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Astronomy: a success story in education

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Abstract

HOU is a global educational organization that promotes inquiry-based scientific education. Astronomy provides firm scientific grounds for this purpose; the mathematics needed is simple, the data can be acquired with simple instrumentation in any place on the planet, and the physics is rich with a broad range of levels. The Global Hands-On Universe association (http://www.globalhou.net) makes use of the astronomical universe as a training lab. This contribution reports the current activities of the HOU sonsortium, the use of robotics telescopes for education, and the experience of introducing relevant pieces of astronomical research within the educational world.

1 Introduction

A clear disaffection for scientific studies at universities, in particular mathematics and physics, is currently observed in the occidental world, including most of the European countries at pointed out by Rocard inform. However, professionals in this field are needed for the future of our moderm society. The specific pedagogical concept underlying, the HOU project is the practical use (Hands-On) of real astronomical data in classrooms. The project does not aim at teaching comprehensive astronomy courses but rather at challenging pupils in order to teach them what is a scientific work, how to comprehend data and interpret them within physics and mathematics courses. The objective is to form open-minded pupils able to think by themselves. The innovative aspects of this project are both technical and educational.

Hands-on Universe (HOU) was originally born in the Lawrence Livermore Laboratory in California (U.S.A.) but now is spread all over the planet with nodes in all continents. The original highly technological concept is being adapted to the educational environment in the various countries. As today Global-HOU (G-HOU) has nodes in more than twenty countries with different languages, degree of technological development and wealthyness. G-HOU is implementing the Galileo Teacher Training Program, an educational project of the

International Astronomical Union. This contribution summarizes the main developments of G-HOU in tools, exercises, training and networking activities for scientific education.

2 HOU-tools

G-HOU has implemented and tried in the educational environment several tools developed either by members of the team or by collaborating groups. Tools include programs and instruments.

Two main programs have been used within the G-HOU environment:

- Stellarium, a free open source planetarium (http://stellarium.sourceforge.net/), to plan astronomical observations and to teach diurnal and yearly motions of astronomical objects.
- SalsaJ, a free java-based program, developed by the European Union HOU (EUHOU) to process and analyze astronomical images. SalsaJ is based on ImageJ, a public domain Java imaging processing program (http://rsbweb.nih.gov/ij/). The software has been designed to be a multi-platform, multi-lingual package for image manipulation and analysis in the classroom. Its design enables easy implementation of new facilities and basically requires no in-situ maintenance. SalsaJ allows to measure the fluxes, sizes or the time evolution of astronomical objects becoming a fundamental tool for any educational research project.

Three basic types of instruments have been considered for the G-HOU educational programs:

- Small radiotelescopes to observe the 21 cm line of atomic hydrogen. These small instruments allow an efficient mapping of the distribution of HI gas in the Galaxy. Simple kinematical models can be developed in the classroom based on the curricular study of the circular motion and basic geometry. Radio astronomical observations can be carried out during day time and even in poor weather conditions. This makes them ideal for teaching astronomy interactively in the classroom.

  The radiotelescope is a modified television antenna with a diameter of 2.3 m that provides an angular resolution of about 7°. The receiver of the Onsala facility has a bandwidth of 2.4 MHz and 255 frequency channels, so that each channel is 9.375 kHz wide. A good spectrum is obtained in just 30 seconds. The HI line profiles are processed in the classroom with SalsaJ and used to map the spiral arms.
- Web Cam systems to obtain digital images of the nearby astronomical bodies with small amateur telescopes. As an example, HOU-Poland designed a low cost Webcam system (including threads to attach the Webcam to small telescopes) that was implemented in the European Union during the period 2004–2006. This instrumentation can be used to observe solar spots and track the solar cycle, to observe Mercury and Venus

transists, Solar System objects, stars, galaxies and nebulae. Students record the images in electronic format allowing them to carry out measurements on the data.

- The Faulkes Telescopes are two 2 meters telescopes that are only for educational purposes, one in Hawaii and another in Australia. These telescopes are available to teachers for them to use as part of their curricular or extra-curricular activities and are fully supported by a range of educational materials and a team of educators and professional astronomers (see http://faulkes-telescope.com for more details).

  The telescopes can be used in real time and the teachers select their targets, filters and exposure time. Only imaging capabilities are available though new spectroscopic capabilities are under development. The telescope design is Altitude-Azimuth with Telescope Control System based upon that of the William Herschel Telescope in La Palma Observatory. The Primary mirror diameter is 2 m and the focal ratio f/10.

  Faulkes telescopes allow carrying out research projects with high school students.

3 Exercises and wiki

There are many kinds of exercises in the HOU webs. They can be classified into three main groups:

- Exercises to introduce the contents of Physics High School Curriculum.

  There are many exercises to illustrate the Kepler laws (orbital motion of Jupiter moons, the orbit of stars in galaxies, the orbits of planets around the Sun) and its power as a means to measure the mass of distant objects. These exercises can be used together with astronomical observations during "Physics Labs" at high school level. Good exercises can also be found on orbital motion and, in general, on kinematics. Unfortunately, good exercises for other branches of physics, such as electromagnetism, are rather unusual.

- Exercises to introduce the contents of Mathematics High School Curriculum.

  There are two sets of exercises: the Sun as a MathLab and the Moon as MathLab (http://www.houspain.com/gttp) to introduce mathematical concepts making use of astronomy and space research. There is a broad range of concepts that can resource to these exercises: from very simple calculations of the surface of polygons in Solar Sails to heuristics to optimize space travel. Statistical concepts are introduced by deriving the age of different areas in the Moon through the level of craterisation. The relation between Cartesian and spherical coordinates can be fully exercised through the position of stars and planets in the sky.

- Exercises to introduce astronomical concepts.

  This is, by far, the largest set of exercises. Measuring the mass of stars with HR diagrams, the light curves of supernovae, the light curves of stars with transiting planets, detecting supernovae in other galaxies, observing asteroids and meteorites, measuring the geographical coordinates of a given location on the Earth surface...

Figure 1: Wiki-HOU

Wiki-HOU is a service designed and developed by HOU-Spain to distribute and update exercises for education in the Spanish secondary system (E.S.O./Bachillerato); it is accesible through http://www.houspain.com/gttp (Fig. 1)

Wiki-HOU is an open and frienly tool, to allow teachers to find, download and upload information easily. To precent students access the solutions of the exercises, Teachers have a personal access key based in a username and pasword. This Wiki-HOU allows two classes of users, registered and the rest of users.

To become a registered user, users must fill a short web-based form; after they are contacted via email for security purposes.

HOU Spain have deloped several applications, that are included in the Wiki-HOU, a sample of them are:

- The Solar-System as a Mathlab: contains a collection of exercises that encourage math skills. This computer application is divided into two large sets of exercises, called "Sailing through space" and "The stellar traveller".

  The first one trains students in changes of coordiantes (cartesian to spherical, ...), calculation of distances in a two and three dimensional space, conic equations, elementary geometry... within an astronomical environment using the planets of the solar system and a hypothetical trip on a solar saill ship.

  The second set of exercises brings statistics to the pupils, under the task of designing the route of an interestelar travel to extrasolar planetary systems,the student gains an intuitive notion of minimal path betwen series of points (in our case planets) and the procedure to minimize distances.

  We are making a new version of this application with updates technology and astronomical content (the recent Ikaros mission).

- The moon as a Mathlab: using the moon as an astronomical laboratory to introduce concepts such as the calculation of the density of bodies, gravitational force, measuring distances remotely over a rounded body, and the study of the lunar age.

  Statistics is also put in place by determining the age of the lunar surface through craterization.

All our exercises have been cataloged and adapted to the Spanish educational curriculum. Currently we are developing a multilingual tool for all the resources to share them with the international comunity.