Space travel – the distances to planetary system and travel planning

Name of your Institution: Universidad Complutense de Madrid/AEGORA

Title of the educational scenario template: Inquiry-based teaching

Title of your educational scenario: The space traveler – Mapping planetary systems into space

Educational problem

Students are taught about the Solar System and the existence of extra-solar planetary systems. However, they are not acquainted with them. Astrography and the location of these planetary systems, the properties of the stars that heat the planets and concepts like the difficulty of finding habitable planets are not discussed on scientific bases.

Textbook teaching of the subject is limited and there is an overwhelming communication in the media that drives to misconceptions due to the absence of true scientific background.

This scenario aims to make students learn astrography, basic reference planes and the location of planets in Space. Students will also learn about the properties of the stars illuminating extra-solar planetary systems and the properties of the planets. The scenario makes use of the e-tool "The Solar System as a MathLab" developed by UCM/AEGORA to display the location of the planetary systems in Space, the properties of the stars and to measure the distance to/between planetary systems.

Educational scenario objectives

During this scenario, students will:

1. Learn about the main planes used as reference for astrography: the equator and the galactic plane

2. Learn the actual location of planetary systems in Space, whether they are clustered or not

3. Get acquainted with the properties of extra-solar planetary systems: properties of the star, number of planets, location of planets...

4. Learn about measuring distances at galactic scales

5. Introductory learning about the impact of the parent stars in the evolution of planetary atmospheres

Characteristics and needs of students

Students have a limited exposure to the real science beyond the media "scientific" hit parades. Extra-solar planets are hot topics in media but students have not access to real scientific knowledge. This exercise is intended as a primer to teach students to find the sounding scientific knowledge behind the media news.

The exercise will also allow students to interact (e.g. by working in pairs) and develop social and collaborative skills, allowing them to see that Science can be a group activity and not only a solitary one. This change of perception may trigger an increased interest for Science in many of them, and eventually a turn to Science careers.

Rationale of the educational approach and parameters guaranteeing its implementation

The activity is designed according to the **Inquiry-Based model** and it follows a scientific approach. Students are asked to make predictions on the characteristics and habitability of the planets, depending on the parent stars properties. Based on their research, they are asked to come up with their own conclusions and propose a trip to the system they ind more interesting and find out the total distance to be covered.

Different groups are expected to produce different trips; an open discussion among them will help in maturing the knowledge. At the end, an article on the media about a recent discovery of an extra-solar planet will be discussed.

Learning activities

1. Question-eliciting activities

a. exhibit curiosity

You may begin your lesson with the online presentation that includes videos describing the Solar System, the planets and the characteristics that made the Earth a life-hosting planet. Trigger a conversation with your class by asking your students simple questions like: whether they think that all stars can host planetary systems; what life is and whether it can be sustained in any condition; whether life-sustainable planets can exist in all the planetary systems and whether human beings can travel to them.

You may inform your students about what they will do during this exercise:

• Learn about the references in space to locate stars and planetary systems

• Study the distribution of extra-solar planetary systems and their properties

• Search for planetary systems in the night sky

• Investigate the properties of planetary systems and the possibility that life emerges in them

• Find out the time it would take to travel to them

b. define question from current knowledge

During your discussion with students, make sure to ask them some of the following questions in order to engage them further and check their background regarding the subject.

1. How are reference systems defined?
2. How is the position of stars in the sky given?
3. Whether all stars can host planetary systems or not
4. What is life? Which conditions make life feasible?
5. Which planets in the Solar System can host life? Why?
6. Does the Sun affect life on Earth? Does the Sun vary?

2. Active investigation

a. propose preliminary explanation or hypothesis

Planetary systems are wide-spread around the Galaxy. Some of the them are very close to the Earth. Many of them host several planets. But, which are the characteristics of their parent stars?

The project includes three main tasks for students:

a) Describe the characteristics of the Sun and the planets in the Solar system (location, temperature, composition...)

b) Describe the reference system and the location of extra-solar systems in it.

c) Describe generic distances and properties.

d) Describe the temperature/density requirements for life (if teachers feel proficient in the field they can expand into the properties of life, DNA and RNA chemical structure, molecular building up and robustness)

b. plan & conduct simple investigations*

After students have made their predictions, you may divide your class into working groups.

Inform your students about the two main tasks of the exercise.

In the first part students will use "The Stellar Traveller" tool available within the wiki source of HOU service in Hands-On Universe, Spain (url: www.houspain.com). The tool is programmed as a JAVA applet and requires to have JAVA installed. It works with any navigator.

*Note that the tool contains a detailed help online explaining the coordinates systems and the meaning of concepts like '*parsec*' or '*spectral type*'.

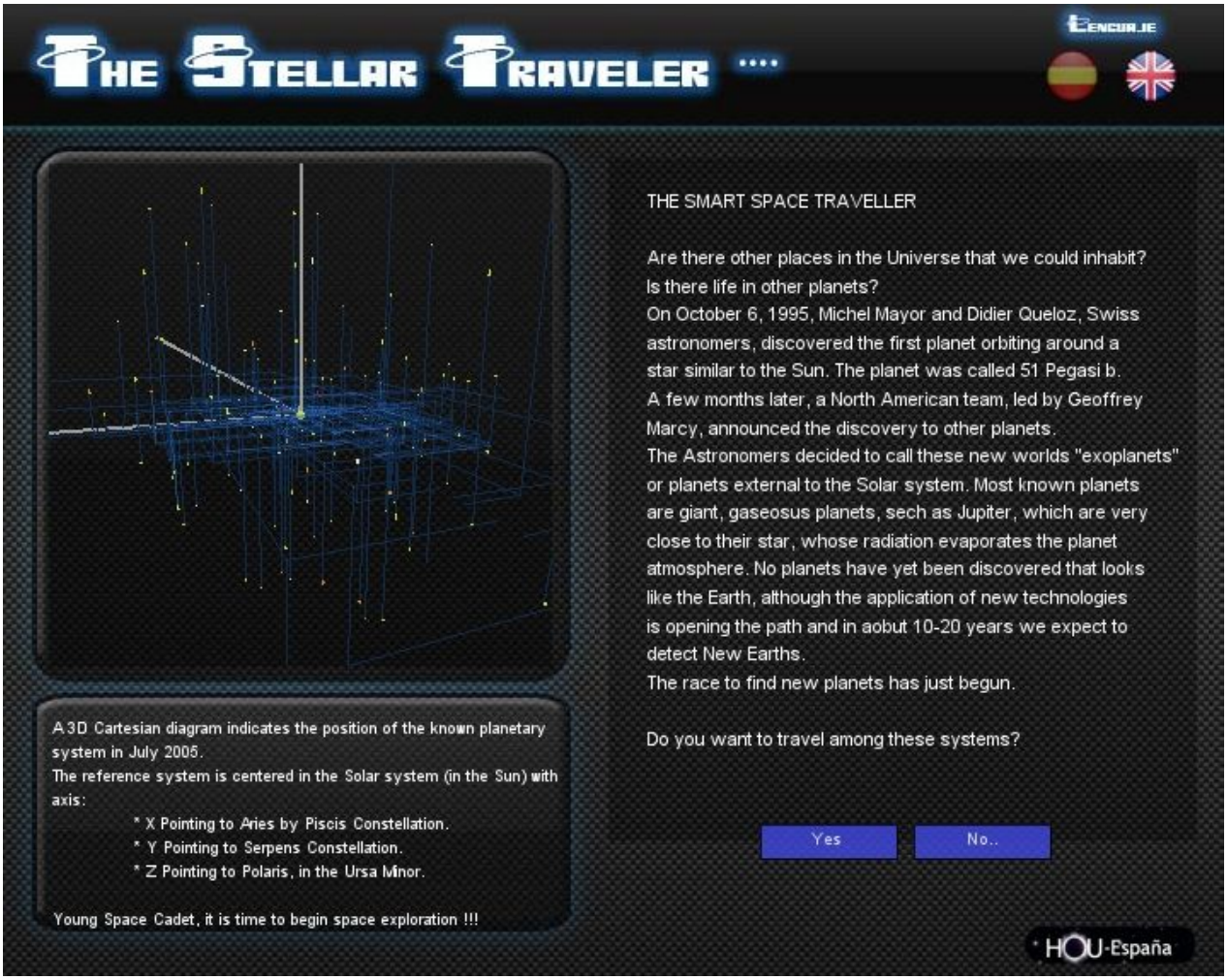

Figure 1: Access page to the tool. An interactive e-learning system provides tips to students on the main characteristics of the systems and the mathematical knowledge required to measure distances and plan an efficient trip.

By making use of the tool, students will select some planetary systems and define a trip. This task is planned to be carried out in small groups. They have to fill-up a worksheet describing the rationale behind their selection. The selection has to include 4 extra-solar planetary systems.

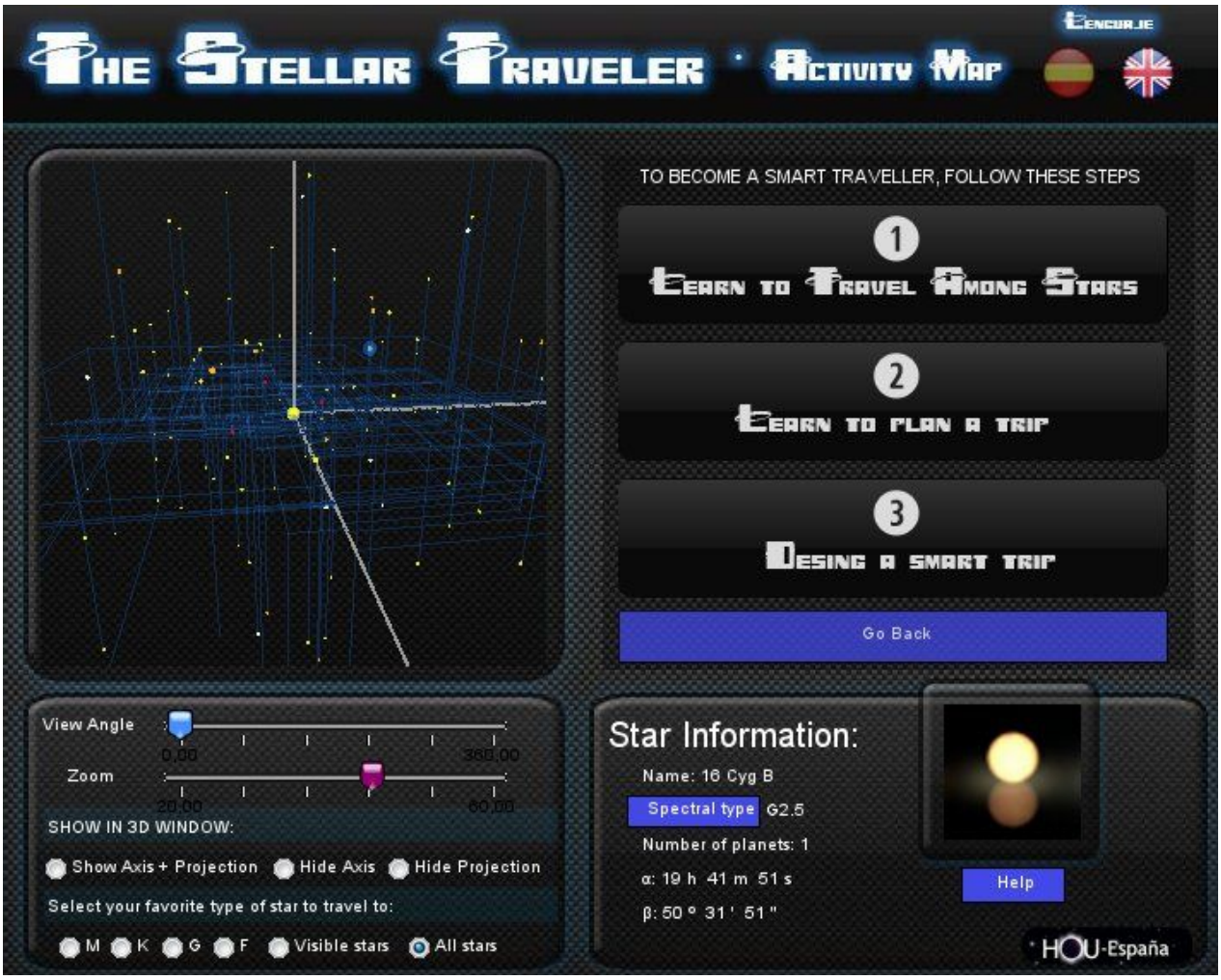

Figure 2: The location of the nearby planetary systems is shown in the upper left panel. The students can zoom and rotate the 3D display to select a given planetary system. Just by clicking on the selected system, the right bottom display will show the information of its location and planetary content.

In the second part, students in the groups and will study the properties of the selected (4) planetary systems: star, planets, planets location and produce a Worksheet including the main results of this research. This includes:

• A determination of the distances between planetary systems

• A determination of the orbital period using Kepler laws; the semimajor axis provided in the tool and the star's mass

• An estimate of the surface gravity assuming that the planets have a similar radii to Jupiter's

• A summary with the characteristics of the Solar System planets that are more similar to those found around other stars

• A critical description of the similarities and differences between the planetary systems they have selected and the Solar System

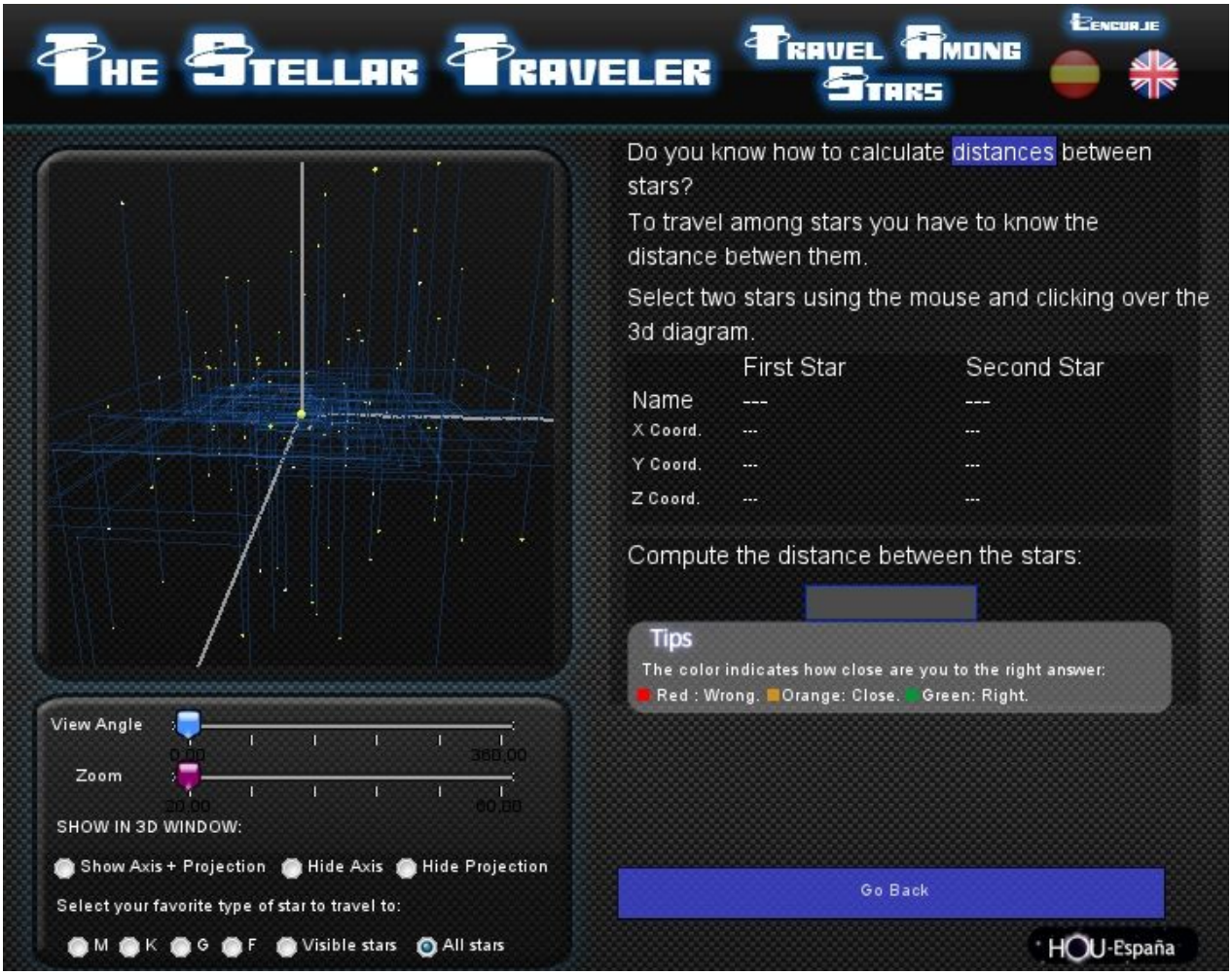

Figure 3: Help tool for measuring the distances between planetary systems. "The Stellar Traveller" tool shows a separate and highlighted "help-on-line" link with the definition of Cartesian and spherical coordinates systems and the equations for the coordinates transformation.

3. Creation

a. gather evidence from observation

Students will select one (1) planetary system from the list to be observed. Then, they get information about the magnetic activity of the star. Magnetic activity produces a a variable flux of high energy particles and radiation that interacts with the atmospheres of the planets in the

planetary systems. The observations will be intended to measure the magnetic activity of the star by the variability of the flux in the Hydrogen Alpha line of the Balmer Series (Hα at 6562 Angstroms) and the B-V color.

b. Making the measurements

Students will be given the chance to visit La Hita observatory (in Toledo, Spain) and manipulate the telescope to make observations of the parent star. Eventually, these observations could be carried out with the Faulkes Telescope Project or even, the data could be withdrawn from scientific data archives. The use of data archives will depend on the knowledge and ability of the teacher driving the research.

4. Discussion

a. explanation based on evidence

Ask students to answer the following questions. Students will be working in teams as before in order to produce their calculations:

1. which are the means to measure the variation of the stellar radiation?
2. how trustful are they?
3. are there any variations detected?
4. are they reasonable?
5. which would be the impact of these variations at the distance where the planets are?

Based on the exercise you performed and on your answers in the previous questions write your report on the template given (at the end of this document).

b. consider other explanations

Discuss with your students about the following:

» can the Earth atmosphere be responsible for the variations observed?

» are the brightness variations of the stars relevant for the emergence of life?

c. Critical reading

Select a recently released article (TV, printed press) about planetary system discoveries and discuss with your students:

- why is this article relevant? How many planets like this are known?
- how far it is? How long it will take to travel to this planet (at the speed of light)?

5. Reflection

a. communicate explanation

Make an overview of what has been discussed in the classroom during the exercise. You may focus on the following issues:

- did you face any difficulties when seeking for information on planetary systems?
- are there enough references on them? Are they reliable?
- is it possible that there are planets like the Earth in other planetary systems?

Furthermore discuss why would it be easier to find *'Jupiters'* than *'Earths'*.

Ask your students to present their results and build together a big mosaic with the location and properties of the extra-solar planets. Mark the location of the systems in a night sky map and locate nearby constellations. Finally ask your students to comment on the feasibility of detected extra-solar planets.

Which strategies would they propose?

Should planet-star eclipses be frequent?

Is it feasible that the stellar intrinsic brightness variations affect the planets atmosphere?

Participating roles:

In this scenario **students** start by talking reference systems, measuring motions and what they know about motions in the Solar System and the sky. After an introduction to the subject they are acquainted with the Solar System just as another planetary system.

The **teacher** is a facilitator and guides the students through the process of measuring and reflection. He/she introduces students to the pertinent concepts, directs them to the problem at hand by asking questions and shows them how to use the tool. He/she also may organize a visit to the observatory and propose new observations with the students.

Tools, services and resources:

1.Computers, Internet connection and Java

2. Wiki-HOU (Spanish) platform
3. The Stellar Traveler platform » http://www.houspain.com/app/en_trav/]
4. Manuals num. 1 and 3

   Manual 1: Astronomical coordinates, Distances, Magnitude

   Manual 3: Kepler´s laws, Conics, Orbital movement

STUDENT'S SHEET

1. SELECT FOUR SYSTEMS AND WRITE DOWN THEIR PROPERTIES IN THE TABLE*

STAR	COORDINATES	DISTANCE TO SUN (light-years)	No. of Planets and semimajor axis (AU)	Orbital Period (Earth years)	Properties of the Star
	α δ		P1 P2 P3	P1 P2 P3	Mass Spectral-Type
	α δ		P1 P2 P3	P1 P2 P3	Mass Spectral-Type
	α δ		P1 P2 P3	P1 P2 P3	Mass Spectral-Type
	α δ		P1 P2 P3	P1 P2 P3	Mass Spectral-Type

***Special notes:**

2. COMPUTE THE DISTANCES AMONG THE STARS AND CHECK WITH THE TOOL
3. SELECTE ONE STAR FOR A MORE DETAILED STUDY AND ANSWER THESE QUESTIONS:
    - Why have you selected this star?
    - Is it cooler or hotter than the Sun?
    - Are the planets similar to the Earth?
    - Are the planets similar to Jupiter?
    - Why do you think that most of the planets are similar to Jupiter?
    - Does the Solar radiation affect the Earth? How?
    - What is a Solar storm? Does it affect the Earth? How?
    - Does the star in your planetary system have storms?
    - Have you detected variations in the brightness that could be caused by storms?
    - Describe the observations you have carried out

Note for the **teacher**: If the students have finally conducted astronomical observations they should add in here the measurements they have obtained, when and how.