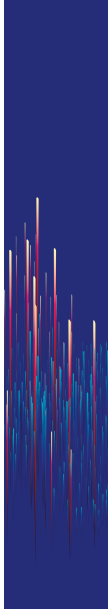

Sound practices in climate change education

BY PEGGY M. MCNEAL AND HEATHER L. PETCOVIC

As science educators affiliated with a university teacher preparation program, we were interested in promoting effective climate change education for practicing and future classroom teachers. We knew that many middle school teachers were teaching climate change early in the *Next Generation Science Standards* (NGSS Lead States 2013) adoption process, compelled by their own concerns and advocacy interests. These teachers, we reasoned, would be an excellent source of information for practicing teachers less familiar with climate change instruction, and for future teachers who had yet to enter the classroom. Thus, we convened focus groups with middle school teachers from across the country who were actively teaching climate change, and we discussed their experiences and practices (for the full study, see McNeal, Petcovic, and Reeves 2017). We found that these teachers' insights fell into three broad themes that showcase sound practices in climate change education:

1. connecting students with local climate change impacts;
2. encouraging students to collect, analyze, and draw conclusions from their own data; and
3. fostering relationships between climate scientists, teachers, and students.

Connecting students with local climate change impacts

The teachers in our focus groups emphasized that although addressing climate change regionally and globally is necessary, we need to connect students to local impacts of climate change to make it personally relevant to them.

Relating climate change to water shortages was a straightforward way that a California teacher made the concept real for her students while encouraging conservation. Other teachers suggested having students learn about local economic and agricultural changes, such as shifting harvest times for farmers. Multiple teachers suggested having students study local *phenology*, monitoring the timing of seasonal changes.

Connecting changing climate to regional recreational activities was also suggested as a way to introduce students to local impacts. A Florida teacher planned for students to observe the health of coral reefs during snorkeling field trips. Teachers from New England talked about how students have less snow for skiing. A West Virginia teacher involved her students in monitoring the water chemistry of brook trout habitats because these fish are popular with local fishers. Overall, these teachers agreed that fostering students' ownership for the local environment is crucial to motivating climate literacy.

Encouraging students to collect, analyze, and draw conclusions from their own data

Collectively, teachers in our focus groups conveyed the importance of having students collect

real data, enabling them to make sense of data, and allowing them to come to their own conclusions using data.

The teachers shared many examples of opportunities for students to collect and analyze data. A New Jersey teacher involved students in beach profiling, which includes measuring and collecting data about beach contours. By taking the same measurements over time, students created archival data sets that demonstrate change over time. A teacher in Massachusetts engaged students in analyzing data on bloom cycles around Walden Pond. Students then compared these data to Thoreau's 19th-century data on the same plant cycles. Students at a school in western Massachusetts were compiling a longitudinal set of phenological data by having successive years of students add to the series.

The teachers expressed satisfaction knowing that students "are using their intelligence in practical ways and not just relying on other people's opinions … they are making their own judgements based on what they find out there in the world." They agreed that this is a powerful approach to robust lessons in climate change.

Fostering relationships between researchers, teachers, and students

Many of the teachers in our focus groups collaborated with climate scientists and university researchers. These collaborations enhanced lessons and created opportunities for students to work directly with researchers. The partnerships began during university-sponsored teacher workshops, through networking at professional conferences, and from programs that pair teachers with researchers. The value of these experiences for both teachers and students was enthusiastically conveyed. One teacher shared, that after talking with scientists in the classroom, her students became more excited and exclaimed, "Wow! They talked to me!"

Some of these experiences were easy to coordinate and consisted of having scientists as far away as Antarctica videoconference into classrooms to discuss current research and observations. In other cases, small classroom investigations were related to large-scale research projects and provided an opportunity for students to chat with scientists about similarities in projects and data.

How do teachers establish and sustain integrated classroom projects with climate scientists? Some projects that began through programs that pair teachers with researchers continued through efforts to bring the research into classrooms. An Arizona teacher described attending science lectures and stopping speakers afterward to hand them a business card and ask, "Can I call you? Would you talk to my kids?" As a result, she currently collaborates with a paleontologist, a researcher of foraminifera, a polar researcher at McMurdo Station in Antarctica, and another researcher on a Coast Guard cutter—all of whom contribute to work with her students.

Launching *NGSS*-aligned climate change instruction

Embarking on teaching climate change can be intimidating, especially for those who lack support and knowledge about the topic. Teachers in our focus groups proposed that this is an authentic starting point for doing science with students. "Don't be afraid to be a scientist yourself," one teacher said. This teacher added, "You don't necessarily have to have all of the answers; allow them to come out of the discussion." Overall, there was a consensus that teaching climate change is an excellent way to teach science. Figure 1 summarizes ideas for climate change instruction contributed by the teachers in our focus groups.

Additionally, the teachers in our focus groups advocated teaching climate change using a multidisciplinary approach that promotes collaborations with other teachers. They emphasized that applying reasoning, thinking critically, making claims, using evidence in argumentation, and demonstrating the ability to communicate are skills that cut across disciplines. In addition to

generating support and sharing responsibilities, these crossdisciplinary collaborations serve to strengthen climate change knowledge within our professional teaching community.

There are multiple ways to embrace simple, affordable, and sound climate change teaching practices. In addition to the ideas summarized in Figure 1, gathering weather data with rain gauges, barometers, outdoor thermometers, and aerometers is a good starting point. Instructions for many of these instruments are available online, along with easily accessible archived local weather data from the National Weather Service. Additionally, many museums, university outreach programs, and nature and science centers are eager to assist and offer expertise.

FIGURE 1: Summary of ideas shared by teachers in the focus groups

Theme	Suggested ideas
Connecting students with local climate change impacts	• Request weather data from local National Weather Service offices • Connect learning to regional issues such as drought or agricultural impacts • Focus learning on how local phenology is changing • Investigate how climate affects regional recreation such as skiing, water sports, hunting, and fishing • Reach out to older generations for stories about past weather and climate
Encouraging students to collect, analyze, and draw conclusions from their own data	• Look for local longitudinal data sets to compare to students' collected data • Create longitudinal data by collecting data over multiple years • Seek partner schools or researchers (collect the same data and compare across locations) • Collect simple weather data with a classroom weather station and compare to climate averages • Collect data on climate change second-order effects, such as on forestry, agriculture, and fisheries
Fostering relationships between researchers, teachers, and students	• Enroll in university-sponsored teacher workshops and professional development • Contact climate researchers at local universities and invite them to speak to students • Apply for grants sponsored by science institutes to facilitate networking • Attend climate talks and science conferences to meet climate scientists • Apply for science teacher travel and research opportunities (see Resources)

One teacher's example

A Texas teacher fostered an ongoing collaboration with a climate change researcher after they met and worked together through a program that pairs teachers with researchers. She described her initial experiences with this researcher as ones that profoundly changed her teaching and learning: "It opened up a total different world. … I found myself trying to gobble up everything I could on oceanography, climate change, polar science, and I think that really made a difference." Bolstered by this experience, she launched into lessons on ocean cycles with her eighth-grade class, focusing especially on the carbon cycle. By participating in an ocean sciences curriculum sequence from the Lawrence Hall of Science (Regents of the University of California 2018), she taught students how to conduct chemical tests, then together they sampled water from three local sites along the Gulf Coast. The active process of data collection generated questions about the observed high levels of carbon dioxide in the

samples. At the time of our focus group meeting, her students were analyzing and interpreting the data, learning more about carbon flows, and working to construct explanations.

This example highlights each of the themes identified as sound practices in climate change education by

- connecting students with local climate change impacts;
- encouraging students to collect, analyze, and draw conclusions from their own data; and
- fostering this through a relationship with a climate scientist and a science center associated with a public research university.

Conclusion

Science teachers want to help students learn in ways that are significant and relevant; thus, increasing climate literacy should be a priority for middle school science teachers. Like the teacher in our example, we suggest starting with manageable lessons and projects by using some of the ideas and resources suggested below and offered in Figure 1, seeking collaborations with other teachers, and reaching out to local climate scientists for support. By involving students in collecting authentic data that relate to local climate issues while working hand-in-hand with climate researchers, we can build a foundation for climate change education that prioritizes this issue and provides students with the necessary knowledge to meet important challenges that lie ahead. ●

REFERENCES

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NGSS Lead States. 2013. *Next Generation Science Standards: For states, by states*. Washington, DC: National Academies Press. *www.nextgenscience.org/next-generation-science-standards*.

Regents of the University of California. 2018. MARE: Marine activities, resources and education. *http://mare.lawrencehallofscience.org*.

RESOURCES

Many climate change webinars are available in the NSTA Web Seminar Archive, such as Climate Change Here and Now: Forest Ecosystem Impacts, May 12, 2010—*https://common.nsta.org/resource/?id=10.2505/9/WSCCH10_May12*

Teacher travel opportunities—all expenses paid—*http://michaelrwing.com/teachers/all-expense-paid-teacher-travel-opportunities*

Suggested climate change and citizen science resources for middle school science teachers

- Budburst—*http://budburst.org*
- CitSci.org—*www.citsci.org/CWIS438/Websites/CitSci/Home.php?WebSiteID=7*
- CoCoRaHS—*www.cocorahs.org*
- Cyclone Center—*www.cyclonecenter.org*
- GLOBE and NASA Globe Observer—*www.globe.gov* and *https://observer.globe.gov*
- I See Change—*www.iseechange.org*
- iNaturalist—*www.inaturalist.org*
- Journey North—*https://journeynorth.org*
- Nature's Notebook—*www.usanpn.org/natures_notebook*
- Phenoclim—*http://phenoclim.org*
- Rink Watch—*www.rinkwatch.org*
- SciStarter—*https://scistarter.com*
- Students Discover—*http://studentsdiscover.org/teaching-modules*
- Zooniverse—*www.zooniverse.org*
- Regional projects include the NC King Tides project [*http://nckingtides.web.unc.ed*], Mountain Watch [*www.outdoors.org/conservation/climate-energy/citizen-science.cfm*], and Climate Watch [Australia; *www.climatewatch.org.au*]

Resources for teaching climate change

- NASA Global Climate Change—*https://climate.nasa.gov*
- NOAA Climate.gov—*www.climate.gov*
- The Polar Hub—*https://thepolarhub.org*
- PolarTREC—*www.polartrec.com*
- The Science Education Resource Center at Carleton College—*https://serc.carleton.edu/index.html*

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