Out with the old and in with the new

by Bob Riddle and Kristen Ross

Spring in the Northern Hemisphere is not only a transition between seasons, it is also a transition between the brighter starry winter skies and the relatively dimmer skies of the spring season. Astronomically, this is often described as "coming in like a lion and going out like a lamb," with reference to the stars of Aries the Ram setting over the western horizon as the stars of Leo the Lion are rising in the east.

Our solar system is also going through a transition from the old to the new. If you were asked to draw a diagram of the solar system showing the orbits of the planets around the Sun, how many circles or orbits would you draw? By now, most would probably draw eight, showing only the eight planets as defined by the International Astronomical Union a few years ago. However, there are probably still some Pluto holdouts whose drawings would show nine. At the planetarium, I have been teaching that we live in a solar system of at least 15 planets: the eight planets, Mercury through Neptune; and seven named dwarf planets, Ceres, Pluto, Haumea, Quaoar, Makemake, Eris, and Sedna. I also point out that there are actually many more planets in our solar system (as Figure 1 shows), and that this number will probably continue to increase.

The solar system is actually categorized into three divisions, or groups of objects: planets, dwarf planets, and small solar system bodies (SSSBs). What are SSSBs? They are the other Sun-orbiting objects that are not in orbit around a planet or dwarf planet and include comets, asteroids, and meteoroids. Students can investigate the organization of objects in our solar system. Typical student questions include the following: What qualifies an object to be a member of one of the groups? What do the objects in each group have in common? Are there other ways to group the members of the solar system? These are questions that students can consider as they work out their own classification scheme. The goal is for students to understand how classification works and how to choose criteria for organizing objects by properties or features. Planets can be organized into categories such as inner or outer planets, with rings (or without), with moons, or having an atmosphere with certain components.

Gustav Holst, composer of "The Planets" (1874–1934)

Students can access information about the planets from a variety of sources on the internet, but one of the best websites for planetary data, pictures, history, and much more is the Nine Planets website, maintained by Bill Arnett. From the information and links at this website students can, for example, create graphic organizers showing how they would group the members of the solar system. Students can also sort pictures of solar system objects into groups according to their own criteria (see Resources).

Have students take a grand tour of the solar system by following the model used in the book *The Grand Tour,* by Ron Miller and William Hartmann. The tour is organized from the largest planet, Jupiter, to some of the smaller objects in the solar system. Published in 1981, the book is now definitely outdated; however, the arrangement of the solar system objects by size is still an interesting way to visualize the great diversity of these objects.

Using 200 miles as the minimum diameter, web designer Alan Taylor has created a long poster that shows the 88 objects in the solar system that are 200 miles or larger in diameter, starting with the Sun (861,800 miles or 1,390,000 km) on the left and asteroid Davida (203 miles or 326 km) on the right (see *http://kokogiak.com/solarsystembodieslargerthan200miles.html*).

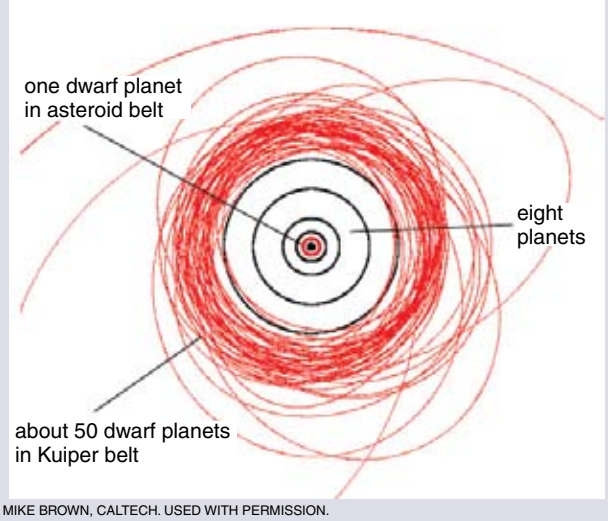
A STEAM-powered solar system

STEM, or science technology engineering, and mathematics, is a very familiar acronym. In a recent NSTA article, this was modified by the inclusion of the letter A to represent the inclusion of the arts into science education (Shapiro 2010). The arts are a very broad area and obviously include student artwork of the planets, moons, and other objects. However, the arts are more than drawings and there are many exciting ways to intergrate the arts into a science curriculum, regardless of the topic. Activities could involve kinesthetic modeling, staged performances, model building, and music.

With this in mind, a middle school music teacher (coauthor Kristen Ross) and I composed a plan to teach a lesson on the solar system that would integrate science with the musical composition *The Planets* by Gustav Holst (Figure 2). This musical composition reflects what was known about each of the seven planets during Holst's lifetime, as well as his own personal interest in Eastern mysticism and astrology. Earth was not included in his orchestral suite, nor was the yet-to-be-discovered planet Pluto.

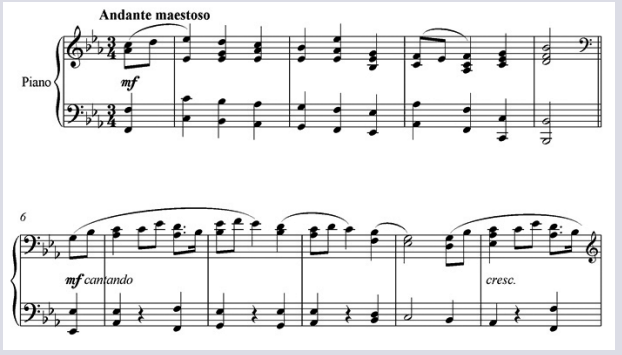
This project was integrated with a unit on soundtracks in music class. Using the knowledge students had already learned about movie soundtracks, we approached *The Planets* like a soundtrack to the planets. Following a presentation comparing current and historical views of the solar system, we studied the titles of each movement and brainstormed predictions of what they might sound like

FIGURE 1 The "new" solar system



MIKE BROWN, CALTECH. USED WITH PERMISSION.

FIGURE 2 The Jupiter theme from "The Planets."



set to music. For example, the planet Mars is subtitled "The Bringer of War," which we suggested might sound like an army marching into war. Students offered their own insight, suggesting that we might hear a lot of drums, loud dynamics, and a steady marching beat.

After examining each subtitle, we started playing the movements in random order. Students were responsible for analyzing the musical elements of each piece and matching it to the correct planet. We discussed how Gustav Holst wrote the movement to match the subtitle of the planet and whether or not our predictions were right.

This project was continued to give students the chance to design their own soundtrack. Students compiled songs that they felt were appropriate for each planet and justified their choice on a CD booklet they designed. To expand on this project, students could design a media presentation (e.g., PowerPoint) incorporating images of the planets and their chosen soundtrack selections. Students could even write their own compositions. ■

For further study

1. Gustav Holst's life spanned the late nineteenth and early twentieth centuries. Using the Astronomy Timeline (see Resources), students can research some of the astronomical discoveries or events that occurred, for example, the discovery of the two moons of Mars by Asaph Hall.
2. Using software like Movie Maker on Windows systems, students can create their own composition for a planet or solar system object or combine images of their object with music they think matches the properties or description of a planet.
3. Students can create their own mnemonic sentence or phrase for the names of the planets and dwarf plants of their choice.

April

3	Moon near Antares
4	Moon furthest south
5	Cassini flyby of Saturn's moon Titan
6	Last quarter Moon
7	Pluto stationary
	Cassini flyby of Saturn's moon Dione
8	Mercury at eastern elongation
9	Moon at apogee (404,002 km)
11	Moon near Jupiter
14	New Moon
15	Moon near Mercury
16	Moon near Venus
	Mars near the Beehive Cluster
	Moon near the Pleiades
18	Mercury begins retrograde motion
21	First quarter Moon
22	Moon near Mars
23	Moon near Regulus
24	Venus passes the Pleiades
	Moon at perigee (367,141 km)
25	Moon near Saturn
27	Moon near Spica
28	Full Moon
	Mercury at inferior conjunction
	Cassini flyby of Saturn's moon Enceladus
30	Moon near Antares

May

1	Moon furthest south
4	Venus near Aldebaran (Taurus)
6	Last quarter Moon
	Moon at apogee (404,236 km)
9	Moon near Jupiter
12	Moon near Mercury
14	New Moon
15	Moon furthest north
16	Moon very near Venus and M35
20	First quarter Moon
	Moon near Mars
	Moon at perigee (369,733 km)
	Moon near Regulus (Leo)
21	Venus very near M35
23	Moon near Saturn
24	Moon near Spica (Virgo)
27	Full Moon
28	Moon near Antares (Scorpius)
	Moon furthest south
31	Saturn ends retrograde motion

Visible planets

Mercury will be visible over the southwest horizon after sunset. By the end of the month, it will move into inferior conjunction and will not be visible until May, when it will become visible as a morning planet over the eastern horizon before sunrise during the last half of the month.

Venus will become more visible over the southwestern horizon after sunset and will be near Mercury for the first part of April.

Mars will be visible over the southern to southwestern horizon at sunset, but will gradually dim in apparent magnitude as the Earth pulls away, increasing the distance between the two planets.

Jupiter will be visible over the eastern horizon as a morning planet, rising about an hour before the Sun rises.

Saturn will be visible nearly all night as it rises around sunset and sets around sunrise.

Reference

Shapiro, D. 2010. Reaching students through STEM and the arts. *NSTA Reports* 21 (5). *www.nsta.org/publications/news/story.aspx?id=56924.*

Resources

Astronomy timeline—*www.windows.ucar.edu/tour/link=/the_universe/uts/timeline.html*

Dwarf planets—*www.gps.caltech.edu/~mbrown/dwarfplanets*

Dwarf planets—*http://sse.jpl.nasa.gov/planets/profile.cfm?Object=Dwarf*

Gustav Holst—*www.gustavholst.info*

Miller, R., and W.K. Hartmann. 2005. *The grand tour: A traveler's guide to the solar system.* New York: Workman Publishing.

Music for the planets—*http://nineplanets.org/musiclist.html*

Solar system bodies larger than 200 miles in diameter—*http://kokogiak.com/solarsystembodieslargerthan200miles.html*

The Nine planets—*http://nineplanets.org*

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