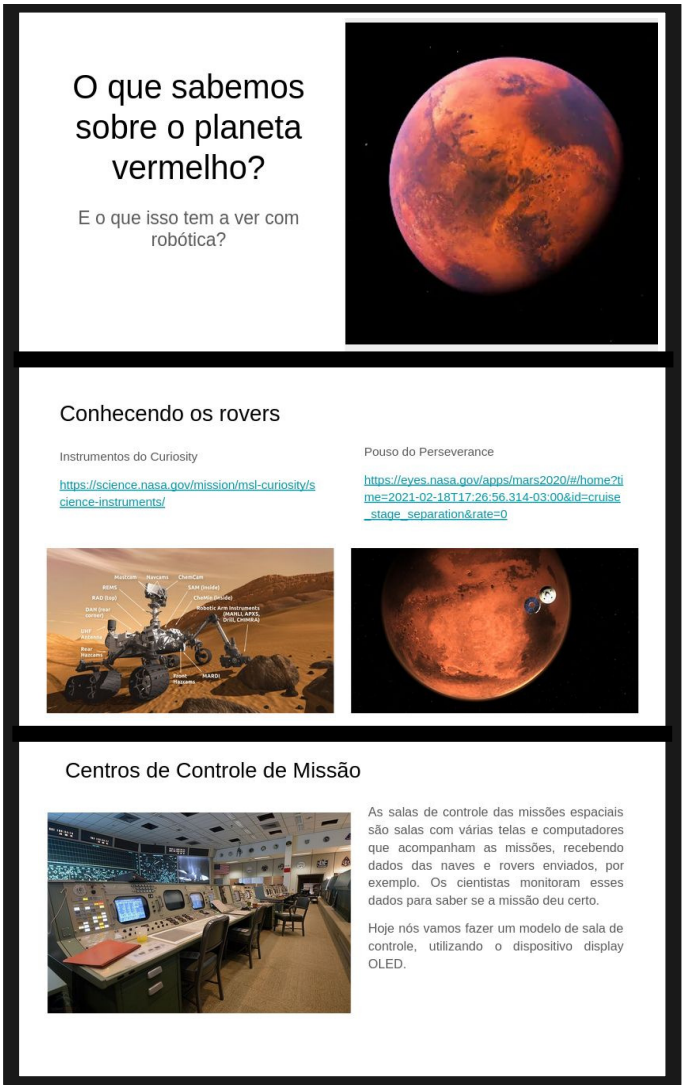


**Figure 2.** Examples of the slides shown in class to contextualize the project.

The OLED display has been positioned to represent one of the computers on which scientists receive mission information. The construction of the model that some students made can be seen in Fig. 5.

The mBlock software was used for both projects. It enables coding in blocks, which is easier and more attractive for younger students.

## 3. Results

Fig. 6 shows all the rover models the students made. In Fig. 7, the movement of the servo motor can be seen, simulating the motion that occurs in real rovers to perform experiments with ChemCam, for example.

Fig. 8 shows the message we programmed to appear on the display. As a simplification, in order for the students to understand that scientists are monitoring data on computers to see if the mission was successful or not, the suggested message was "The rover has landed". This simple sentence was also useful for the students to understand how the OLED display works.

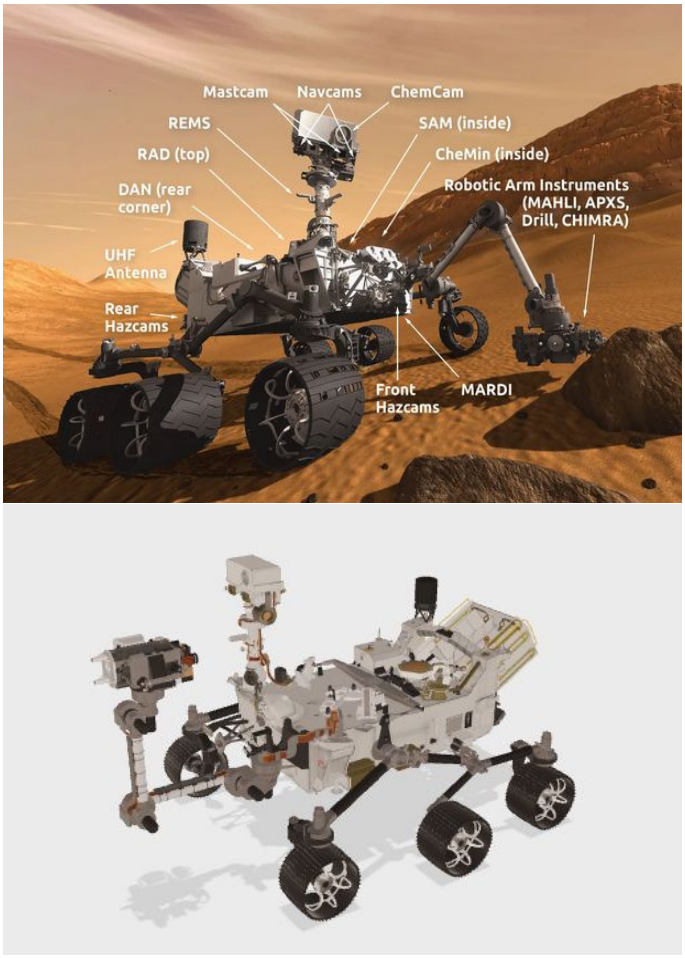


**Figure 3.** Top panel: appearance and instruments of the Curiosity rover. Bottom panel: appearance of the Perseverance rover. Source: https://science.nasa.gov/mission/msl-curiosity/science-instruments/ and https://science.nasa.gov/mission/mars-2020-perseverance/rover-components/.

## 4. Conclusions

This practice showed that astronomy can motivate the study of other subjects, considering the students' interest and doubts. Although there were questions about robotics, the issue that most caught the students' attention was the possibility of life on Mars. Some students mentioned the lack of protection from radiation, the extreme climate and the composition of the atmosphere as obstacles to life on the red planet.

In addition, teaching practices using concrete (manipulable) teaching materials, such as three-dimensional models, are important. This type of material enables the development of logical thinking and motor coordination Silva et al (2021) and, in the case of classes with blind students, facilitates inclusion because it is tactile Camargo (2012).

This activity has the potential for many improvements, such as the inclusion of other electronic devices (LEDs and motion sensors, for example) and wheels in the rovers' models, and also printing other sentences and even images on the OLED display.

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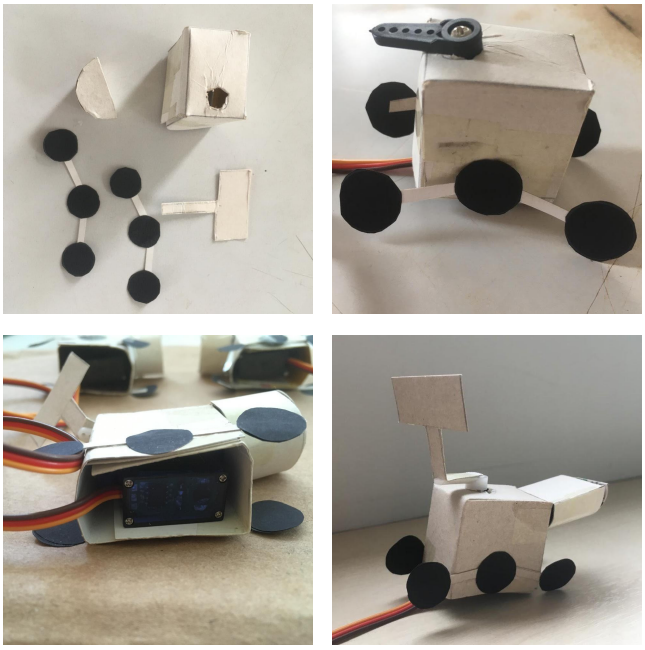

**Figure 4.** Construction of rover models.

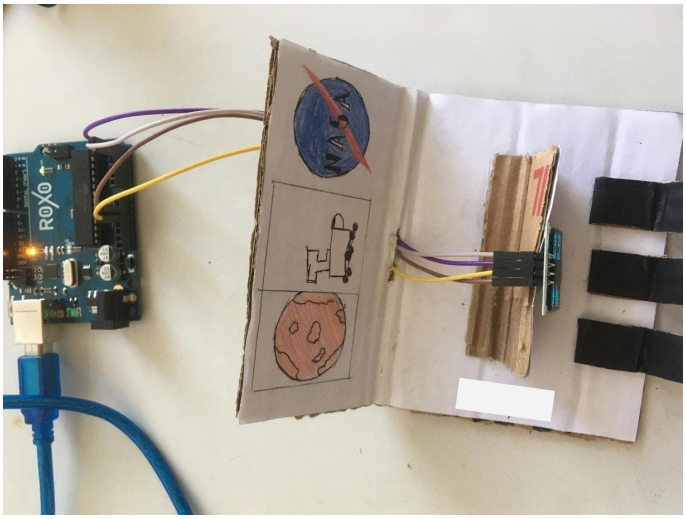

**Figure 5.** Construction of the mission control center model.

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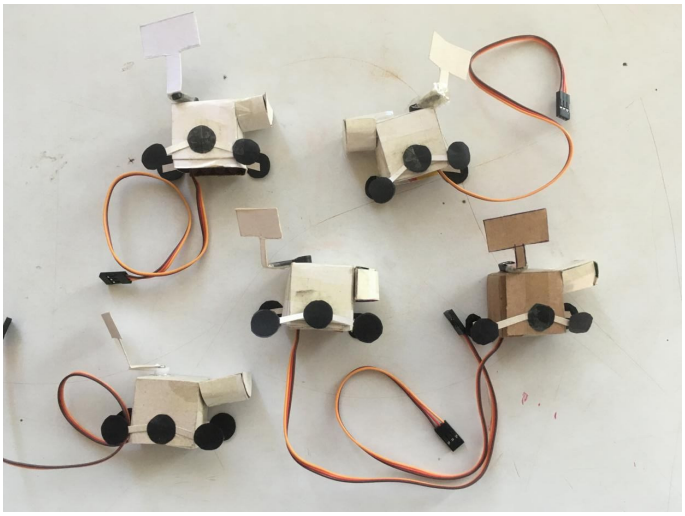

**Figure 6.** All the rover models made by the students.

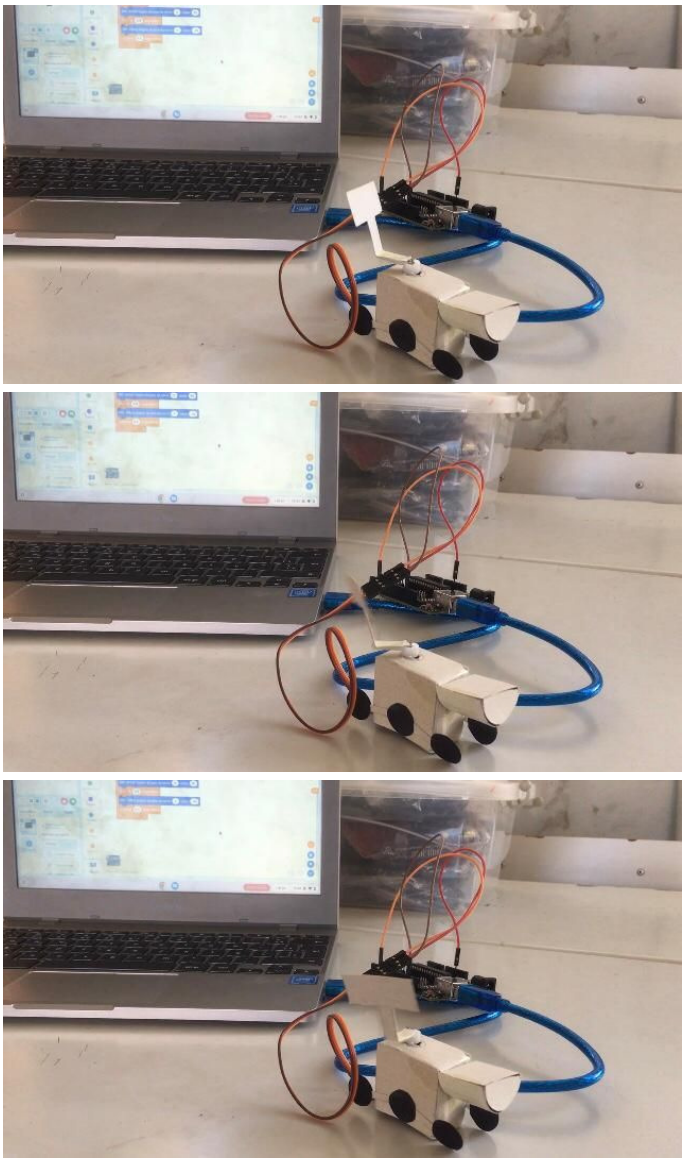

**Figure 7.** Movement of the servo motor.

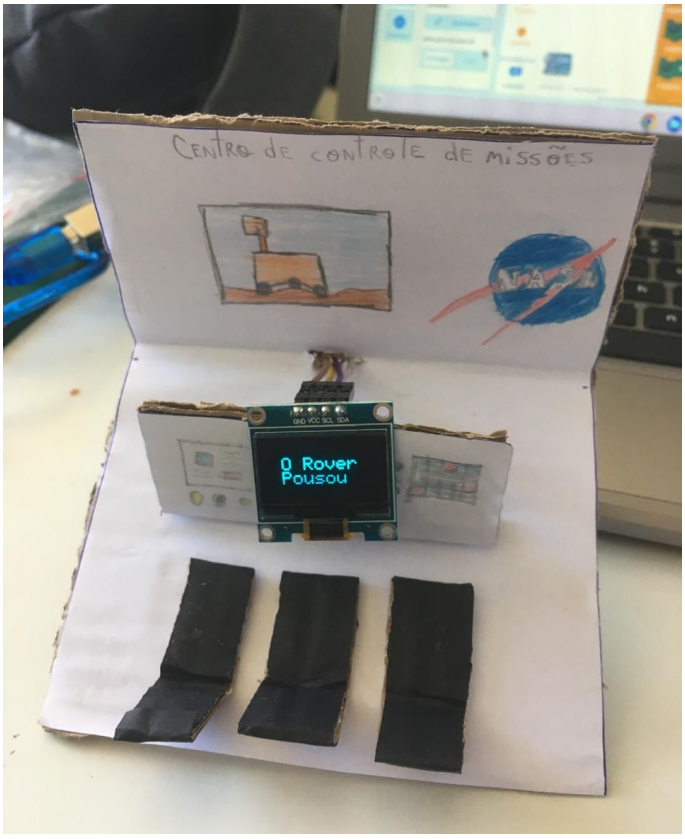


**Figure 8.** OLED display in the mission control center model.