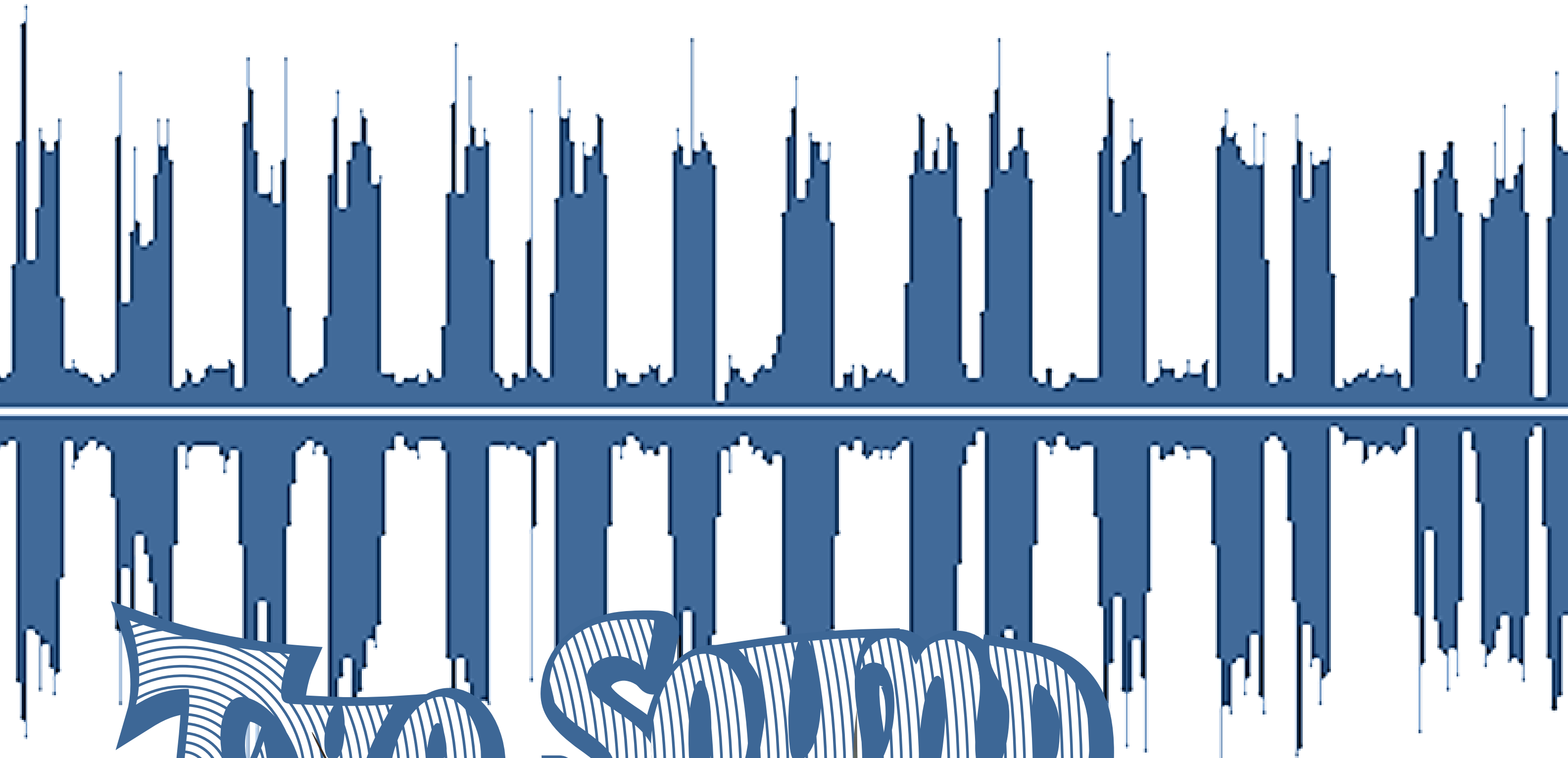

The Sound of Crickets

James L. Larsen and Peggy LeMone

Open the door, let them out.
—Nobel Laureate Freeman Dyson, advice to a young science teacher

All too often our science classes take place entirely behind classroom walls, with few opportunities for students to directly experience nature. In the modern world of computers and video entertainment, students spend little time outdoors, a phenomenon described by author Richard Louv as "nature deficit disorder" (Louv 2008). As a result, some have less experience to draw upon as they try to evaluate claims and counterclaims in the media and public discourse.

With the range of conflicting ideas about issues such as climate change and global warming, it has never been more important to "open the door, and let our students out" to evaluate the validity of such claims by observing nature, collecting data, and providing evidence. The good news is

Using evidence-based reasoning to measure temperature using cricket chirps

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it has never been easier for students to gather and share data using the internet and programs such as Global Learning and Observations to Benefit the Environment (GLOBE) (see "About the GLOBE program"). This article presents one GLOBE scientist's investigation of cricket chirping and its relation to temperature—which demonstrates the importance of gathering data and interpreting evidence for ourselves.

Cricket chirps and temperature

Humans have always been fascinated by crickets. From ancient cave drawings to Charles Dickens to Disney, crickets have long been a part of our art, folklore, and culture. There are about 900 species of crickets, which are members of the family *Bryllidae.* The nocturnal songs of house and field crickets can be heard in most locations throughout the United States. The familiar "chirp" sound is produced by male crickets to attract females and repel other males, and can be heard by other crickets due to tympanic membranes located just below the middle joint of each front leg. It was this chirping that became the focus of an investigation by Peggy LeMone, former chief scientist for the GLOBE program.

Consider a statement about crickets that you may have heard or read: *You can use cricket chirps to measure temperature*. How does a scientist go about determining if this claim is true, or a myth based on pseudoscience? When LeMone heard this statement, she was a bit skeptical about its accuracy, so she set out to see for herself if there was any evidence to support it. In one of her entries on the *GLOBE Scientists' Blog* (2007), LeMone documents how stepping outside and observing nature allows us to collect our own evidence, or at least look with a more practiced eye at the data others have collected to determine if a claim has any basis. Her experience outside helps her direct her efforts to uncover if the claim is true, and provides an interesting example of scientific inquiry.

Testing the claim

The following excerpts have been adapted from LeMone's *GLOBE Scientists' Blog* (2007). This posting describes her investigation and her use of evidence to determine whether crickets really can tell temperature (**Editor's Note:** The source of this material and the accompanying figures is the GLOBE website at *www.globe.gov*. All Rights Reserved.):

> Did you know that you could count cricket chirps to estimate temperature? I heard this a number of years ago, but never thought much about it until I heard it mentioned on television this summer. Was this true, or just an urban myth? I decided to go outside and see for myself.
>
> In August, I started listening to crickets. I estimated the "cricket temperature" from the first formula I found on the web:
>
> Cricket temperature = number of chirps in 15 seconds + 37

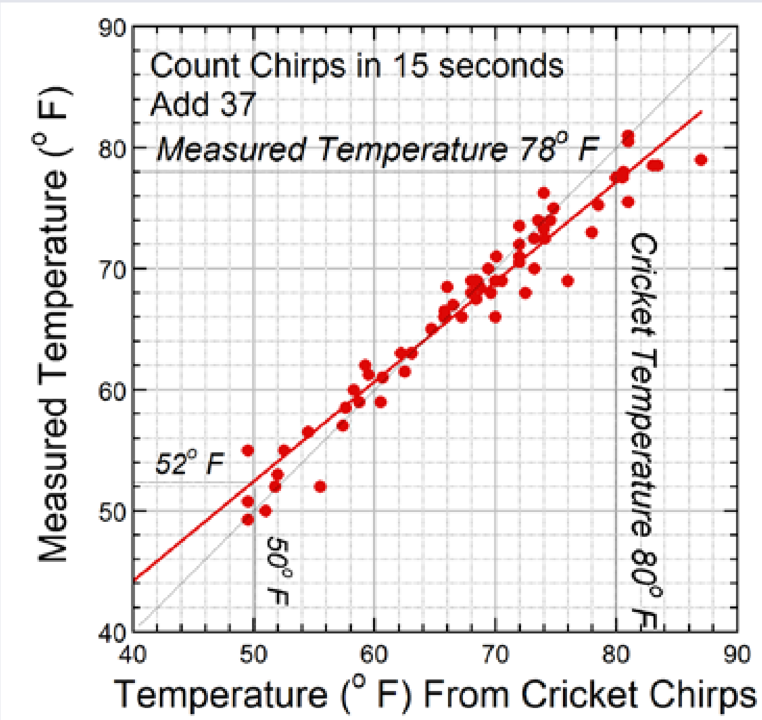
The original formula LeMone found was in degrees Fahrenheit. She needed to see if this worked before she could use the data to derive the formula in degrees Celsius.

> I measured the actual temperature by taking the average from two thermometers. One is mounted on the house at about eye level (1.5 m) beneath the overhang where we park our car. The second lies on the table on our deck, at about 1.5 m above the ground. A louvered sunroof on the deck keeps the thermometer from cooling too much. In both places, there is enough wind for ventilation, but I had to ignore the house-mounted thermometer if our car was warm (i.e., recently driven). Though I did not have a GLOBE instrument shelter, the height matches that for the GLOBE air temperature protocol.

FIGURE 1

Air temperature measured using cricket chirps.

For this graph, the number of chirps during 15 seconds is added to 37 to get the air temperature. The highlighted temperature readings are for the red "best-fit" line.



About the GLOBE program.

Global Learning and Observations to Benefit the Environment (GLOBE) is a worldwide hands-on, primary and secondary school-based science and education program. GLOBE promotes and supports students, teachers, and scientists and encourages collaboration with NASA and National Science Foundation Earth System Science Projects (ESSPs) on inquiry-based investigations of the environment and the Earth system.

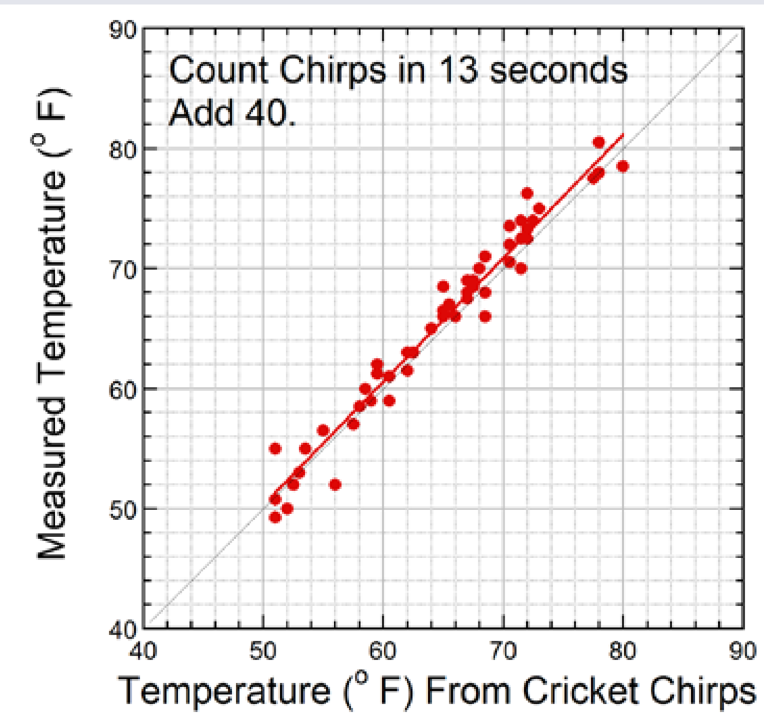
Announced in 1994, GLOBE began operations on Earth Day 1995. Today, the international GLOBE network has grown to include representatives from 110 participating countries and 129 U.S. partners, coordinating GLOBE activities that are integrated into local and regional communities. Due to their efforts, there are more than 50,000 GLOBE-trained teachers representing over 20,000 schools around the world. GLOBE students have contributed more than 20 million measurements to the GLOBE database for use in their inquiry-based science projects.

GLOBE brings together students, teachers, and scientists through the GLOBE Schools Network in support of student learning and research. Parents and other community members often work with teachers to help students obtain data on days when schools are not open.

FIGURE 2

Air temperature measured using cricket chirps.

For this graph, the number of chirps during 13 seconds is added to 40 to get the air temperature. As in Figure 1, the gray diagonal line is where the points would fall if the method were perfect, and the red line is the line that best fits the data.



A GLOBE instrument shelter is a standard device used in the GLOBE monitoring program to standardize temperature measurements. The GLOBE air temperature protocol is a scientifically established technique for site selection, exposure, instrument type, calibration, and procedure.

It took me a week or two to figure out how to count cricket chirps. Fifteen seconds was too short a time—I kept ending up with numbers like 30.5 chirps. Or I would lose track, or start too early or too late. So I tried 30 seconds—that way if I was between 60 and 61 chirps, the resulting error would be divided by 2.

Then I discovered that the crickets did not always chirp together (CHIRP CHIRP CHIRP) but sometimes got out of synch (chir-rurp chir-rurp chir-rurp). In this case, I would count the chirps when they were in unison, and try to maintain the beat until they got back in unison again. To make things more accurate, I would count chirps for five 30-second periods, average the number, and then divide the average by two. If there were two sets of crickets that were not always chirping at the same time (say an "alto" group and a "soprano" group), I would count the alto chirps for one 30-second period and then count the soprano chirps.

LeMone's experience outside led her to think about how complicated such a seemingly simple thing, such as listening and quantifying cricket chirps, can be. She then set out to see how her data fit the formula she had found on the internet:

I ended up with a lot of data for temperatures above 70°F (21°C), but getting numbers at the cooler temperatures was harder.

Since temperatures are the coolest around sunrise, I had to start getting up around 2:00–3:00 a.m. and 5:00 a.m. to get data for the cooler temperatures.

How well did the formula work? You can see from the first graph, in Figure 1. If everything (the formula, my counting, the thermometers) worked perfectly, all the red dots would fall on the gray line, that is—along the gray line the "cricket temperature" is equal to the measured air temperature.

In the graph, the data are close to the gray line, but not always on it. The red line is the

straight line that best fits the data. Notice that the red line drops below the gray line for high temperatures. Thus from the red line, for a "cricket temperature" of 80°F (27°C), the measured air temperature is only 78°F (25.6°C). Similarly, from the red line, a cricket temperature of 50°F (10°C) corresponds to a measured temperature of 52°F (9°C)—not exactly right.

To make things more accurate, LeMone looked for a new formula. She used a computer program to find an equation for the "best-fit" line for temperature *(y)* as a function of number of cricket chirps per time interval *(x)*. She tried the program for different time intervals until she found the one for which the slope of the "best-fit" line was closest to 1, which in this case was 13 seconds. The *y*-intercept of this line gave the number she then added to the cricket chirps: 40. The resulting formula LeMone used was:

Cricket temperature (Fahrenheit) = number of chirps in 13 seconds + 40

She could then plot cricket temperature against measured temperature, as shown in Figure 2 (p. 39).

Using this method, the points (and the red line) lead to temperatures much closer to the gray line, as shown in Figure 2.

Clearly this approach works slightly better. The red "best-fit" line through the data lies almost on top of the "perfect-fit" gray line. I later found this method was also on the web.

Once LeMone knew there was a relationship between cricket chirps and temperature, she used her data to get the formula in Celsius degrees. By adding 9 to the number of chirps per 15 seconds and dividing the total by 2, she was able to calculate the air temperature in Celsius. In this case, LeMone chose to divide the result by 2 so that she was working with only whole numbers, since the time interval for cricket chirps for a slope of 1 was 7.5 seconds.

Finally, let us plot the data to show the relationship between cricket chirps and the temperature in Celsius degrees. Figure 3 shows this relationship. Again, the red "best-fit" line and the data are close to the "perfect-fit" gray line.

Learning from observation and data

LeMone went on to do more analysis of her results. She used the internet to find similar studies that she could use to compare her data. By stepping outside, making her own observations and relating them to other data, her conclusion—that cricket chirps could indeed be used to estimate temperature—was supported with scientific evidence. Thus a statement that may have seemed more myth than science was supported with data.

Many scientific-sounding claims about how nature works, or how we would like to believe it works, depend on people not questioning, or not having enough experience outside to question. Pseudoscientific claims abound in our culture and media and are often made to advance a particular agenda. Those making such claims often rely on passive acceptance by their target audience. However, by thinking critically, collecting data, and examining claims, we can determine if evidence supports them.

Have your students test scientific-sounding claims they come across, as LeMone did. Does their own experience in nature support such statements? Are there observations and data to support the claims? Can they make their own new observations of nature that provide evidence to support or refute them? Figure 4

FIGURE 3

Air temperature measured using cricket chirps.

For this graph, the number of chirps during 15 seconds is added to 9 and the total divided by 2 to get the Celsius air temperature. As in Figures 1 (p. 38) and 2 (p. 39), the gray diagonal line is where the points would fall if the method were perfect, and the red line is the line that best fits the data.

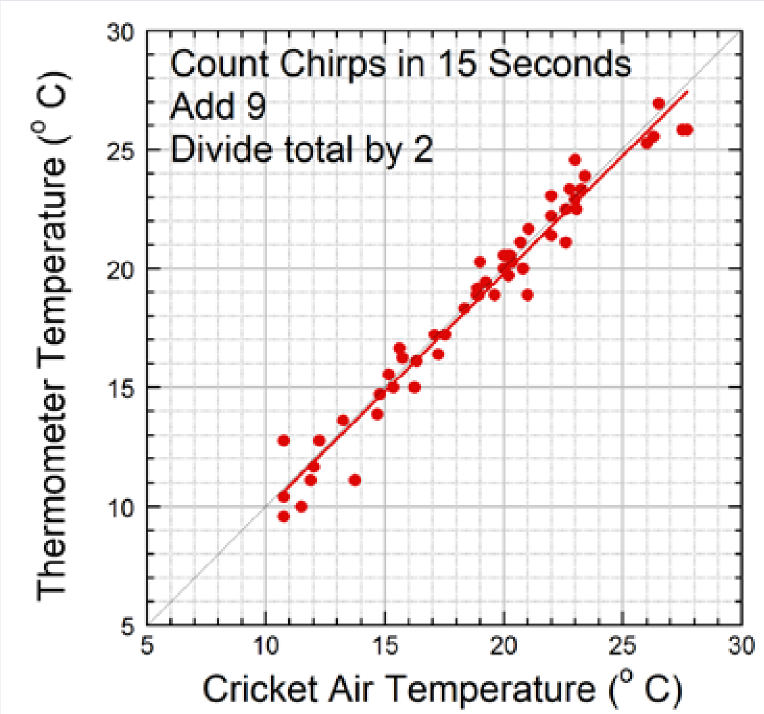


FIGURE 4

What does nature tell you? Sample student activities.

Extending the cricket research

LeMone only studied the species of crickets that lived near her house. Have your students work collaboratively with schools in other locations to design a research project and test if her conclusions hold true for different species of crickets. Part of the appeal of science is that it always leads to new questions to study.

Examining scientific-sounding statements for accuracy

Have students select a scientific-sounding statement they hear or read in the media and then reframe it as a question that can be researched by observation and collection of data. For example: Global warming cannot be true—it is colder this year than it has ever been!

Students have most likely heard this before, or similar statements that question the science behind climate change. Rephrase this statement as an inquiry question that will allow them to use established protocols or design their own procedures, collect data to answer the question, and develop a scientific conclusion.

Students can set up a temperature-monitoring station that uses a temperature protocol similar to the one found on the GLOBE website (see "On the web"). They can use the data they collect for a week, a month, or a year (if you make it an ongoing project) to see how it compares to longer-term local temperature data available through the National Oceanic and Atmospheric Administration's (NOAA) website (see "On the web").

Students can also query the GLOBE database, which contains data collected by students in over 100 countries, using its online tools to compare temperature data with other GLOBE schools. The GLOBE database allows students to sort and graph data into visualizations that can help them see if there are any differences from year to year. Depending on the level of your students, they may use statistical techniques to research schools with a long history of recording data to determine the significance of any variation they see.

Framing a research question and then observing and collecting data will allow you to begin a discussion on how many ways we can measure temperature, and how long we have been collecting temperature data. It will also help you uncover why short-term observations might not be the best way to argue for or against climate change and global warming.

Taking part in the GLOBE Student Climate Research Campaign 2011–2013

GLOBE's Climate Research Campaign will empower students, teachers, and communities around the world to realize their individual and collective potential to influence one of the most challenging issues of our time. The campaign will launch in 2011 and will culminate with an international student research conference in 2013.

The Climate Research Campaign will provide a variety of opportunities for meaningful, relevant, and important student research leading to understanding and action from local to global scales. If you are interested in participating in this initiative, contact the GLOBE Climate Research Campaign at *ClimateCampaign@globe.gov.*

provides some examples of student activities to use in your classroom.

Conclusion

In this media-driven age, evidence-based reasoning is more important than ever. Amidst claims and counter-claims, we need to make sure that our students have enough experience outside of the classroom to determine if such assertions are supported by real world observations and data. It is our obligation, as Dyson suggests, to "let our students out" to experience and learn from nature and think critically about evidence obtained from our observations.

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NSTA Connections

For more information on temperature, check out the "Energy: Thermal Energy, Heat, and Temperature" NSTA Science Object. NSTA Science Objects are free, online, inquiry-based content modules. Visit *http://learning center.nsta.org/products/science_objects.aspx.*

On the Web

GLOBE website: *www.globe.gov*

National Oceanic and Atmospheric Administration (NOAA) website: *www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp*

References

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