



Discover the COSMOS Demonstrators

Galaxy crashes - Galaxy Classification and Formation

Name of the Institution: Ellinogermaniki Agogi / NUCLIO

Title of the educational scenario template: Inquiry-based teaching

Title of the educational scenario: Galaxy Classification and Formation

Version: 1.0

Educational problem:

Galaxies may be viewed by students to be immutable or even abstract objects. In this scenario students get to “experiment” with galaxies and find out how they are formed and why they have the shapes they do.

Textbook teaching of the subject is inherently limited, due to the dynamic nature of the related processes. Moreover, lack of sophisticated telescopes in schools makes direct observations of galaxies a non-trivial task, to say the least.

This scenario aims to fill these gaps and get students to understand galaxy formation.

Educational scenario objectives:

During this scenario, students will:

1. Learn about the different shapes of galaxies.
2. Learn about the Hubble classification system.
3. Get acquainted with making and studying astronomical observations.
4. Learn about simulations and how they may be used in a scientific context.

Characteristics and needs of students:

Students have limited exposure to stellar objects, these being beyond their range of perception, and limited theoretical knowledge, these being only tangentially treated in the curriculum.

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.



Discover the COSMOS Demonstrators

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 matter of Galaxy Formation and conduct a research which is supported by indicative question. Based on their research, they are then asked to come up with their own conclusions and compare them to their initial predictions. The whole activity is based on students' creation and observing skills. Students have the opportunity to work with real scientific instruments and simulations of real phenomena and thus develop an understanding of the phenomenon through hands-on activities.

Learning activities:

• Question-eliciting activities

a. Exhibit curiosity

You may begin your lesson with a presentation of a video or numerous pictures depicting different galaxies. Trigger a small conversation with your class by asking your students what they know about galaxies in general.

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

- Learn how to classify galaxies
- Study images of galaxies which they will collect themselves using a robotic telescope
- Investigate the origin of the shape of the galaxy they'll observe using simulations.

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 do galaxies form?
2. What kind of galaxies are there and how do we classify them?
3. How long does it take for a galaxy to be formulated?
4. How many galaxies are there in the universe?
5. What is a galaxy composed of?
6. What is so special about the centre of galaxies? Why are galactic centres so bright?



Discover the COSMOS Demonstrators

- **Active investigation**

- a. Propose preliminary explanation or hypothesis**

Astronomers are able to catalogue galaxies according to their morphology due to the existence of certain classification systems. In order to investigate the origin of these morphologies astronomers use simulations. Students will put themselves in the position of amateur astronomers. Their project includes two main tasks:

- a) They will try to classify galaxies according to a classification system
 - b) They will study the process of their formation using simulations.

a) Show your students pictures of different galaxies and ask them whether they can come up with a classification scheme. Discuss with them their ideas, and try to form a classification system according to their proposals. Make sure that students are keeping notes of their ideas and the classification system they proposed. After students finalize their predictions, mention the Hubble classification system and ask them whether they are acquainted with it. Discuss with students the Hubble classification system and compare it to the classification system they proposed.

b) Ask your students whether they can imagine how such galaxies are formed. Discuss with them how could these shapes have been created and introduce the central idea of investigating the past of galaxies and the universe in general by creating respective simulations.

- b. Plan & conduct simple investigation**

After students have made their predictions, in order to prepare for the exercise, ask your students to study the 'Related theory' section of 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 a copy of the Hubble Tuning Fork worksheet and a set of pictures of different galaxies. Students, divided in groups, will study the morphology of different galaxies and attempt to categorize each of them using their worksheets (Tuning Fork Worksheet.jpg and Students Record.xls).

In the second part students will choose one of the galaxies indicated below and make an observation using a robotic telescope from the DSpace platform. After they retrieve their observation they will study the morphology of the galaxy, classify it and attempt to reproduce its shape using a 'galaxy crash' simulation.



Discover the COSMOS Demonstrators

You will be using the DSpace platform in order to perform your observations.

The 'Galaxy Crash' simulation

Students will use the "Galaxy Crash" simulation in order to recreate the shape of the galaxy they have observed with the telescope.

<http://burro.astr.cwru.edu/JavaLab/GalCrashWeb/GCSolo.html>

During the simulation the students can set several parameters like the inclination of the galaxy, the plane of the galaxy that is perpendicular to the rotation axis, galaxies separation distance (in kiloparsec), the relative masses of the galaxies etc. After the simulation is initiated the students can get a 3D view of the collision by rotating and zooming the image in the view port.

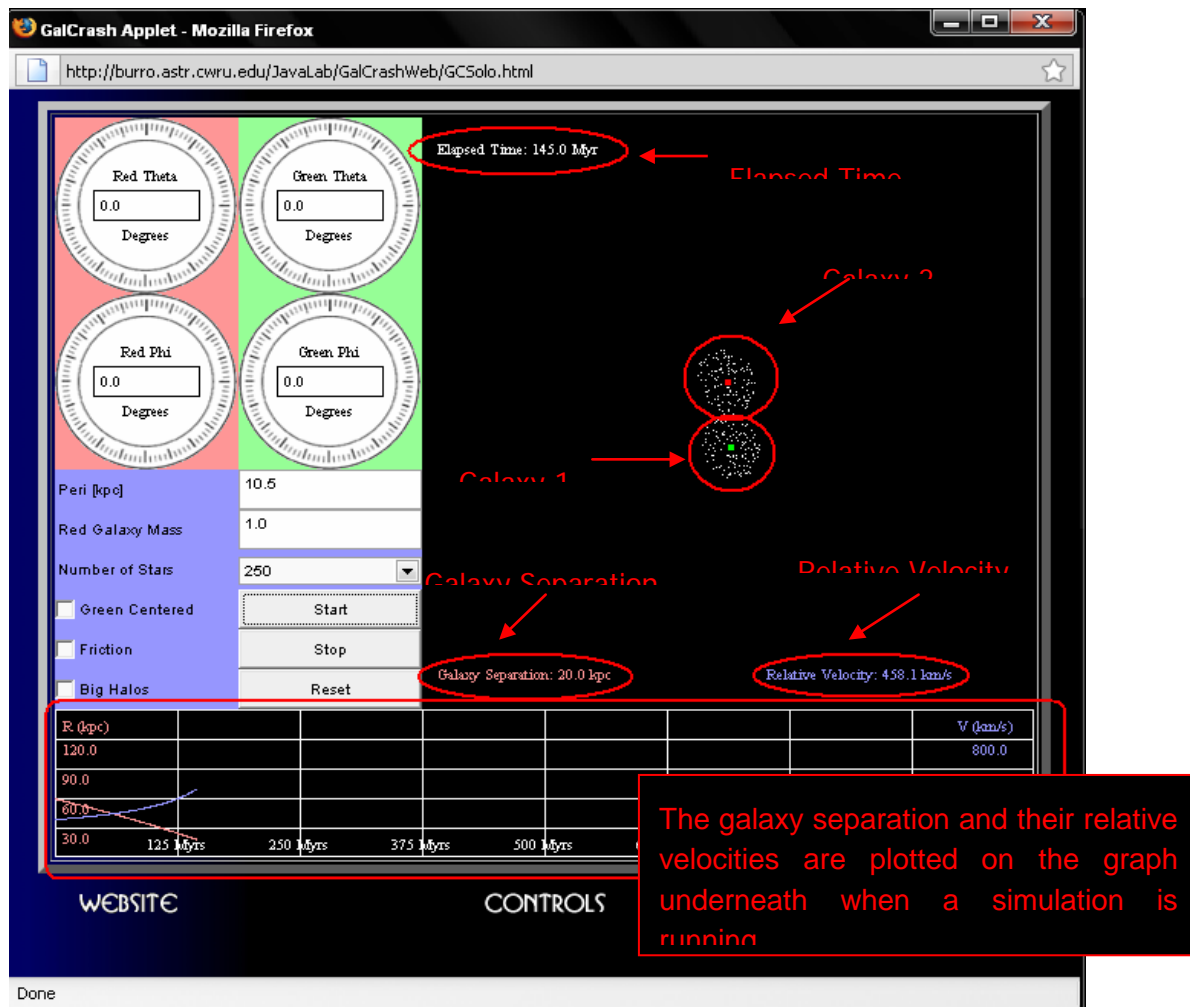


Figure 1. "Galaxy Crash" simulation (For more information see: <http://burro.astr.cwru.edu/JavaLab/GalCrashWeb>).



Discover the COSMOS Demonstrators

- **Creation**

- a. Gather Evidence from observation**

As it might take time in order to receive your observation from the robotic telescope, you may perform the observation first.

- b. Making the observation**

Students may observe one of two the following galaxies:

M51 and its companion, NGC 5195

Coordinates: 3:29:53.16, 47:11:48.120

Filter: Color

Exposure: 180 s

NGC 4038 - The Antennae

Coordinates: 2:01:52.68, -18:51:54.00

Filter: Color

Exposure: 180 s

The information mentioned above is appropriate for making observations using the robotic telescopes of the 'Faulkes Telescopes project' from the DSpace.

In the following steps students study Galaxy Classification systems and learn about Galaxy Formation.

- **Discussion**

- a. Explanation based on evidence**

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

1. How good is the agreement for the classification of each galaxy? Are there some galaxies which are disagreed on more than others?
2. In which class does the galaxy you've observed belongs to? What comments do you have regarding the morphology of the galaxy?



Discover the COSMOS Demonstrators

3. Explain which parameters you used for your best model in the simulations you have carried out.
4. How long did it take for this interaction to reach the observed stage?
5. Based on your simulation, describe how the current shape of the galaxy has been formed.
6. Based on your simulation, what do you think will happen to these galaxies in the future?
7. What happens to the relative velocities of the galaxies as they reach their point of closest approach (perigalacticon, or peri for short)?
8. 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

Ask your students to evaluate the Hubble Galaxy classification.

- Do they believe there should be some extensions to this classification system?
- Do they know of any other classification systems? You may mention the de Vaucouleurs system and ask your students to compare the two systems. (For more information regarding the two systems, see: http://en.wikipedia.org/wiki/Galaxy_morphological_classification)
- Compare the parameters each team used in order to produce the images of the galaxies. Check if all teams have used more or less the same parameters, if not discuss about the different scenarios regarding the formation of the galaxies under investigation.

• 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 classifying the galaxies from the images provided?
- Can all galaxies be clearly classified using the Hubble classification system?
- Is there need for a more detailed classification system?
- In what way could the classification system be improved?



Discover the COSMOS Demonstrators

Furthermore discuss the different shapes of galaxies. You may focus on the following issues:

- What parameters are involved in the shaping of galaxies?
- Why are spiral galaxies more active in terms of star formation?
- How long does it take for a galaxy to form?
- What kind of galaxy is the Milky Way?

Ask your students to present the images they've obtained from their simulations compared to the images from the telescope. Ask students to comment on the similarities and differences between the images. Finally ask your students to comment on the accuracy of the method followed and whether the adaptation of such simulations can in fact produce valuable information for astronomers.

Participating roles:

In this activity students start by talking about galaxies and what they know about them. After an introduction to the subject they are acquainted with the DSpace platform to learn about galaxy classification and with the *Galaxy crash* simulation to study galaxy formation.

The teacher is a facilitator and guides the students through the process of simulation and experimentation. 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 DSpace and Galaxy crash tools.

Tools, services and resources:

1. Computers with internet connection and flash
2. DSpace platform