Final Discover the COSMOS Demonstrators

Setting references when everything moves – stellar streams

Name of the Institution: Universidad Complutense de Madrid/AEGORA

Title of the educational scenario template: Inquiry-based teaching

Title of the educational scenario: Star formation – Moving groups in the Galaxy

Educational problem:

Students are taught about and familiarized with simple reference systems as those drawn on the black board. However setting a reference system is not trivial and it is closely related with the concept of relative motion and inertial reference systems.

Textbook teaching of the subject is limited due to the lack of accessible and inspiring experiments. Students are familiarized with GPS devices but they do not understand how the references are set.

This scenario aims to provide an initiation experiment to fill these gaps based on the stellar streams in the Gould's Belt. It is also linked to the science to be carried out by the GAIA mission of the European Space Agency.

Educational scenario objectives:

During this scenario, students will:

1. Learn about the motion of the Earth, Solar System bodies and Stars.
2. Learn about apparent motion and the relevance of distant bright objects to set references.
3. Get acquainted with making and studying astronomical observations.
4. Learn about measuring stellar motions by comparing images taken decades apart.

Characteristics and needs of students:

Students have limited exposure to real problems; they work on well defined ideal environments. Neither they are familiarized with the basic principles behind the modern technologies behind everyday activities

The exercise will also allow students to interact (e.g. by working in pairs) and develop social and collaboration 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 in Science in many of them, and possibly 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 based on the mater of setting references to measure the motions of bodies. Based on their research, they are than asked to come up with their own conclusions and participate in a research project to undisclose members of a stellar moving group. Students have the opportunity to work with real scientific instruments and visit the facilities to develop an understanding of the measurements through hands-on activties.

Learning activities:

1. **Question-eliciting activities**

a. Exhibit curiosity

You may begin your lesson with the online presentation that includes videos describing the motions of objects in the Universe, from the Earth to the Galaxy. Trigger a small conversation with your class by asking your students simple questions like: how would they determine that something is moving in the sky or whether they could find any difference between the motions of the International Space Station, a shooting star or an asteroid .

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

- Learn how to measure the motion of stars and asteroids
- Study images of a large star forming region in the Galaxy to determine the variations between different epochs.
- Visit the observatory
- Investigate the characteristics of the stellar population unveiled by their peculiar motions.

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 reference systems are defined?

2. How references are set when everything moves?

3. Are the laws of physics the same, everywhere in the moving Universe?

4. Why stars get trapped in galaxies?

5. Why do stars move within the galaxies?

6. What kind of orbits do you expect stars to follow?

2. Active investigation

a. Propose preliminary explanation or hypothesis

Stars orbit around the center of the Galaxy as Solar Sytem bodies orbit around the Sun. Objects in the Solar System have very different types of orbits. Which would be the expected orbits of objects in the Galaxy?.

Their project includes three main tasks:

a) Describe to the students the types of orbits of Solar System bodies (elipses around various bodies, the Sun, Jupiter, Saturn, comets, the inclination of Pluto orbit...)
b) Look at images of other galaxies and try to extrapolate from them, the kind of orbits that may be expected. Look for rings and binary galaxies. Display the Magellanic stream.
c) Build the distance scale of the Universe with the students, investigate the velocity of the galaxies and the velocity of the stars. Discuss with them their ideas about how to set references to measure the motion of stars.

b. Plan & conduct simple investigation

After students have made their predictions, in order to prepare for the exercise, ask your students to study their student's book. 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 be given access to the image mosaic and select an area for study. Students, divided in groups, will study the differences between images taken at different epochs: type of objects, high and low stellar densities, brightness variations, peculiar bodies and produce a Worksheet including the main results of the visual inspection.

In the second part, students will set up ten stable references for the astrometric calibration of the plate and proceed, aided by the e-tool, to calibrate it. After, they will measure the variation of the coordinates of moving objects. The will include those data in the Worksheet.

Students will be given the chance to visit the LaHita observatory and manipulate the telescope used for the observations.

The '*Moving Groups*" tool

Students will use the '*Moving Groups*" tool to access the data and make the astrometric measurements on a platform in Spanish and especially adapted for them (http://www.astronomiayeducacion.es).

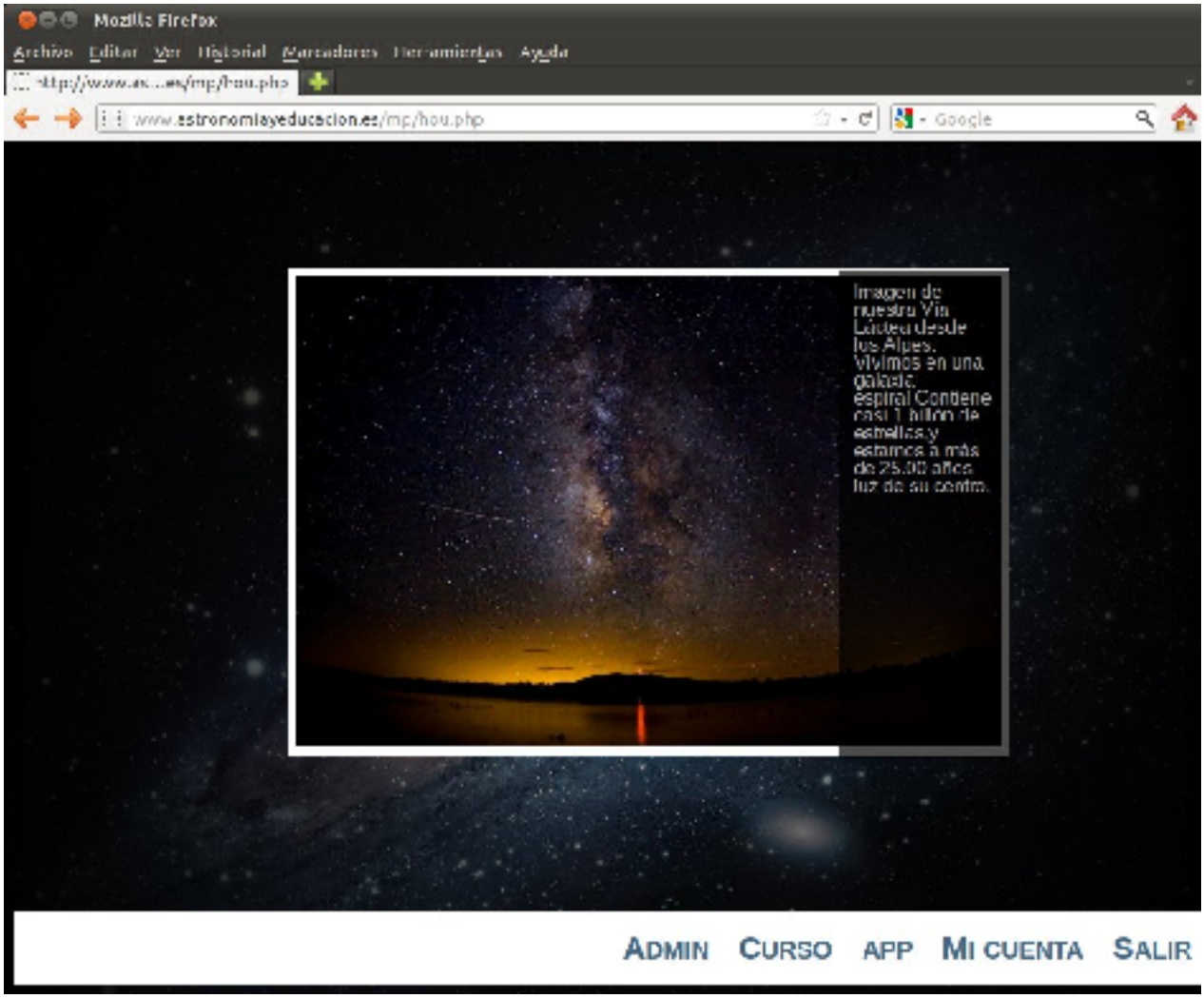

Figure 1: Access page to the tool. Teachers have some administration rights that can be used by them and followed up to track the evolution of their students.An interactive on-line course (CURSO) is available for teachers and students with movies describing the motions of objects in the Universe.

3. Creation

a. Gather Evidence from observation

The mosaic with interactive images is made accessible to the students. They may select any region in the mosaic. Every tile has to be worked by small groups who first have to seek for differences in the images obtained 30 years apart.

Figure 2: Select an area for study in small groups.

b. Making the measurements

Students will have to measure the variations in the astronomical coordinates of the stars they suspect are moving. They have an aided tool behind to make the astrometric calibration of the field. They will produce an excel spread sheet reporting the differences found between images obtained at different epochs. They will have to discuss whether the differences are relevant or not.

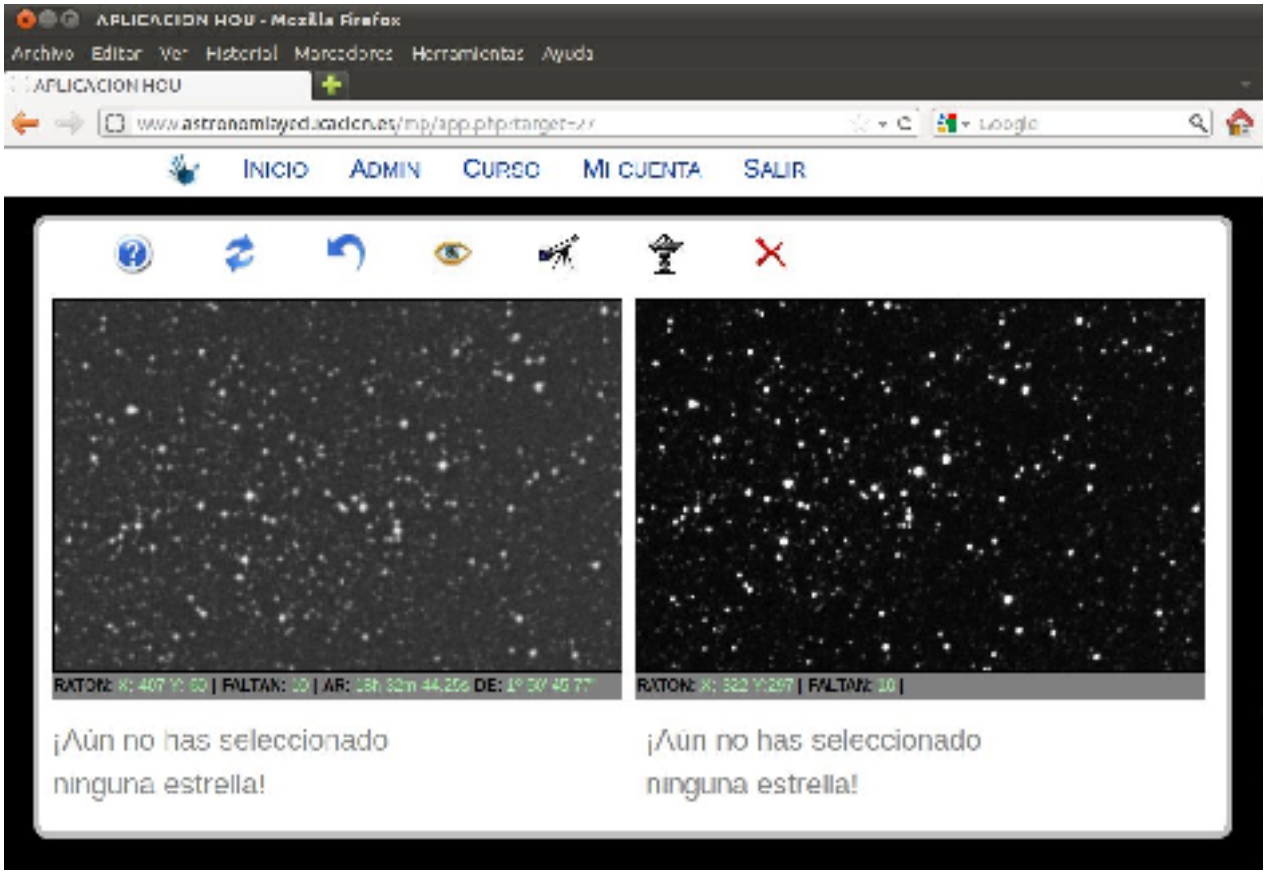

Figure 3: The application interface to measure the variations in small stellar fields between epochs.

c. Making the measurements

Students will be given the chance to visit the observatory, manage the telescope and propose new observations.

4. Discussion

a. Explanation based on evidence

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

1. Are there large variations or patterns can be recognized over the years? Why?
2. Are all the objects point-like? Are their binaries or multiple systems?

3. Are there brightness variations?, are the brightness variations real? How would you determine?
4. Are as many variable sources in all the tiles?
5. Have you identified any moving object?, does it move towards the Galaxy center? How could you determine its true velocity?

Based on the exercise you performed and on your answers in the previous questions write your report on the given template.

b. Consider other explanations

Discuss with your students about:

- whether the reported motions can be associated with the motion of Earth or the motion of the Sun

- whether the brightness variations are caused by the contrast in the images or are real and how could they correct for that

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 studying the images provided?
- Are there enough references in all the fields? Are they reliable?
- Have you detected any galaxy in the field? Would it be a good reference?

Furthermore discuss whether the results are dependent on the tile studied. Is it equally probable to find moving stars in all the field?, is their any chance to detect a Solar System body in the images?

Ask your students to present their results and build together a big mosaic with the location and direction of motions of all the stars. Ask students to comment on the similarities characteristics of the vectorial field built from all the tiles studied. Finally ask your students to comment on the accuracy of the method followed and the implications of coherent stellar motions.

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 '*Moving Groups*" to learn about motions and measure the variations in stellar fields.

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 with internet connection and Java
2. Wiki-HOU (Spanish) platform