# Engaging students in independent astronomy research projects

*by Bob Riddle*

A *Framework for K–12 Science Education*, on which the *Next Generation Science Standards (NGSS)* was based, is divided into three dimensions: scientific and engineering practices, crosscutting concepts, and disciplinary core ideas (NRC 2012). With these dimensions serving as a guide, teachers can create lessons in which middle-grade (6–8) students develop a deeper understanding of Earth and space concepts, their implications, and their applications across other content areas.

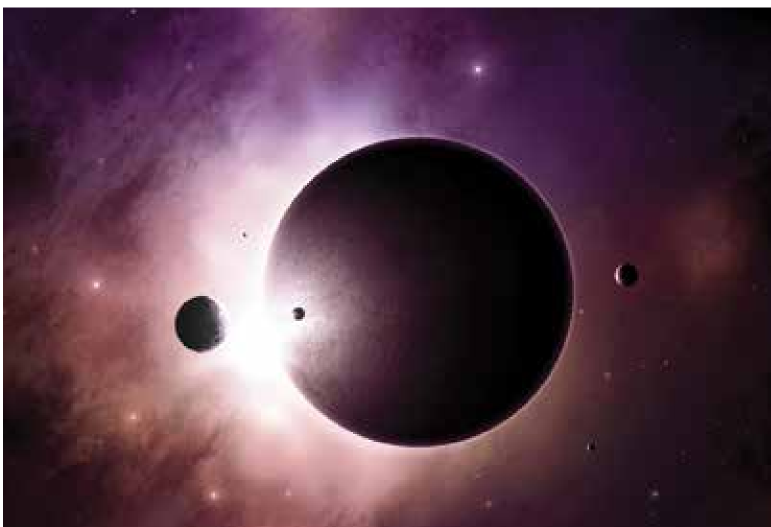
The most relevant *NGSS* standard is MS-ESS1: Earth's place in the universe (Achieve Inc. 2013), which contains disciplinary core idea ESS1.A: The universe and its stars. One component of this disciplinary core idea, "Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe," could serve as the basis of an independent research project where students compare and catalog some of the different shapes of galaxies (see Figure 1 to see how this project connects with the *NGSS*) (NRC 2012, p. 174). A model project, Cool Cosmos, is described below. As part of this project, students requested images of three different-shaped galaxies from a robotic-controlled remote telescope and then used image-processing software to bring out colors and other details

## Background: Images in astronomy

Astronomy is not exactly a hands-on science; many astronomers rely on data about remote and distant objects obtained through instruments such as ground-based, or orbiting, telescopes. In most cases, the data collected are not the image or picture one sees online and in print. Many of these data are collected using imaging instruments, such as a charge-coupled device (CCD), and then the image data undergo image processing using software designed to make otherwise unseen features more visible.

Image processing is the heart of much of modern astronomy; as image technology has advanced, the ability to see more-distant objects, as well as more detail in objects, has likewise advanced. The goal of astrophotography, the imaging of celestial objects by both the amateur and professional astronomer, is to capture the maximum amount of light radiation possible. For telescopes, size matters, meaning that the larger the mirror, the more light radiation may be captured. We also know that the location of the telescope matters, an issue primarily dealing with optical astronomy and the interference of Earth's atmosphere. Now there are telescopes in Earth's orbit outside the Earth's atmosphere. By being outside the atmosphere, the telescope is not limited to what it can see, as opposed to having some forms of radiation blocked by the atmosphere. There is also a new technology called *adaptive optics,* in which the telescope mirror flexes to compensate for turbulence in the atmosphere that would normally make the object's image go in and out of focus. Whatever the means of observation, the raw data collected by the instruments need to be processed into a usable format.

In the beginning, astronomy was done using the eyepiece of a telescope, and objects observed were sketched on paper. While this is still a practice among astronomers, the introduction of the camera for capturing images quickly became the norm. As with any developing technology, astrophotography has evolved, in this case from the use of chemical-based photographic plates and film and specialized, hypersensitized film, to the use of devices equipped with CCD. The CCD, which was invented at Bell Labora-



tories in 1969, is a device with a light-sensitive surface. A CCD-based picture is constructed from the data created when light energy strikes the CCD. This light energy is converted to an electrical charge, with the amount or intensity of the electrical charge then assigned a series of computer bytes that represent a specific color from the visible spectrum.

There is an interesting history of how telescope technology has evolved and how our perception of the universe has changed as a result. Teachers could design projects in which students explore this by using the resources and information at the Telescopes From the Ground Up website (see Resources). Additionally, the planetarium movie *Two Small Pieces of Glass*, produced for the 2009 International Year of Astronomy, is an excellent short movie that follows two middle school students and their science teacher at a star party as they discuss and learn about the development of the telescope (see Resources).

## Cool Cosmos: Comparing shapes of galaxies

Among the many distinct objects populating the visible universe are the huge collections of stars we refer to as *galaxies*. Our planet and solar system are within what we believe to be a spiral-shaped galaxy, and our Sun is one of several hundred million stars making up the Milky Way galaxy. Galaxies are seen in different shapes and may be cataloged or grouped by their respective shape. In addition to spiral-shaped galaxies, there are elliptical-shaped galaxies, interacting galaxies with irregular shapes, and dwarf galaxies, among others. Galaxies like our solar system are thought to have developed in a similar manner, from the gravitational interactions of the material making up clouds of interstellar matter. Due to the mutual gravitational attractions, the material spirals inward, collapsing and spinning the cloud. It is uncertain, however, whether individual stars formed first and then coalesced into groups to eventually become galaxy size, or if the material came together before stars began forming.

The Cool Cosmos was an after-school project that involved middle school students at the African-Centered College Preparatory Academy in Kansas City, Missouri. While the overall goal of the project was to engage students in some of the practices astronomers use (specifically data acquisition and image processing), there were other goals, aligned with the *NGSS*, as well (see Figure 2). Participating students took advantage of a remote robotic telescope operated by NASA and Harvard University called OWN (Observing With NASA). Students requested images of three galaxy shapes, spiral, elliptical, and irregular, from the OWN website and used free MicroObservatory image processing software (see Resources) to work

**FIGURE 1** Connections to the *Next Generation Science Standards* (Achieve Inc. 2013)

| | | |
|---|---|---|
| **Standard**<br>MS-ESS1. Earth's place in the universe | | |
| **Performance expectation**<br>MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. | | |
| **Science and engineering practices**<br>Developing and using models<br><br>Analyzing and interpreting data | **Disciplinary core idea**<br>ESS1.A. The universe and its stars<br>**Component idea:** Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.<br>**Disciplinary core idea**<br>ESS1.B. Earth and the solar system<br>**Component idea:** The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. | **Crosscutting concepts**<br>Systems and systems models<br><br>Nature of science<br>Science knowledge assumes an order and consistency in natural systems. |

**FIGURE 2** Cool Cosmos project student goals

- Describe how telescopes and imaging techniques have improved with changing technology.
- Describe how these changes in telescopes and imaging have allowed for new discoveries.
- Describe how a CCD image is acquired.
- Describe the difference between image data provided in the FITS file format and a standard computer graphic file.
- Use internet resources to learn additional information about galaxies.
- Describe the various shapes of galaxies and the role that gravity plays in the shape of a galaxy.
- Use the OWN website to request images of galaxies and download data files for the images in the FITS format.
- Use the MicroObservatory image-processing software to convert FITS data files into color or monochrome (one color) pictures.

with the images they received (Figure 3). Prior to doing their own project, students spent some time working with a partner completing the tutorial lessons on how to use the MicroObservatory image-processing software with the data files. The data file is provided in the FITS format (FITS, or Flexible Image Transport System, is the standard data file format used in astronomy). A FITS file is not just a graphics file, such as GIF or JPEG; a FITS file could also contain a variety of scientific data sets (access is free).

Once they completed the tutorials, students had working knowledge of image requesting and image processing and were ready to request their images of galaxies. Assessment was based on a rubric that focused on how well a student made image requests, did additional research about each galaxy, and used the image-processing software. All students were given a flash drive for saving downloaded image data files, their processed images, and their report files and observing logs. The flash drive also contained the image-processing software, as the software is able to run from the flash drive and did not require installation on a computer.

For a more structured approach, there are other options, such as a series of well-developed lessons on the OWN website From the Ground Up! One of the lessons, "What Does the Universe Look Like in Color?," could even serve as a lesson guide for students to follow. Regardless, the end result is the same—image-processed pictures of different-shaped galaxies with a short, written description of each galaxy imaged. If image processing is not possible, students could still find different galaxy shapes by searching for and requesting images from the Sloan Digital Sky Survey (see Resources; access is free). Teachers can use these resources and suggested projects as the beginnings of a series of activities that will lead students to meet the performance expectations for this standard.

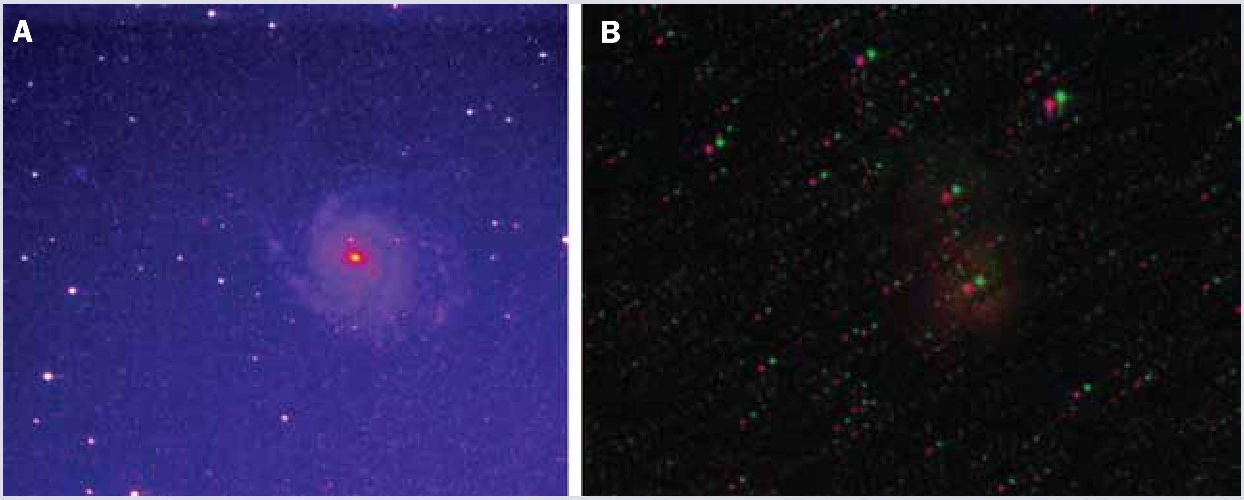
## Celestial events

While not exactly a celestial event (but tied to our calendar year, which is essentially based on celestial events), the first of two Friday the 13th days this year falls on September 13, with the second occurring on December 13. Coincidentally, these two dates are 13 weeks apart. There can be two or three Friday the 13ths in a year; the 13th occurs more times on Friday than any other day of the week; and any month that starts on a Sunday will have a Friday the 13th.

On Sunday, September 22, at 4:44 p.m. EDT, the Sun will have reached the celestial coordinates of 18 hours right ascension and 0° declination. This is the day of the September equinox, when the Sun rises due east and sets due west for a 12-hour daylight period and a 12-hour night period. In astronomical terms, the Sun is on the celestial or sky equator; in geography, the Sun is also on the equator. In either instance, the Sun has reached this point with respect to the Earth and stars as a result of the Earth's revolution around the Sun, which in turn gives rise to the Sun's apparent eastward motion along the ecliptic. As the Sun crosses the equator on the September equinox, it is also moving south.

Throughout this month, the two inner and faster-moving planets, Mercury and Venus, and the outer planet Saturn will be visible over the western horizon at sunset. As each planet moves in its respective orbit, there will be several evenings when the planets will group together in arrangements or conjunctions close enough to fit within a binocular field of view.

**FIGURE 3** Examples of galaxy images used with the Cool Cosmos project




Spiral galaxy in false color (A). Nongalaxy object showing poor registration (B).

## Visible planets

**Mercury** will be low above the western horizon at sunset this month and may be difficult to observe without a relatively flat horizon.

**Venus** will shine brightly above the western horizon at sunset near the bluish-white star Spica, and the pair will set a couple of hours after the Sun.

**Mars** will rise a couple of hours before the Sun and will be observable daily all month above the eastern horizon before sunrise. Grab your binoculars on the mornings of September 7, 8, and 9 to watch as Mars passes across the Beehive Cluster, an open star cluster in Cancer.

**Jupiter** will rise just after midnight and be observable daily all month above the southeastern horizon before sunrise.

**Saturn** will be above the southwestern horizon this month and will set several hours after the Sun sets.

## September

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| 2 | Thin waning crescent Moon near Mars |
| 5 | New Moon |
| | Venus near Spica |
| 7–9 | Mars transits Beehive Cluster |
| | Waxing crescent Moon near Venus |
| 9 | Waxing crescent Moon near Saturn |
| 11 | Waxing crescent Moon near Antares |
| 12 | First quarter Moon |
| | *Cassini* flyby of Titan |
| 15 | Moon perigee: 367,394 km (228,288 mi.) |
| 16 | Sun enters Virgo (astronomical) |
| 18 | Venus passes Saturn (September 18–23) |
| 19 | Full Moon |
| 20 | Pluto ends retrograde motion |
| 22 | September equinox (4:44 p.m. EDT) |
| | Sun enters Libra (astrological) |
| 23 | Waning gibbous Moon near the Pleiades |
| 25 | Waning gibbous Moon near Aldebaran |
| 26 | Last quarter Moon |
| 27 | Moon apogee: 404,308 km (251,225 mi.) |

28 Waning crescent Moon near Jupiter

30 Waning crescent Moon near Mars

## References


Achieve Inc. 2013. *Next generation science standards. www.nextgenscience.org/next-generation-science-standards*.

National Resource Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.


## Resources

Adaptive optics—*www.eso.org/public/teles-instr/technology/adaptive_optics.html*

*Cassini* at Saturn—*http://saturn.jpl.nasa.gov*

From the Ground Up!—*www.cfa.harvard.edu/webscope*

Galaxies—*http://messier.seds.org/galaxy.html*

How do galaxies form?—*www.zooniverse.org/project/hubble*

MicroObservatory Robotic Telescope Network—*http://mo-www.cfa.harvard.edu/MicroObservatory*

Observing With NASA (OWN)—*http://mo-www.cfa.harvard.edu/OWN*

Riddle, B. 2009. Scope on the skies: The new Milky Way galaxy. *Science Scope* 32 (6): 72–74.

Sloan Digital Sky Survery: SkyServer: Galaxies— *http://cas.sdss.org/dr6/en/proj/basic/galaxies*

Telescopes From the Ground Up—*http://amazing-space.stsci.edu/resources/explorations/groundup*

*Two Small Pieces of Glass—http://sdrv.ms/TalDLF*


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