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## Educational activities with Arduino to learn about astronomy

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### Abstract

There is a need to promote better science, technology, and mathematics (STEM) education at all school levels. Arduino makes it possible by creating the next generation of STEAM programs that empower students on their learning journey through middle school, high school, and university. These kinds of technologies make it possible to make abstract concepts concrete and manipulable, far from the experience of children and young people, increasing the possibilities of learning. Following the constructionist ideas and practices, the National Institute for Astrophysics has developed *play.inaf.it*, a web platform that collects various coding, educational robotics, making, and tinkering activities, using astronomy and astrophysics as a tool to develop computational thinking and all the skills that are typical of scientific research in the STEM field.

In this paper we want to present two projects created by the Play group. The first one aims to create, using an Arduino board, one LED and a photoresistor, an exhibit capable to describe one of the methods most used to identify exoplanets: the transit method, which exploits the fact that the brightness of a star decreases when the planet passes in front of it, with respect to our line of sight. Thanks to this project it is possible both to know Arduino and understand the information that astronomers can obtain from so-called light curves, such as the orbital period, the size of the planet, etc. The second activity aims to create and turn on one or more constellations using Arduino and some LEDs. In this way it will be possible to describe - through an active, cooperative, and operational approach - what are the stars, the constellations and the close relationship that has linked man to the sky since the dawn of time.

Thanks to Arduino it is possible to encourage creativity, allowing everyone to give shape and substance to their ideas because the only limit we can set is our imagination.

### Keywords

Arduino, Astronomy, Coding

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## 1. Introduction

Today we are facing an extremely fast and constantly evolving technological evolution. In this context, the development of new digital skills is essential. For this reason, it is necessary to find new strategies and didactical tools that allow to provide those skills related to logical and critical thinking and communication skills.

Boys and girls know how to use computers and mobile devices quite effectively, but most of them have only a little experience and understanding of how a computer works and the general principles of how electronic devices work. Furthermore, in a rapidly changing era, it is important that they develop skills and practices that involve innovative technologies. Therefore, the need to promote understanding on these topics, which fall under the broader term STEM (Science, Technology, Engineering and Mathematics), is essential [1]. Hardware platforms, such as Arduino, and educational robotics make this possible by creating the next generation of STEAM programs that accompany students on their learning journey from elementary school to university. Technologies such as these represent a unique educational tool that provides hands-on teaching activities to create attractive learning environments that satisfy students' scientific curiosity.

Following the constructionist ideas and practices of J. Piaget, who claimed that the learning process is an energetic process of building knowledge, and S. Papert [2], who considers robotic technologies as "objects to think" stating that the acquisition of new knowledge is most effective when students are engaged in building products that have personal meaning for them, the National Institute of Astrophysics has developed Play INAF, a web platform that brings together different codes, educational robotics, manufacturing, and tinkering activities using astronomy and astrophysics as a tool to develop computational thinking and all the typical skills of scientific research in the STEM field.

In this paper we describe two projects, made with the Arduino board, and show how this

hardware can provide a great contribution to the dissemination of astronomical knowledge.

## 2. *Play.inaf* platform

Following the constructionist ideas and practices of Papert and Piaget, the National Institute of Astrophysics has developed *Play.inaf* (Fig. 1). It is a web platform, which collects various coding, educational robotics, making and tinkering activities, which use astronomy and astrophysics as a tool to develop computational thinking and all the typical skills of scientific research in the STEM field. Computational thinking and research activity are inseparable, and it is essential that children develop this ability from an early age, to face all the challenges that will arise in life. It is for this reason, for its importance and for its link with research, that the National Institute of Astrophysics has decided to engage in the development of resources capable of helping children to develop computational thinking in accordance with its research field and with what is his third mission.

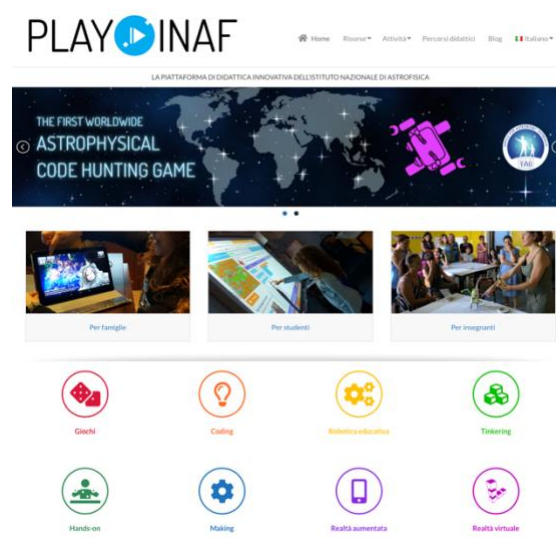


Figure 1. The home page of the Play INAF web platform.

## 3. The Arduino board

Microcontrollers, like Arduino are very popular in STEM education.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards can read inputs, like a

light on a sensor or a finger on a button, or a Twitter message, and turn it into an output, activating a motor, turning on an LED, publishing something online.

All the inputs are processed by the code that is loaded onto the board and suitable outputs are produced. The code is mainly developed in a C-like programming language using the Arduino IDE, an open-source environment that helps users write code and load it onto the board. Arduino's advantages range from being economical, to being multi-platform, to being extensible with additional shielding, i.e., electronic boards that implement specialized operations such as WIFI communication.

#### 4. The two activities

In this section we will describe the two activities carried out thanks to the Arduino board and which have been published on the Play INAF web platform.

##### 4.1 How to detect an extrasolar planet with the transit method

This first activity, designed for high school students, aims to create, using an Arduino board, one LED and a photoresistor, an exhibit capable to describe one of the methods most used to identify exoplanets, the transit method.

In the last year, almost 4000 extrasolar planets have been discovered, and their number is constantly increasing. Most extrasolar planets were discovered through the method of transits; each time a planet is placed in the same direction of view as the observer, and passes in front of its star, it causes a periodic decrease, equal to the intensity of the brightness of the latter. Through ground or space telescopes, a periodic variation of the star's brightness can be detected, whose periodicity is equal to the rotation period of the exoplanet. If we project the change in the brightness of the star on a graph, we will see a regular increase and decrease in the star's light caused by the transit of the planet. By studying the frequency of the curve of light, the astronomers obtain information on the period of revolution of the planet.

To build a planetary transit simulator, students use two Arduino boards. With the first one, and

thanks to a stepper motor, they can realize the model of the planetary system. The stepper motor is an electric synchronous motor very precise, quick, and easy to control through an electronic card, called driver. To modify the rotation speed of the planetary system, we will use a potentiometer, whereas to change the direction of rotation we will use a button.

With the second Arduino board instead, the students can realize the sensor to detect the variation of the luminosity. The variation of the luminosity is detected by photoresistor connected to the Arduino board (Fig. 2) Furthermore, just as happens in telescopes and other research tools, all data will be recorded on an external memory, in particular all time and brightness variation data will be loaded on a microSD card. This will allow us to study the data also later by means of other software such as Excel, Matlab, etc.

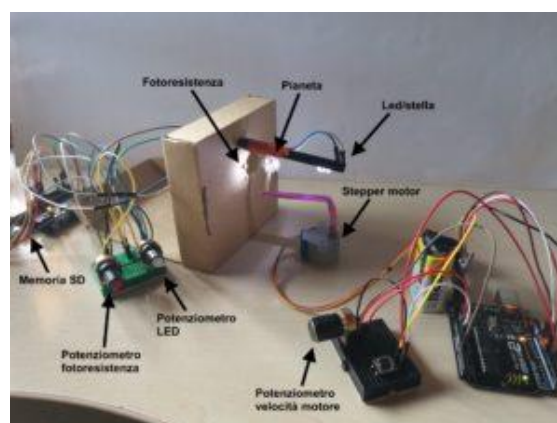


Figure 2. Photo of the circuit realized to describe the transit method. In this image you can see the two Arduino board and all the elements of the circuit.

Finally varying a few parameters – as for example the rotation speed, the dimensions of the planet, the distance of the planet from the star – the students can see how the relative curves of light change and how the astronomers can study the characteristics of the extrasolar planets (Fig. 3).

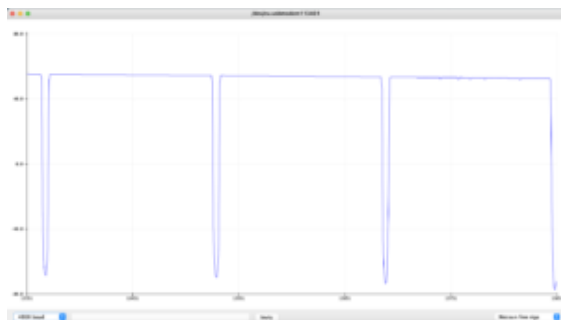


Figure 3. Example of a light curve obtained thanks the Arduino board.

On the Play INAF web platform, you can find all the details, the electronic scheme, the code, and many other information about this project.

#### 4.2 Light up the constellation

The second activity aims to create and turn on one or more constellations using Arduino and some LEDs. In this way it will be possible to describe, through an active, cooperative, and operational approach, what are the stars, the constellations and the close relationship that has linked man to the sky since the dawn of time.

First, the students have to choose the constellation that they would like to represent. After that, they should carefully measure, with a ruler, the apparent distance between the various stars which compose it, and their position, so they can precisely reproduce the constellation you have chosen. At this point, the students place on the breadboard the various LEDs (which represent the stars of the constellation), taking care of placing them in the right position and at the right distance from each other. To make this easier, you can print the map of the constellation, in the scale you prefer, so that you already have the right organization of stars. To correctly represent the colors of the stars, you can use LEDs of different color. The colors of a star depend on the temperature of its photosphere. If the star is very warm, it will appear white, if it is colder, it will be yellow orange, if it is even colder than that, it will be red. Once they have arranged all hardware connections, we can pass on to programming the board. In this way, after uploading the software, they can see the constellation that they have realized light up (Fig. 4).

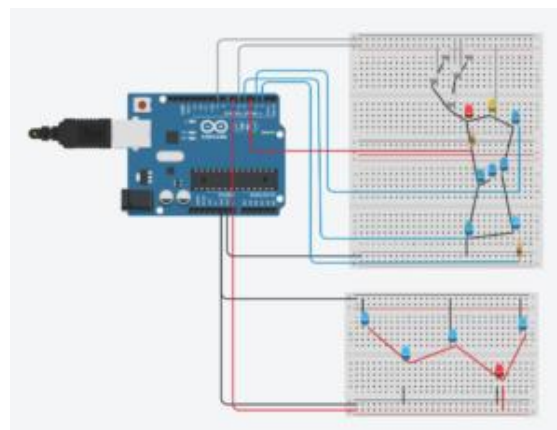


Figure 4. Example of the circuit with the Orion e Andromeda constellation

## 5. Discussion

Due the pandemic, these activities were presented for only in a virtual mode during the *European Code Week 2021*. Both projects are described in detail, with all the instructions for creating the circuit and writing the code on the Play INAF web platform.

The constellation project turns out to be very simple both in the construction of the circuit and in the writing of the code. For this reason, it can represent the first step to start making simple projects with Arduino. In fact, given its simplicity, this activity has been tested, with great success, with about 80 middle school students who, using coding, discovered what constellations are and the importance. However, having developed this activity during the lockdown period due to the COVID - 19 pandemic, this activity was carried out in virtual mode and both the code, and the circuit were developed using thinkercad. Despite this, all the students managed to create their own constellation by discovering the beauty of the sky that surrounds us.

Finally, both activities were presented, for the first time, to various schools in two webinars during the European Code Week 2021.

## 6. Conclusions

Education in the scientific method in school is often limited to the reproduction of historically relevant experiments, according to a logic that makes the transmission of consolidated knowledge prevail over their (re)construction by

the subjects who have to learn them. This logic can be overturned by adopting a constructionist perspective for which learning is the result of a relationship between ideas and the construction of objects related to them, on the one hand, and the comparison and sharing of ideas and objects, on the other side. In this perspective, the use of platforms such as Arduino represents an element of novelty as it allows to create the conditions for carrying out experimental laboratory activities in which the aspects of invention (personal contribution) and reproduction (the reconstruction of accumulated knowledge) are in the right balance. In addition, the theoretical richness inherent in coding is also reflected in the methodological choices, first of all the laboratory setting, typical of a constructivist learning environment that uses new technologies such as mindtools, tools with which students build knowledge. Coding and robotics allow you to develop computational thinking, which is configured as a fourth skill after reading, writing and arithmetic. Also with the right tool, even very young children can get closer to programming. Coding offers the possibility to learn computational thinking in a fun and engaging way, suitable for school-age boys and girls, because learning takes place in the interaction with a 'real' object and in this sense, Arduino offers an excellent tool for developing all these skills

These activities and the others present on Play INAF offer the opportunity to learn computational thinking in a fun and engaging way, suitable for school-age boys and girls because learning takes place in the interaction with a 'real' object and in this sense, Arduino offers a great tool to develop all these skills. These projects were realized with Arduino, a platform with which it is possible to stimulate creativity, allowing everyone to give shape and substance to their ideas because the only limit we can set is our imagination.

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## References

- [1] Breiner et al., What is STEM? A discussion about Conceptions of STEM in education and partnerships, *School Science and Mathematics*, 2012.
- [2] Papert, S., Children computers and powerful ideas, 1993
- [3] H. Sánchez, L. S. Martínez, J. D. González, Educational Robotics as a Teaching tool in higher education institutions: A bibliographical analysis, *Journal of Physics: Conference Series*, 2019.
- [4] J. Kinchin, Using an Arduino in physics teaching for beginners, *Physics Education*, 2018.
- [5] Martín-Ramos, P., Lopes, M.J., Silva, M.R., Student2student: arduino project-based learning, 2016.