TOTALITY2017

Eclipses Across the Curriculum

The 2017 Great American Total Solar Eclipse coming up in August provides many opportunities for integrated lessons.

By Charles Fulco

In the past three installments, we have been discussing the 2017 Total Solar Eclipse (TSE2017) that will occur on Monday, August 21. This will be the first time the Moon's umbra has touched the continental United States since 1979 and the first totality to span our country coast-to-coast since 1918. From within parts of Oregon and through 14 states to South Carolina, the Moon will completely hide the Sun for a few brief moments, turning daytime to an eerie kind of near-twilight, where the Sun's ghostly corona, bright stars and planets, and other phenomena associated with total eclipses become fleetingly visible.

Fortunately, every part of the country will see at least a partial eclipse, so no one is left out. This eclipse offers a chance for virtually every elementary teacher in the United States to participate in a rare and special teaching opportunity. It also allows educators to enhance their science instruction while increasing the level of science literacy in their classrooms by employing a cross-content approach. This article examines how to derive the greatest level of literacy from the eclipse via interdisciplinary lessons.

Teaching Eclipses Throughout the Year

Upon hearing the word *eclipse*, educators might assume this is an event that falls only within the realm of a one-off science lesson. Not so! Because eclipses are so intertwined in the history of civilization, they offer a large and varied range of information to be taught within a variety of disciplines. Elementary teachers can explore many aspects of eclipses with their students throughout the year, in a wide range of standards-based lessons, activities, and investigations.

Some elementary teachers might initially be wary at the prospect of teaching multiple lessons on a challenging topic. But this upcoming eclipse offers the opportunity to bring in other subject areas while promoting science literacy and raising an awareness of the connection between nature and humanity. Social studies, math, language arts, art, technology, career sciences, and physical education can be incorporated into your eclipse instruction via engaging, hands-on, standards-based lessons that will bring in wonder and excitement while fulfilling your curriculum requirements.

Integrating Multiple Content Areas Into TSE2017

Incorporating instruction into other content areas can be difficult, for several reasons. The teacher attempting to achieve this level of instruction may not be fluent with other subjects. Some teachers are strong in English but struggle with math, yet teaching about TSE2017 can help. Let's start with the initial content area—elementary science. For elementary teachers who may not feel especially strong in this area, many cross-content resources can help with a general understanding of eclipses (see Internet Resources). Once you've got the basics down, you can expand your knowledge into multiple content areas.

Science

Since cultures have historically been fascinated with patterns in nature, let's begin our cross-content explorations by focusing on ancient civilizations. Teaching about ancient civilizations ties in nicely with social studies and math curricula because these civilizations used patterns to tell time on a daily, monthly, and yearly basis, using the celestial math of the Sun, Moon, and stars. Some of these cultures discovered that eclipses have their own patterns as well (notably, the Saros Cycle), which was discussed previously in the second article of this series (Fulco 2017b).

Because of their unusual and awe-inspiring nature, eclipses have been observed and recorded in some way or another in virtually all cultures and historical periods. The discovery of the cycles governing them was one of the great turning points in astronomy. Ancient civilizations—notably, the Greeks, Sumerians, Chinese, and Egyptians—kept meticulous records of eclipses. As their mathematics improved over time, these civilizations came to understand eclipse patterns to the point where they could even predict the next one with a fair amount of accuracy.

Eclipses, especially solar eclipses, were seen by many as demonic and life-threatening occurrences. The Sun's disappearance was a sign that the gods were not pleased with mortals on Earth. Therefore, it was vitally important that people knew when to expect an eclipse. Indeed, two Chinese astrologers literally lost their heads for failing to scare away the Sun-consuming dragon and report the total solar eclipse to their emperor ahead of time!

In my own eclipse instruction, I cover eclipse patterns with fun and highly effective investigations using student-made "Sun clocks." Instructions for these simple timekeeping devices and accompanying lessons can be found online (see Internet Resources). These instruments show students how ancient civilizations were able to discern the approximate time of day and season using the Sun's predictable motion.

Once students are able to note and predict the approximate time of day using their Sun clocks, they can learn about monthly timekeeping with the pattern of the Moon's phases. A "Moon Log" template (see NSTA Connection) can be completed by students both at school and at home (depending on the Moon's visibility during its monthly cycle). After a short while, most of your class will see a pattern between the Moon's changing shape and the time of month.

Next, the concept of lunar calendars can be discussed, noting that even today, the Islamic and Hebrew calendars, among others, use Moon phases to calculate religious holidays and other important dates. Seasonal time can be kept by constructing and using an *analemma*, a device that records the changing height (altitude) of the Sun as the school year progresses, and correlating the altitude to particular dates of the year. See "Find Your School's Analemma," in the October 2014 issue of *Science and Children* for an article on constructing classroom analemmas (Lough and Vanover 2014).

Mathematics

Math is an easy choice for TSE2017 cross-content learning. Elementary students learning about patterns (cycles) can be taught how to apply mathematics to a Sun clock.

Bring students outdoors early in the morning, have them note the position of the Sun's shadow on their clocks, then have them note it again exactly one hour later. Using a protractor, they should observe that the shadow has moved 15° in a *clockwise* direction (assuming you do this activity in the Northern Hemisphere), and then be able to predict the approximate location of the Sun's shadow on the clock at any other time of day. (While not required, you may wish to have them predict the *length* of the shadow as well, asking them if they think the shadow will get longer or shorter as the day goes on.) Go outdoors to confirm predictions at least two or three more times during the day.

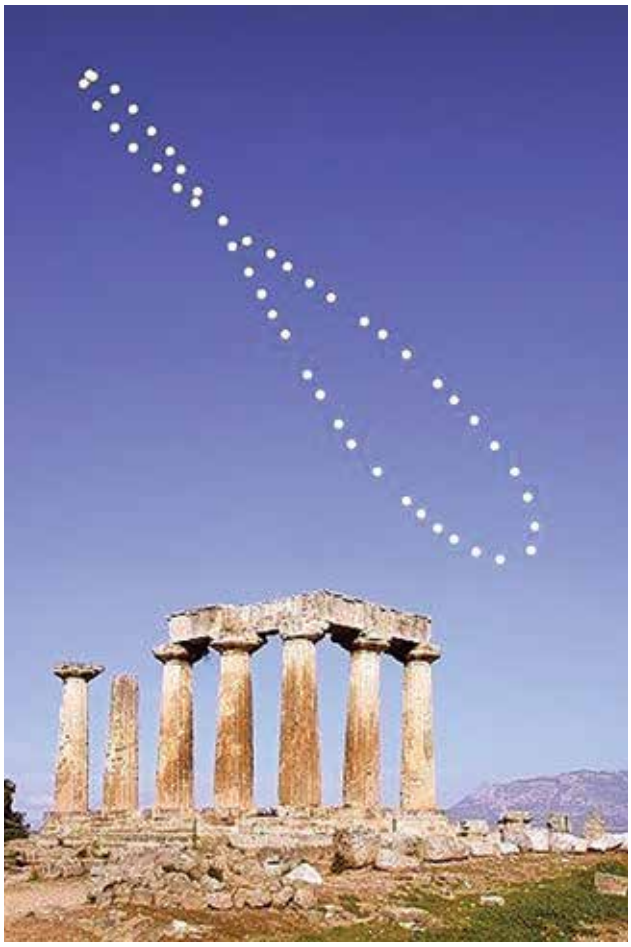
Speaking of patterns, the discovery of the Moon's cycles led to the realization that both solar and lunar eclipses occur in predictable cycles, notably the Saros Cycle, which states that any particular eclipse repeats itself almost exactly 18 years later. (For example, by adding 18 years to the total solar eclipse that occurred in 1999, we know there will be another one in 2017.) You may choose to introduce this cycle to your students, but keep it simple by providing the year of an eclipse, then ask them to derive future or past eclipses using multiples of 18 years to discover the pattern.

In addition, you may explain that because the Sun is 400 times larger than the Moon and the Moon is 400 times closer to us, they appear to be the same apparent size in the sky. This allows the Moon to occasionally completely cover the Sun. To illustrate, have your students cover one eye and use their thumb to "eclipse" a larger object (e.g., a "Sun" on the bulletin board) by drawing their thumbs closer to their eyes until the object is covered. By giving them the average distance to the Moon from the Earth (~385,000 km) and using proportions, have them figure out the approximate distance to the Sun (~150,000,000 km).

ELA/Social Studies

ELA and social studies teachers can find myriad eclipse literature and historical accounts for virtually all reading levels. Depending on student age and reading proficiencies, you might select essays and accounts from James Fenimore Cooper, Mark Twain, and eclipse-dedicated websites. The Great American Eclipse site (see Internet Resources) offers many accounts of totality, including historical maps, grainy black-and-white moving pictures, and front-page *New York Times* coverage of the total eclipse over New York on January 24, 1925, and other literature and artifacts suitable for your classroom. Social Studies segments can include DBQ exercises by interpreting articles and cartoons showing misconceptions and myths of eclipses. You may also wish to compare how civilizations around the world have explained and reacted to eclipses by discussing the eclipse mythologies of different cultures ("Compare and Share" works well for this!).

Incorporating astronomy passages (typically found in state exams) into your ELA and social studies lessons also heightens science literacy. As students build a robust eclipse vocabulary in the months before TSE2017, they will be able to understand the words featured in media reports while improving their reading and listening comprehension. You may want to introduce an "Eclipse Word of the Week" during the school year (e.g., *totality*, *umbra*, *penumbra*, *cycle*, *partial*, *corona*, *prominence*, *crescent*) to reinforce a robust vocabulary within your students.



ANTHONY AYIOMAMITIS

An analemma (above) records the altitude of the Sun throughout the year. See *www.perseus.gr/Astro-Solar-Analemma.htm* for more photos.

Having students journal their observations should be an important part of their Eclipse Day experience, whether they are back at school or still on summer vacation. Students can record this special event using scientific literacy and their new enriched vocabulary to augment their reading and writing for understanding. (Colored pencils are a must for sketching the entire progression of the eclipse from start to finish.)

Other School Programs

Teachers of art, music, technology, physical education, foreign languages, and career sciences can incorporate TSE2017 into their lessons. Artistic learners can enhance their science journals with sketches done during and immediately after viewing the eclipse. Audio learners can

narrate totality and include natural sounds and excited human voices during the event. Music classes can discover and listen to pieces written about the Sun, Moon, and eclipses and find songs with "eclipse" mentioned in them. Technology students can construct their own solar viewers to practice with in the months before the eclipse (see Fulco 2017b). In physical education class, students can "orbit" within a darkened gymnasium, around a "Sun" light source to demonstrate how the Sun-Earth-Moon system causes solar and lunar eclipses. Foreign language instructors can have their classes see how many "science" words they can find that trace their roots to Greek and Latin, using examples such as *corona*, *lunar*, *solar*, and *umbra*. Discovering and reporting on cultural traditions and beliefs about eclipses works well in this subject area as well.

Social Media and Scientific Literacy

Organizations are promoting scientific literacy through social media outlets. NASA has recently released a TSE2017 website and agencies such as Astronomers Without Borders, Eclipse Across America, and the Eclipse Ballooning Project are promoting eclipse literacy by getting teachers and students involved (see Internet Resources).

Teachers can simply sign up to download information and resources from these sites in order to collaborate with their peers around the United States. Classrooms and individuals can contribute to collaborative projects by using something as simple as their smartphones to capture and transfer images and other information. Having students contribute to a larger project will give them a sense of accomplishment and purpose.

Recording the Eclipse

Recording an eclipse on a smartphone or point-and-shoot camera can be a tricky procedure. Since the image of the eclipsed Sun will be small, a filter is required for the partial stages, and getting proper focus and exposure takes practice. (You can see this for yourself by taking images of the Full Moon, which is exactly the same size as the Sun.)

Instead, I highly recommend that these users take videos of their surroundings with their smartphone (avoiding aiming the lens directly and closely at the Sun), making sure to clear out enough data in the phone beforehand to record for at least the several minutes surrounding the middle of the eclipse. Videos should include wide-angle views of the sky, and images and reactions of fellow observers, which is one of the most rewarding parts of any eclipse video (Go-Pro cameras are perfect for this type of application).

Conclusion

While you are addressing the science behind TSE2017, do not lose the human aspect of this fantastic event. An eclipse goes way beyond the scope of the *NGSS* or recording data. It is not simply the Moon covering the Sun. The course of human history has been shaped by total solar eclipses. People's lives have been changed by them, including this author's. With the increased level of science literacy this eclipse provides to all your lessons, both you and your class will appreciate this celestial event—and indeed your entire curriculum—on a whole new level, remembering: No Child Left Inside! ■

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References

Fulco, C. 2017a. Totality 2017: Get ready for the Great American Eclipse! *Science and Children* 54 (5): 60–65.

Fulco, C. 2017b. Totality 2017: Countdown to the Great American Eclipse. *Science and Children* 54 (6): 60–65.

Fulco, C. 2017c. Totality 2017: Eclipses and eye safety. *Science and Children* 54 (7): 58–61.

Lough, T., and C. Vanover. 2014. Find your school's analemma. *Science and Children* 52 (2): 55–59.

Internet Resources

Astronomers Without Borders
www.astronomerswithoutborders.org/awb-programs/community-based-programs/post-eclipse-education-program.html

Eclipse Ballooning Project
http://eclipse.montana.edu

Eclipse Across America
www.eclipseacrossamerica.org

Great American Eclipse
www.greatamericaneclipse.com

Making a Sun Clock
www.exploratorium.edu/science_explorer/sunclock.html

NASA Eclipse Sites

https://eclipse2017.nasa.gov/eclipse-megacast
https://eclipse2017.nasa.gov/public-engagement
https://eclipse2017.nasa.gov/other-education-resources
http://spaceplace.nasa.gov/eclipses/en