As discussed in the January issue of *Science & Children* (Fulco 2017), the Great American Total Solar Eclipse (TSE2017) will occur on August 21 this year—the first total solar eclipse in the continental United States since 1979. It will also be the first coast-to-coast totality since 1918. For many reasons, this is a scientific and educational milestone event of the highest magnitude that should not be missed by any teacher and student whether or not their school is in session on “Eclipse Day” this year.

For the teacher who wishes to include TSE2017 instruction in his or her elementary science curriculum, it is important to have an instructional timeline for lessons, remembering that summer vacation will put your classroom instruction on hiatus for at least a couple months just prior to the eclipse. Some schools will be returning their students on the day of the eclipse. In other cases (notably the Northeastern United States), most schools will still be closed for the summer, so any formal eclipse instruction and preparation will have ended in June.

Having a timeline for instruction should be a part of every teacher’s *modus operandi*. The classic model for this is *Understanding by Design* (Wiggins et al. 1998), which states that having clear end-objectives and assessments inherently guides the instruction leading up to them (see Internet Resources).
Planning “Backward” for TSE2017

Recent interviews show “time constraints” and “teaching to standards” as the two most-mentioned concerns within elementary level science instruction. Understanding by Design (UbD), also known as “Backward Design,” addresses both these issues, along with the idea that the primary goal of education should be the development and deepening of student understanding. Students should be provided with complex, authentic opportunities to engage in science, echoing the similar educational goals of the Next Generation Science Standards (NGSS), STEM, and other science-based learning models. Teaching effective and authentic science curriculum (with TSE2017 having an integral role this year) should employ an instructional model with teachers designing lessons, activities, and investigations after specific goals have been clarified and assessments designed. This “backward” process helps to avoid instruction in which no clear priorities and purpose of instruction are apparent, things which hinder achieve-
ment of objectives. This may sound like the oft-dreaded “teaching to the test,” but with defined instructional goals in sight and effective and purposeful inquiry-based activities developed, it is anything but!

A realistic timeframe for this year’s eclipse instruction begins when you read this article. Understandably, the most difficult logistical obstacle for a teacher to overcome might very well be: “Where do I find the time to teach TSE2017 lessons when eclipses aren’t part of my science curriculum this year?” and “How do I convince my principal to let me teach these lessons since my colleagues and I barely have time to teach the regular curriculum?”

This is where you approach the problem with your backward design solutions already in hand—in this case, an instructional timeline and NGSS-aligned learning objectives and lessons, all demonstrating how you can include segments on eclipses without interfering with the required instruction. Just the fact that a total eclipse is such a rare, special, and wonderfully appropriate event for teachers and students should be reason enough for it to be encouraged to be part of every elementary teacher’s curriculum.

**Designing an Eclipse Unit**

There is no reason not to include units on eclipses as part of at least one of your 2016–17 elementary curricula. A series of lesson plans, investigations, and other inquiry-based activities will assist the teacher in reaching learning objectives and science literacy with a decidedly unique focus. Especially for those elementary teachers who don’t have a way to realistically work the eclipse into their science curriculum, a cross-content unit lets the class explore TSE2017 through the subject(s) of the teacher’s choice, be it social studies, math, ELA, technology—virtually any content area. Remember, these units may be stretched across a good portion of the school year, as long as you keep your student engagement, motivation, and interest at a high level, with reinforcement and brief reviews of prior lessons, outdoor lessons (if possible), and of course, formative and summative assessment lessons bookending each unit.

As an example, let’s take a look at how a grade 1 and a grade 5 classroom teacher can implement instruction in different ways while addressing their respective NGSS Foundation Boxes. No matter which grade you teach, you can use these examples as guides for your own grade level as well.

### Grade 1

Selecting the NGSS grade 1 performance expectation (PE) that states: *Use observations of the Sun, Moon, and stars to describe patterns that can be predicted* (1-ESS1-1), students are directed to make connections between celestial motion and pattern recognition (Figure 1). The obvious patterns in the sky are the daily motion of the Sun, the monthly motion of the Moon, and the yearly (annual) motion of the stars, which should be examined and understood. But we can include eclipses in this unit as well, since they follow very regular and predictable patterns of occurrence.

The grade 1 PE is typically achieved using solar shadow recording, lunar phase observation logs, and star maps. It states that students will “use observations…to describe patterns that can be predicted,” but it does not necessarily require them to use their own direct observations—they may access this data from media, so long as the sites are valid, such as NASA’s International Observe the Moon Night or its dedicated TSE2017 site (see Internet Resources). Of course, you will want to physically demonstrate with a model how the Moon orbits the Earth and can sometimes come exactly between the Sun and Earth to cause a solar eclipse. The important thing is that students recognize and understand that the Moon moves in a very predictable pattern, allowing scientists to accurately predict when eclipses will occur, thereby fulfilling the PE’s objective.

Next, you’ll need to align your lessons to the most appropriate science and engineering practice (SEP): *Planning and carrying out investigations to answer questions or test so-

---

Science and Children

---
olutions to problems...make observations (firsthand or from media) to collect data...; and Analyzing and interpreting data... collecting, recording, and sharing observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. In this case, you may address both SEPs, as they have relevant criteria for eclipse studies and address the need for students to observe phenomena to obtain data (either from direct observation or from other sources) and describe and share observations—another good reason to include TSE2017 in your unit.

The disciplinary core idea (DCI) ESS1.A The Universe and Its Stars, Patterns of the motion of the Sun, Moon, and stars in the sky can be observed, described, and predicted is, like the SEP above, most usually satisfied through more common observations of the motions of those celestial bodies. But again, I believe this DCI is also quite relevant to TSE2017 and eclipses in general, as these celestial events recur in observable and predictable cycles. And since eclipses aren’t frequently observed by students, information from trusted media can be successfully substituted in place of direct observation.

DCIs are synonymous with what we used to call “content instruction,” so information on why eclipses happen should take place here, with simple activities demonstrating how eclipses occur. Again, get your students involved: one student holding a light source (the Sun), another holding a smaller sphere (the Moon), and a third holding a larger sphere (the Earth), with the students simulating the orbit of the Moon around the Earth is a simple yet highly kinetic and visual way of showing the dynamics of eclipses that textbooks simply can’t convey. It doesn’t have to be highly sophisticated at this age—just the idea that the Moon moves around the Earth and can sometimes “get in the way” of the Sun is good enough for now!

Last, an appropriate crosscutting concept (CC), Patterns in the natural world can be observed, used to describe phenomena, and used as evidence, should be included as a way to add a holistic dimension to your unit on eclipses.

An ELA segment here, perhaps a read-aloud followed by verbal assessment, describing how Christopher Columbus used his knowledge of the pattern of eclipses to save himself and his crew from certain death (see Internet Resources), can show that knowledge of patterns and cycles allows for fairly accurate predictions, which can be very useful in the real world—just ask Columbus!

Grade 5

One grade 5 NGSS performance expectation requires that students Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost, and another requires students to Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky (Figure 2).

Integrating a lesson on eclipses might not immediately come to mind when reading this PE, but when one realizes the most pressing problem of solar eclipse observation is eye safety, it makes sense. As you may be aware, even today teachers and students are routinely directed to remain indoors (with blinds closed) during eclipses, the fear being that they will become blinded by the eclipsed Sun’s light. This is an unacceptable educational practice, but it can be resolved using a very simple, inexpensive and easy-to-construct device known as a solar viewer (see NSTA Connection for solar viewer instructions). Building a viewer solves the problem of safe solar observation while reinforcing fine-motor, instruction-reading, and sequencing skills (not to mention bolstering a student’s confidence level upon completion of his/her device).

As discussed in a future installment in this series, crosscutting concepts are a convenient method for introducing a variety of lessons. One CC within the “Earth’s Place in the Universe” DCI states: Similarities and differences in patterns can be used to sort, classify, communicate
and analyze simple rates of change for natural phenomena. A lesson on eclipses that satisfies this can highlight the Saros Cycle (see Internet Resources), a pattern of eclipse repetition that was discovered centuries ago: that dates of similar eclipse paths and durations (“families”) recur in a period of just over 18 years, making it relatively easy to predict the next event in the series, based on prior observations. A simple device (I call it a “Saros Calculator”) can be constructed by writing various Saros family numbers at the top of strips of heavy card stock and their corresponding years of eclipses below, then sliding one at a time into a card stock sleeve with cut-out windows to show as much information as you like your students to see in order to make predictions. To get a feel for the Saros pattern, have students study the dates of past and future solar eclipses (see Internet Resources). Students can note that there were total eclipses in 1927, 1945, 1963, 1981 and 1999. Therefore, through pattern recognition and simple math, students should confidently predict that there should be another in 2017—and of course, there is!

Again, these are just two grade-level examples of integrating TSE2017 into your standards-based science curriculum. But my wish is that every elementary teacher will find time to integrate this rare and spectacular event into his or her instruction during the remainder of this school year. Remember that the NGSS crosscutting concepts option gives you the flexibility to do this!

In Summary

Don’t worry if your elementary grade–level science curriculum doesn’t include NGSS-based lessons that can be easily applied to TSE2017, because other content areas you (or another team member) teach can easily and suc-
cessfully satisfy this requirement (this will be discussed later in this series of articles). However you decide to prepare your students for the 2017 Great American Eclipse, the result will be instructing your students on real-life science, with the goal of seeing a once-in-a-lifetime event (if you are lucky enough to be within the path of totality). Even if you do not experience totality, there are many opportunities that a partial event provides, and you’ll be doing them within a manageable timeframe. See future articles in S&C for more TSE2017 lesson suggestions.

Charles Fulco (saros61@gmail.com) is Education Committee co-chair of the American Astronomical Society’s 2017 Total Solar Eclipse Task Force.

References

Internet Resources
The Eclipse That Saved Columbus www.sciencenews.org/article/eclipse-saved-columbus
Mr. Eclipse www.MrEclipse.com/Special/SEprimer.html
NASA’s Space Place http://spaceplace.nasa.gov/science-standards/en

NSTA Connection
Download instructions for building a solar viewer at www.nsta.org/SC1702.